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Agricultural Experiment Station
University of Alaska

FROM THE DIRECTOR'S DESK

Alaska's expanding agriculture reflects a positive policy for agricultural development within the state: Barley and rapeseed were produced on land cleared during the winter of 1978-79 within the 60,000-acre Delta Agricultural Project near Delta Junction. Plans are underway to develop more than 15,000 acres of new land for dairy farming near MacKenzie Point north of Anchorage. There is renewed interest in cattle ranching on the Kenai Peninsula and on Kodiak Island. Home and village gardening is expanding in rural communities within Alaska. Forest managers are working to increase yields of Alaskan timber and firewood.

These developments are long overdue: Alaskans produce less than five percent of the food they consume and only a fraction of the wood products they utilize. Research at the Alaska Agricultural Experiment Station has made significant contributions to agricultural development now underway in Alaska. Here are some examples:

- Six varieties of cereal grains (barley, oats, and wheat) adapted to Alaska's growing conditions have been developed by the Experiment Station. The two varieties of barley grown on land cleared in 1979 for the Delta Agricultural Project were developed and introduced by the Experiment Station.
- Two varieties of perennial grasses and two varieties of legumes have been developed and released by the Experiment Station for use as turf and forage plants in Alaska. These varieties have excellent winter-hardiness and superior performance under Alaskan growing conditions.
- Eleven varieties of vegetables and fruits adapated to Alaskan growing conditions have been developed and released by the Experiment Station for home gardens and commercial production in Alaska.
- Research in dairy-cattle genetics at the Experiment Station in cooperation with an artificial insemination program for Alaska's dairy industry has increased the milk production of dairy herds within the state. Average milk production per dairy cow in Alaska is comparable to the average milk production per dairy cow in major dairy states.
- Research in beef production has demonstrated that the productivity of native tall grasses and forbs on the lower Kenai Peninsula is equivalent to the True Prairie areas in the midwest. The rate of gain of beef cattle grazing on the native rangelands of the lower Kenai Peninsula is equivalent to cattle gains on the Flint Hills of Kansas.
- Research in soil temperature regimes and nutrient cycling in forest soils has led to forest management practices including thinning and fertilization to increase the productivity of forests in interior Alaska.
- Four superior cultivars of grasses have been developed and released by the Experiment Station for use in revegetation along the Alaska pipeline and on other construction sites in high-latitude areas of Alaska. One of these is the first cultivar developed of true arctic origin.
- Research in agricultural economics at the Experiment Station has been closely integrated with market development for Alaska's agricultural products. A recent projection based on state plans to expand the Delta Agricultural Project indicates that gross annual sales of crops and livestock within the Delta area will approach $23 million by 1986.

These results, developed through long-term support for agricultural research, are being applied to expand the production, processing, and marketing sectors of Alaska's agriculture. Research reported in this issue of *Agroborealis* will help to meet new problems and challenges as Alaska continues to expand its agricultural system.

James V. Drew, Director

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Covering Research in:

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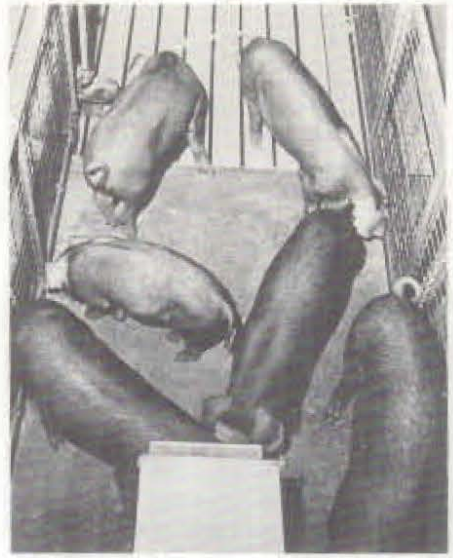

—and much more!

ABOUT THE COVER. . .
Animal Science staff members Terry Wighs, Robyn White, and Fred Husby assess the progress of this Red Duroc pig which is being raised successfully on a diet which includes a meal recovered from Alaska king crab processing wastes at Seward. Research on the feasibility of using this protein supplement is being conducted at the experiment farm at the Agricultural Experiment Station at Fairbanks. See page 4.

Photo by Tom Welsh

King Crab Meal

A Protein Supplement for Swine

By F. M. Husby*

Historically, Alaska has been dependent on external sources for a food supply. Greater than 98% of the red meat and poultry consumed in the state has been imported, with 93% of these products carried via waterborne transport shipments originating in Seattle (17). Alaskan-grown pork has provided less than 1% of the pork consumed in the state (1, 18). When we consider that imported pork has been shipped from a state with an 80% deficit in relation to its pork consumption (12), Alaska's deficit in self-sufficiency becomes even more significant.

Although domestic pork production has been inhibited by several factors, one of the more important has been the lack of a locally produced feed base. Cereal grain production has not been sufficient to satisfy the needs of local livestock producers, and the production of such high-quality plant protein sources as soybeans has been limited due to unfavorable, subarctic, growing conditions. Therefore, the pork producer has had to rely upon imported feed sources to supply both energy and protein in swine diets. Cereal grains have been imported from either the Pacific Northwest or Prince Rupert, British Columbia (3). It would be logical to assume that grain shipped from Prince Rupert originated in the Peace River area of Canada, the nearest major grain-producing area to that port. Both the Pacific Northwest and the Peace River areas produce cereal grains containing several percentage units less crude protein than the same grains produced in other areas of the United States and Canada (4, 7). This could further increase the cost of Alaskan pork production since this lower grain-protein content would necessitate the importation of greater amounts of a protein supplement such as soybean oil meal from the Midwest for the formulation of complete, balanced, swine diets.

Locally produced cereal grains may become available in the future as a result of the state's efforts to develop 60,000 acres in the Delta area for barley production. Depending on cultural techniques, the protein content of barley varieties grown in Alaska are reported to be considerably higher than that of the same varieties produced elsewhere in North America (20).

Since 1974, marine by-product meals have been available as an alternative protein source for the state's swine producers. Prior to the production of fishmeals, meat-and-bone meal was the only locally produced protein supplement available for swine. There are two types of basic fishmeals: those produced by processing waste from human food fishery plants, called marine by-products, and those produced by processing whole fish, usually caught specifically for reduction. When these meals are of high quality, they are considered one of the most valuable ingredients for livestock feeds. The meals consist of clean, dried, ground tissues of undecomposed whole fish or fish cuttings, with or without the oil extracted (15).

Although herring and salmon meal were produced in the 1930s and 1940s, those processors were forced out of business by foreign competition. Therefore, Alaskan fishmeal production repre-

The successful raising of these Red Duroc pigs on a diet containing meal recovered from the processing wastes of king crab at Seward gives a brighter outlook for the potential of domestic pork production in Alaska.

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sents a newly revived industry in Alaska. A large volume of fish-processing wastes have been and currently are disposed of by dumping back into the tidal waters, a practice which not only creates a possible environmental problem, but which wastes a source of high-quality protein. The Federal Water Pollution Control Act Amendments of 1972 and the Environmental Protection Agency's effluent guideline regulations resulted in the construction of waste-reduction plants at Kodiak, Petersburg, and Seward in 1973 and 1974. These plants were installed at that time to meet effluent guideline regulations for shellfish-processing wastes. Some seafood processors faced a closure of their plants by July 1977 and others in 1983 if they did not meet the effluent guidelines and standards of performance for fishmeal, salmon, bottomfish, herring, and scallop waste disposal as set forth by the Environmental Protection Agency. Recently, the Environmental Protection Agency withdrew these latter regulations because it recognized certain economic inequities in the implementation of those regulations in Alaska and will put forth new guidelines this year (5). However, the effluent guideline regulations for shellfish wastes at nonremote sites were not withdrawn.

In 1977, the total fishmeal consumed in the United States was estimated to be 360,000 tons, of which 283,000 tons were produced domestically (6). Of the total domestic production, only 9,255 tons of meal came from shellfish-processing wastes. In contrast, the total 1977 production of Alaskan fishmeal was approximately 7,000 tons, of which about 5,200 tons were produced from crab and shrimp wastes, accounting for more than one-half of the total United States production of shellfish meal, although Alaska's contribution to the total domestic production of fishmeal from all sources is negligible.

In 1976 and 1977, Alaskan shellfish meals averaged $100 to $140 per ton F.O.B. Seattle—a sum less than the cost of production. The remainder of the Alaskan meal, produced from herring, halibut, and salmon wastes, are considered high-quality protein sources for poultry and swine and demand considerably higher market prices. By contrast, the low price received for shrimp meal is difficult to explain when shrimp meal produced in the Gulf States has been reported to be an excellent protein source (9, 10). The low price for crab meals can be explained in part by the limited use of these meals in livestock feeds. Crab meals have been reported to be completely unpalatable to pigs (8,11) and, until recently, were not considered as a protein source for ruminant animals, either. The low palatability and the presence of high ash and chitinous material are the major limitations of crab meals in livestock rations. Richards (16) notes that the molecular structure of chitin is very similar to that for cellulose, differing only in the substitution of an acetylamine group for the hydroxyl group on carbon 2 of the glucose units. Therefore, one might anticipate that at least part of the chitinous material in crab meal would be subject to degradation by rumen microflora, as is cellulose. Recently, Patton and Chandler (13) and Patton, Chandler and Gonzalez (14) reported that ruminants could utilize part of the chitin molecule as an energy source and that blue crabmeal could supply some of the crude protein.

The amount of high-protein feed meal which can be salvaged from fish-processing wastes is shown graphically above. Crab processing results in about 80% waste of which 30% can be recovered as meal. This means that 12,000 tons of crab meal could be produced from an annual catch of 100 million pounds.

Although fishmeal production in Alaska is now low, an example of potential meal production, were more wastes processed, would be the amount of meal from the estimated king crab catch of 1977. The king crab catch was approximately 100 million pounds in Alaska. Processing results in 80% waste, and, of the waste, 30% can be recovered as processed meal (P. Larson, Seward Fisheries, personal communication). This would result in 12,000 tons of king crab meal or about twice the state's current total production of all fishmeals.

King crab meal is composed of shells, viscera, and unextracted meal and averages 35 to 40% crude protein. Some of the nitrogen is found in a nonprotein nitrogen form bound to chitin. However, the protein contributed from viscera and unextracted meal should be of excellent quality and could be readily utilized by nonruminant animals. The objectives of this study were to evaluate the performance of growing pigs fed king crab meal as a protein supplement and to determine the effect of physical separation on the feeding value of king crab meal for swine.

EXPERIMENTAL PROCEDURE

Four growth trials were conducted between the spring of 1976 and the fall of 1977 with 72 Duroc pigs. All pigs were housed in groups of four over partially slotted floors in an environmentally controlled confinement building. Feed and water were supplied *ad libitum*—at all times. Initial and final body weights were recorded and daily gain and feed efficiency were determined at the conclusion of the trials. Trials varied from 95 to 124 days in length.

King crab meals were analyzed for dry matter, ether extract, ash, crude fiber (2), and acid detergent fiber (19). The chemical composition of king crab meals, barley, and soybean meal used in Trials 1, 2, 3, and 4 are listed in Table 1. In Trial 4, king crab meal was separated through a 40-mesh sieve (Tyler Standard Soil Sieve) and the material less than 40 mesh was compared to the whole meal as a protein supplement replacement for soybean oil meal in barley diets. All diets were formulated to contain 16% crude protein during the growing phase for pigs of 40 to 125 lb. body weight when diets were then formulated to contain 13% crude protein until the pigs attained 220 lb. body weight. Diets for Trials 1 and 2 are shown in Table 2A. In Trials 1 and 2, coarse ground barley, the best-suited cereal for production in Alaska, was the main source of energy. King crab meal replaced 0, 25, 50 and 100% of the crude protein supplied by soybean oil meal in the barley-soybean meal basal diets. When pigs attained an average body weight of 125 lb., the crude protein content was reduced to 13% by increasing the barley and decreasing the soybean meal and king crab meal in proportion to maintain the 0, 25, 50, and 100% ratios. The high calcium content of king crab meal created an imbalance of calcium to phosphorus at higher levels of replacement of soybean

Table 1: Chemical Composition of King Crab Meals, Soybean Meal, and Barley (%)

Item	King Crab Meal					
		Trial 4				
	Trials 1, 2 & 3[a]	Whole	<40 Mesh	>40 Mesh	Soybean Meal	Barley
dry matter	94.3	95.6	95.4	95.6	89.5	88.6
crude protein	40.1	41.7	48.1	35.7	44.0	12.8
ether extract	1.4	3.0	4.2	1.8	1.3	1.7
ash	36.8	36.9	31.7	41.3	5.8	2.2
crude fiber	17.9	17.6	—	—	—	—
acid detergent fiber	20.7	20.6	15.6	27.4	10.1	7.8
calcium	12.4	9.0	7.9	10.3	0.24	0.08
phosphorus	1.8	1.6	1.4	1.7	0.66	0.4

[a]See Tables 2A-2B for diet composition.

Table 2A: Composition of Swine Diets, Percent of Diet, Growing and Finishing Period, Trials 1 and 2 (%)

Ingredient	Basal	25% KCM[a]	50% KCM	100% KCM
	Grower[b]			
barley	85.3	86.1	85.9	85.4
soybean meal	11.7	8.8	5.8	—
king crab meal	—	3.1	6.3	12.6
limestone	1.0	—	—	—
dicalcium phosphate	1.0	1.0	—	—
sodium phosphate	—	—	1.0	1.0
trace mineral salt	0.5	0.5	0.5	0.5
vitamin-antibiotic premix	0.5	0.5	0.5	0.5
	Finisher[b]			
barley	95.6	95.6	95.6	95.4
soybean meal	1.9	1.4	0.9	—
king crab meal	—	0.5	1.0	2.1
limestone	1.0	1.0	1.0	1.0
dicalcium phosphate	0.5	0.5	0.5	0.5
trace mineral salt	0.5	0.5	0.5	0.5
vitamin-antibiotic premix	0.5	0.5	0.5	0.5

[a]King crab meal.
[b]Grower diets contained 16% crude protein and were fed from 40 to 125 lb. body weight. Finisher diets contained 13% crude protein and were fed from 125 to 220 lb. body weight.

Table 2B: Composition of Swine Diets, Percent of Diet, Growing and Finishing Period, Trial 3 (%)

Ingredient	Basal	25% KCM[a]	50% KCM	75% KCM	100% KCM
	Grower[b]				
corn	77.2	77.9	77.5	77.1	76.6
soybean meal	19.8	14.8	9.9	4.9	—
king crab meal	—	5.3	10.6	16.0	21.4
limestone	1.0	—	—	—	—
phosphate, defluorinated	1.0	1.0	—	—	—
sodium phosphate	—	—	1.0	1.0	1.0
trace mineral salt	0.5	0.5	0.5	0.5	0.5
vitamin-antibiotic premix	0.5	0.5	0.5	0.5	0.5
	Finisher[b]				
corn	86.9	87.2	87.0	86.8	86.4
soybean meal	10.6	8.0	5.3	2.6	—
king crab meal	—	2.8	5.7	8.6	11.6
limestone	1.0	—	—	—	—
phosphate, defluorinated	0.5	1.0	0.5	—	—
sodium phosphate	—	—	0.5	1.0	1.0
trace mineral salt	0.5	0.5	0.5	0.5	0.5
vitamin-antibiotic premix	0.5	0.5	0.5	0.5	0.5

Table 3: Growth Performance of Pigs Fed Several Levels of King Crab Meal with Barley (Trial 1 and 2)

Item	Basal	25% KCM[a]	50% KCM	100% KCM
number of pigs	8	8	8	8
KCM dietary intake, %	0	3.1	6.3	12.6
average daily gain, lb.	1.76a	1.74a	1.72a	1.54b
average daily feed cons., lb.	5.81	5.85	5.96	5.70
feed:gain ratio	3.36c	3.40c	3.54d	3.70e

[a]King crab meal.
NOTE: a,b,c,d,e values followed by the same letter are not significantly different (P<.05).

meal. In order to maintain a calcium: phosphorus ratio close to the preferred 2:l ratio, sodium phosphate, monobasic, was supplemented in diets that contained greater than 50% replacement of soybean meal with king crab meal. Trial 1 differed from Trial 2 only by initial pig weights of 32 and 40 lb., respectively.

Trial 3 was designed and conducted in a manner similar to Trials 1 and 2 described above except that corn was the cereal and a treatment was included with a 75% replacement of soybean oil meal with king crab meal. Diets are shown in Table 2B. Trial 4 was designed to determine the effect of physical separation of king crab meal. Diets were as follows: barley-soybean meal basal, 50 and 100% replacement of soybean meal with king crab meal and 50 and i00% replacement of soybean meal with king crab meal that was finer than 40-mesh separation. (Although Trial 4 is presently being replicated, the data presented here has not yet been statistically analyzed).

RESULTS AND DISCUSSION

King crab meal composition (Table 1) is characterized by a crude-protein content of approximately 40%, a low ether extract, and high ash and fiber contents. The crude protein content is similar to the amount of protein in meals of plant origin. (The composition of soybean meal, the leading protein supplement utilized in swine diets, is included in Table 1 as a comparison, as is the composition of Edda barley, a Swedish variety introduced to Alaska in 1951.) However, some nitrogen is contained in the chitin molecule of crab shells and is released as ammonia when chitin is degraded and is not a form usable by monogastrics. The low ether extract would indicate a lower total energy content than fish meals produced from wastes of fin fish which have an oil content approximately four times that of king crab meal. The fiber content is composed mainly of chitin which is not digested by monogastrics and would further dilute the total available energy of king crab meal when compared to soybean oil meal. Whole king crab meal is composed of large shell particles (0.5 cm. or about 1/5 in. diameter) and a very fine powder which may represent the unextracted meat and viscera. Following physical separation through a 40-mesh screen, the material finer than 40 mesh had a greater crude protein content and lesser amounts of ash and fiber than that retained by the screen, which contained

Table 4: Growth Performance of Pigs Fed Several Levels of King Crab Meal with Corn (Trial 3)

Item	Basal	25% KCM[a]	50% KCM	75% KCM	100% KCM
number of pigs	4	4	4	4	4
KCM dietary intake, %	0	5.3	10.6	16.0	21.4
average daily gain, lb.	1.87a	1.90a	1.65b	1.67b	1.47c
average daily feed cons., lb.	6.16	5.98	5.68	5.54	5.98
feed:gain ratio	3.31d	3.25d	3.60e	3.81e	4.13f

[a]King crab meal.

NOTE: a,b,c,d,e,f values followed by the same letter are not significantly different (P<.05).

Table 5: Growth Performance of Pigs Fed Several Levels of Separated King Crab Meal with Barley (Trial 4)[a]

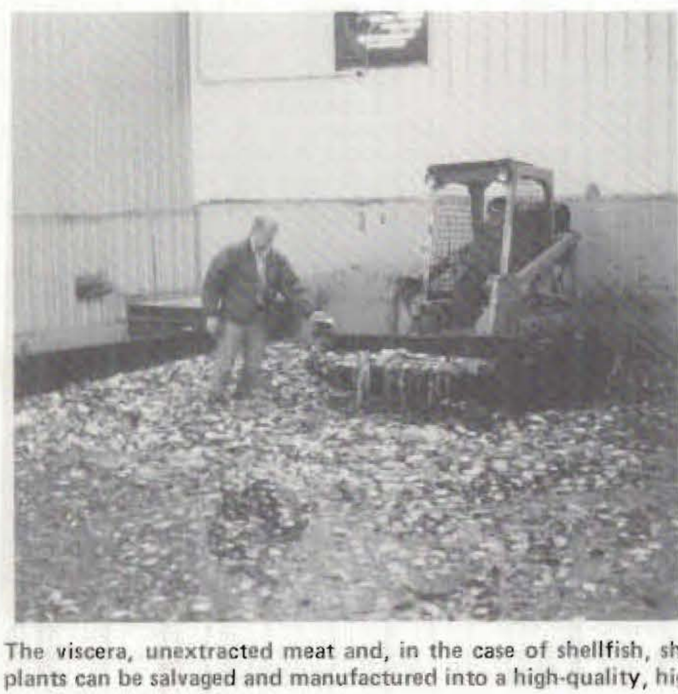
Item	Basal	50% KCM[b] Whole	50% KCM[b] 40 Mesh	100% KCM Whole	100% KCM 40 Mesh
number of pigs	4	4	4	4	4
KCM dietary intake, %	0	4.7	4.1	9.3	7.6
average daily gain, lb	1.60	1.53	1.62	1.25	1.58
average daily feed cons., lb	5.39	5.48	5.37	4.22	5.17
feed:gain ratio	3.31	3.59	3.30	3.79	3.42

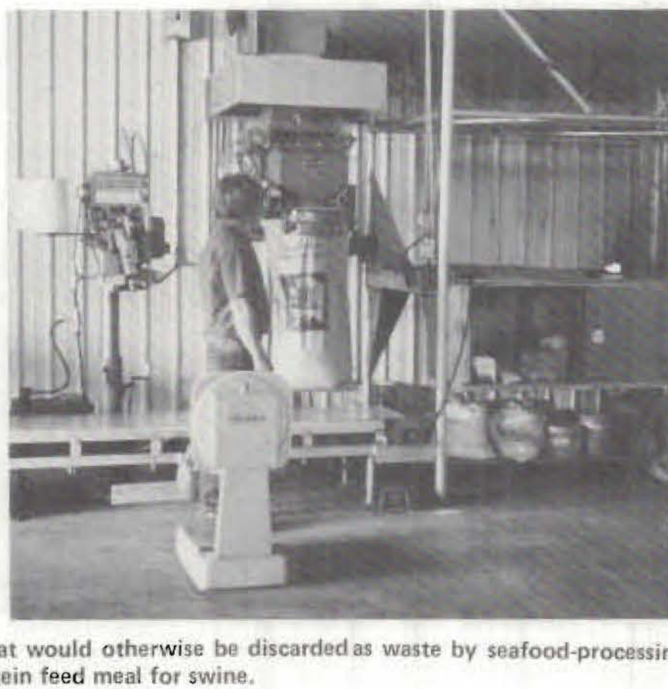
[a]This trial is presently being replicated; the data given here were not statistically analyzed.
[b]King crab meal.

less crude protein and greater amounts of ash and fiber. If the finer material represented viscera and unextracted meat, then it should have a higher protein content and a higher-quality protein than the whole meal which contains some crude protein in the amino form on the chitin molecule. Therefore, the fine material would be expected to be a higher-quality protein supplement than the whole meal for monogastric animals.

Growth performance data from Trials 1 and 2 (Table 3) were combined since no difference in performance was detected between the different initial body weights. Average daily gain was not significantly different between the basal and the 25 and 50% levels of replacement of crude protein from soybean meal with king crab meal. However, the efficiency of gain was slightly reduced at the 50% level of replacement. Substitution of king crab meal for soybean meal at the 50% level would depend on the relative prices of the two supplements. A 50% replacement level corresponds to a total dietary intake of 6.3%. The inclusion of king crab meal in commercial swine diets should be less than 6.3% to maintain both the rate and efficiency of gain. At the 100% replacement level, the rate of gain was significantly lower than the basal, 25, and 50% replacement levels and the efficiency of gain was less than the basal and 25% level. This indicated that the 100% replacement level did not furnish enough digestible protein to replace soybean meal economically as the sole supplemental protein source. Average daily feed consumption was similar for all diets and indicated that palatability of diet containing king crab meal may not have been a major problem.

Growth performance of pigs fed king crab meal with corn is presented in Table 4. Although corn is not produced as a livestock feed in Alaska, corn-soybean meal diets are fed to approximately 85% of the pork produced in the "Lower 48." Alaskan shellfish meals are marketed through Seattle and may be considered for inclusion in corn-soybean meal diets if the feeding value were known for king crab meal in corn-based diets. Both the rate and efficiency of gain were not significantly different (P<.05) between the basal and the 25% replacement level. Average daily gains and feed efficiency for the 50, 75, and 100% replacement levels were significantly less (P<.05) than the basal and the 25% level. Replacement of soybean meal with king crab meal at the 25% level corresponded to a 5.3% level of dietary intake. The maximum practical utilization of king crab meal in swine diets as a percentage of dietary intake would be between 5.3 and 6.3% where there was no difference in growth performance in corn-soybean diets (Trial 3) and only a slight reduction in feed efficiency in barley-soybean diets (Trials 1 and 2), respectively.





The viscera, unextracted meat and, in the case of shellfish, shells that would otherwise be discarded as waste by seafood-processing plants can be salvaged and manufactured into a high-quality, high-protein feed meal for swine.

Meals produced by plants such as that shown above, at Seward, can salvage a valuable food-processing by-productand help to cut costs while improving the efficiency of swine production.

Growth performance of pigs fed separated king crab meal is presented in Table 5. The average daily gains were similar for the basal, 50% whole-meal, and 50 and 100% separated-meal diets. A reduction in average daily gain resulted from replacement of 100% of the soybean oil meal with whole king crab meal and this was similar to the results in the first three trials. Feed efficiency was reduced only at the 100% level of replacement with whole meal. A reduction in feed efficiency at the 50% level with whole king crab meal was not detected as reported in barley-based rations in Trials 1 and 2. Physical separation at 40 mesh removed some of the shell wastes and possibly resulted in a material (<40-mesh) that represented protein from viscera and unextracted meat wastes. Viscera and unextracted meat would contain a higher-quality protein and have a feeding value nearer that of soybean oil meal. Further work is needed on the effects of physical separation, but it may represent a low-cost method of improving crab-meal wastes for swine.

CONCLUSIONS

King crab meal can replace 50% of the crude protein from soybean meal in barley-soybean meal diets with a slight reduction in feed efficiency. King crab meal can replace 25% of the crude protein of soybean meal in corn-soybean meal diets. The maximum level of king crab meal as a percentage of dietary intake would be between 5.3 and 6.3%. Physical separation may be a low-cost method of improving king crab meal as a protein supplement for nonruminant livestock. The cost of king crab meal is approximately one-third that of soybean oil meal in Alaska, and, when included in swine diets at levels reported above that do not alter rate or efficiency of gain, the total cost of swine production can be substantially reduced.

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Buckwheat in full flower.

Buckwheat

A New Look at an Old Crop

By Frank J. Wooding*

BACKGROUND

Buckwheat has never ranked as an important crop in Alaska, even though it is not new to the state. Prior to the 1867 United States purchase of the territory, Russian agricultural colonies were reported to have grown this crop successfully at Yakutat and at various places in the Cook Inlet area (3). Shortly after their establishment near the turn of the century, the Alaska Agricultural Experiment stations began reporting successes with buckwheat. In 1899, buckwheats obtained from Siberia and Maine were grown to maturity on test plots located at Sitka and Kenai (4). Over the years, small patches of buckwheat have been and continue to be grown in Alaska. In the past, homesteaders frequently grew buckwheat as a first-year crop on newly cleared land. It was also popular as a green-manure crop preceding potatoes. Today, the little buckwheat produced in Alaska is grown primarily by organic health food enthusiasts on a very small scale. Also, a few people living in remote bush areas still grow buckwheat to supplement a subsistence lifestyle.

The commonly cultivated buckwheat plant (*Fagopyrum esculentum* Moench) is entirely different from other grains and is not a grass. It is a summer annual with branched stems and broad, arrow-shaped leaves. Flower panicles (loosely and irregularly branched clusters) and leaves rise from the nodes, both on the main stem and branches (above). Growth habit is indeterminate, with flowers opening more or less continuously until climatic conditions become unfavorable in the fall. Consequently, the seed crop does not all mature at one time (1, 5). At harvest, flowers, green seed, and mature seed are present on the plant simultaneously. This condition necessitates swathing and field drying before the crop can be combined. Swathing is usually carried out immediately after a killing frost, or when approximately 75% of the seeds are mature, whichever event occurs first. Seed shattering and lodging can occur soon after a severe frost (2).

Buckwheat yields are generally lower than are those for other grains but the value in the market place is usually higher. In Canada, yields ranging from 15 to 19 bushels per acre are common, although 38 bushels per acre or higher have been recorded (2). United States buckwheat yields have been relatively constant over a period of many years, averaging around 20 bushels per acre (7, 8). The lack of improvement in yield is a major reason why buckwheat production in the U.S. has declined from a high of 22 million bushels in 1866 to 366,000 bushels in 1970 (7). There has been little effort to improve buckwheat through plant breeding. Modern varieties of other grain crops have steadily increased their yield advantage over that of buckwheat (6).

RECENTLY DISCOVERED MARKET POSSIBILITIES

During the fall of 1977, an agricultural trade mission visited the Orient in search of markets for products from Alaska and found several Japanese trade firms interested in purchasing buckwheat (9). In Japan, consumption of buckwheat exceeds production, and, in recent years, the Japanese have imported approximately two-thirds of the Canadian crop from 87,700 acres. The Japanese mix buckwheat flour with wheat flour in the manufacturing of buckwheat noodles. Hulls from the seed are used for stuffing pillows (2).

Consequently, the possibility of a lucrative Japanese market for buckwheat stimulated renewed interest in growing this crop in Alaska. However, no recent research data were available on growing buckwheat in Alaska. It was indeed time for the Agricultural Experiment Station to take a new look at an old crop. In 1978, a research program was initiated to re-evaluate buckwheat as a crop for interior Alaska.

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Table 1. Buckwheat trials conducted at Fairbanks and Delta-Clearwater in 1978.

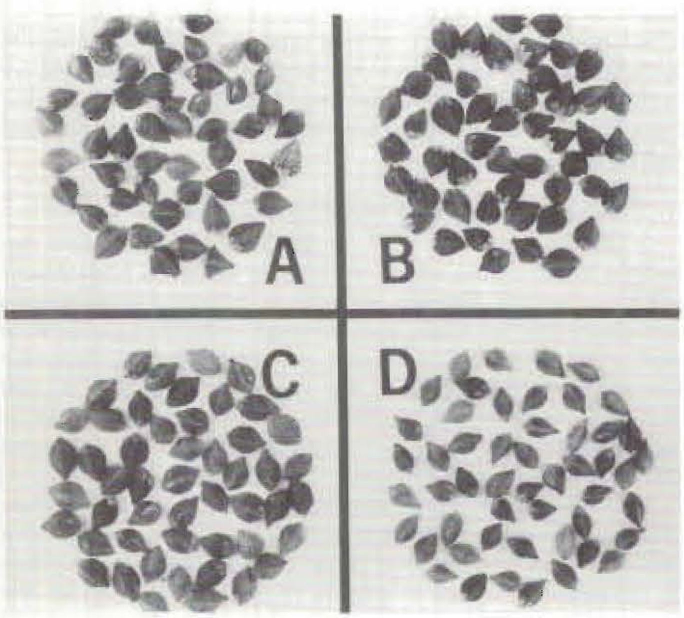
Cultivar (Variety) or Type	Seed Source	Fairbanks Seed[a] Yield bu/acre	Fairbanks Ripe Seed at Frost %	Delta-Clearwater Seed[a] Yield bu/acre	Delta-Clearwater Ripe Seed at Frost %
Pennquad	Pennsylvania	51.3	85	15.7	55
PA Composite	Pennsylvania	21.7	45	4.8	10
PA-158	Pennsylvania	17.7	40	5.2	10
Tokyo	Canada	34.2	70	8.4	30
Mancan	Canada	26.3	50	4.5	10
CM-15	Canada	43.0	90	30.3	65
Tempest	Canada	27.4	75	10.8	35
Botan Soba (Hokkaido)	Japan	14.1	35	4.0	10
Japanese	Illinois	35.2	70	19.6	55
Common	Minnesota	33.9	55	7.4	25
Common	New York	33.6	60	—[b]	—[b]
	Average	30.8	61	11.1	31

[a]The standard test weight of buckwheat is 48 lb/bu. To express yields as lb/acre, multipy bu/acre times 48.
[b]Common buckwheat from New York was not planted in the Delta-Clearwater trials.

RESEARCH AIMED AT IMPROVING YIELDS

For the initial phase of the research, seed of eleven different buckwheat cultivars and types were obtained from Canada, Japan, Pennsylvania, Minnesota, Illinois, and New York. Test plots were planted at Fairbanks and Delta-Clearwater. A list of entries and the results of these trials are given in Table 1. Fairbanks yields were noticeably higher than those obtained at Delta-Clearwater. The growing season for buckwheat at the Delta-Clearwater site was abruptly terminated by a killing frost which occurred during the third week of August. However, CM-15, an early-maturing experimental line, produced a very respectable yield of 30 bushels per acre. At Fairbanks, the growing season was more than a month longer, extending into late September. Two buckwheats, Pennquad and CM-15, produced exceptionally high yields of 43 and 51 bushels per acres, respectively.

CM-15 and Pennquad show progress in overcoming the indeterminate growth habit which has kept yields low and made harvesting difficult. These two buckwheats reached peak flowering early in the growing season and the seed matured faster and more uniformly than all other entries in the test. Pennquad is a large-seeded tetraploid variety developed by the Pennsylvania State University (6). CM-15 is a small-seeded experimental line developed by the Agricultural Canada Research Station at Morden, Manitoba.



Seed of four cultivars of buckwheat: A=Mancan, B=Botan Soba (Hokkaido), C=Pennquad, and D=CM-15.

Two large-seeded buckwheats, Mancan and Botan Soba, were included in the test because these varieties currently satisfy a major portion of the Japanese market. Mancan is grown in Canada primarily for export to Japan (2). Botan Soba is grown on Hokkaido, the northernmost island of Japan, and its quality is highly valued by the Japanese. Both varieties were late maturing, had a high degree of indeterminate growth, and produced low yields. Their poor adaptation to interior Alaska was particularly noticeable at the Delta-Clearwater site where the growing season was shortened by an early frost.

Seed samples of Mancan, Botan Soba, Pennquad, and CM-15 are shown below. Samples of Pennquad and CM-15, the two most adapted varieties, will be sent to Japan for quality analysis. It is hoped that at least one of these varieties will be acceptable for the Japanese market.☐

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Mine Reclamation

in

Portions of West Germany, Union of Soviet Socialistic Republics and Alaska

By Jay D. McKendrick*

There are three obvious justifications for reclaiming lands damaged by surface mining. In order of their priority, they are: 1) to reduce and/or eliminate hazards to human health and well-being, 2) to restore biological productivities and capacities for uses unfeasible on mine spoils, and 3) to remove unsightliness, thus promoting aesthetics. The 95th Congress passed an act entitled the "Surface Mining Control and Reclamation Act of 1977" which was aimed at regulating surface mining operations to "establish a nationwide program to protect society and the environment from the adverse effects of surface coal mining operations" (5). Another stated purpose was to: "assure that the coal supply essential to the Nation's energy requirements, and to its economic and social well-being is provided and strike a balance between protection of the environment and agricultural productivity and the Nation's need for coal as an essential source of energy."

Congress also noted that:

> because of the diversity of terrain, climate, biologic, chemical, and other physical conditions in areas subject to mining operations, the primary governmental responsibility for developing, authorizing, issuing, and enforcing regulations for surface mining and reclamation operations subject to this Act should rest with the States (5).

Unreclaimed heaps in a fire clay mine of the USSR produce only scattered patches of vegetation. The low soil stockpiled on the horizon will be used to return this area to its original crop-producing capability.

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Coarse-textured materials are used to construct roadways among reclaimed fields of the surface coal mines near this West German town. That practice not only provides better roads, but also saves valuable loam soils for crop production.

Permitting states to set their own environmental reclamation standards appears to be the most appropriate action in this instance. In order for Alaska to initiate such a program, a certain amount of technological information would be needed. Perfunctory mimicking of standards set in other states would be inappropriate for Alaska due to basic environmental differences between Alaska and the other states. Surface mining reclamation projects in other cold regions, such as parts of the USSR and Canada should have more relevance to Alaska than those of the temperate United States.

During the summer of 1977, the author and four other Americans spent almost three weeks on a rapidly paced inspection of mine reclamation projects in parts of the Federal Republic of Germany and the Union of Soviet Socialistic Republics. Others in the delegation included: Harold T. Jorgensen and Don Calhoun, then of the Bureau of Land Management, now retired; Richard Hodder of Montana State University; and Farrell Branson of the U.S. Geological Survey. A series of protocol meetings for the exchange with the USSR commenced in 1972 with the signing of an agreement to cooperate on environmental matters. The agreements included previous and subsequent visits to the United States by Soviet technicians and scientists.

The goal of such bilateral exchange is the expeditious transfer of environmental technology. The demands for more energy from coal resources and the concerns over environmental damages due to mining are obviously in conflict and can be resolved only with compromises and rapid technological advancements. How various nations are meeting the challenge is of interest to every country facing the dilemma. Normal scientific communication processes have been notoriously slow among and between nations in the past.

RECLAMATION EFFORTS CAN BE SUCCESSFUL

Examples of successful reclamation were observed in both countries visited. Germany has a longer history of reclamation (about forty years) than does the USSR (about twelve years). In both countries, where reclamation is either underway or completed, the usual goals are to develop either agricultural cropland and forests or to convert the spoils into a public recreational facility. In no instance is wilderness or wildland management a part of the reclamation program, a goal which might be desirable for parts of Alaska. Both the USSR and the Federal Republic of Germany seem to be most concerned with maintaining or expanding their national food, fiber, and wood production. This is obviously important in Germany because of its relatively small size.

Slurries of loam are pumped into dyked areas during the reclamation of West German coal mine spoils.

Such production is deemed a necessary goal by members of the Ministry of Agriculture in Moscow because, even though the USSR has a vast land resource, that nation's arable soils amount to only 10% of the land, of which 70% require irrigation. Further encroachment of urban development and industrialization on croplands is of major concern to the Soviet government's agricultural specialists. Thus, reclamation is aimed primarily at restoring biological productivity and land-use capabilities, rather than alleviating hazards to human health and/or well-being.

With respect to Alaska, we saw only one example of reclamation in a cold climate and none in dedicated wilderness areas. But a recent report by Kevin Klose in *The Washington Post* (3) suggests the USSR is beginning to strip mine in permafrost regions; consequently, reclamation problems in those areas of Siberia may be environmentally similar to some Alaskan locations. Future bilateral exchange should allow Alaskans who are concerned with surface mine reclamation to visit the Siberian sites.

ADEQUATE PLANNING IS IMPORTANT

We observed several points important to mine reclamation for Alaska—and the United States in general. The combining of reclamation goals with those of mine development *before excavation begins* is fundamentally critical because reclaiming older mine spoils seems to be a greater problem than taking care of current spoils. Completing the job while men and equipment are still in the vicinity is more efficient than moving back into abandoned sites. Without plans for saving them, surface soils were irretrievably lost during past mining efforts. Borrowing soil from one area to reclaim another is the only option under such conditions, and that is often an unacceptable alternative.

Saving surface soils is obviously a key to restoring biological production. Once

After the slurry of loam has dried, farming begins on the reclaimed fields of the lignite mining district.

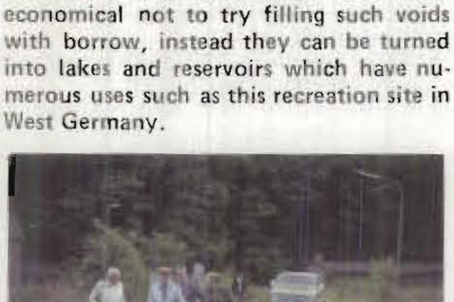
The sapling plantation in the foreground will develop into a forest such as those beyond the farmland in this view of reclaimed mine spoils in West Germany.

suitable soils are replaced, plants and animals can be reestablished in the area. The kind of biological community desired dictates the necessary technical options: determining which options should be applied will, likewise, be fundamental to any program in Alaska. For instance, in some of the German coal fields, regulations demand that a certain depth of top soil be replaced on croplands. At some sites, where the amount of naturally occurring surface soil is less than that required in the regulations, requirements are met by topping reclaimed forests and roadways with coarse-textured and subsoil materials, thereby saving prime surface soils for the adjacent croplands. But even with the savings incurred by this practice, top soil is borrowed from other areas to meet the regulatory requirement.

FLEXIBILITY OF REGULATIONS IS ESSENTIAL

Each mine has its own special characteristics and problems. Forest reclamation of a surface-mined oil shale deposit in Estonia succeeded by transplanting saplings onto the rocky rubble, and the resulting forests resemble those often found on dredge tailings near Fairbanks, Alaska. Mulching with peat seems to be a satisfactory soil treatment, and no top

When surface mines are terminated, a void in the landscape usually occurs because of the minerals removed and the displacement of overburden. It is most economical not to try filling such voids with borrow, instead they can be turned into lakes and reservoirs which have numerous uses such as this recreation site in West Germany.



Two U.S. observers walking a country road with their German hosts. This area was once an open-pit lignite mine.

Recently reclaimed wheat field at a Ukraine manganese mine. Undulating topography results from differential settling of leveled spoil heaps from the mine.

Ukrainian students picking currants growing on reclaimed manganese mine spoils.

soil was used on those Estonian sites. In contrast, top-soiling with surface horizon materials is quite important for cropland reclamation in the Ukraine. Terracing steep slopes in the high rainfall district of Georgia is not necessary to control erosion. In that area, exposed soils remain barren for only two to three weeks because natural plant invasion is very rapid.

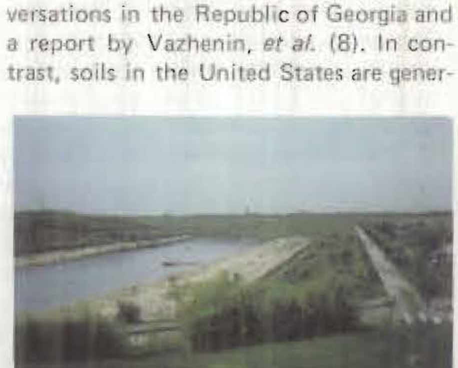
In other localities, terracing has proved important for controlling runoff erosion. Top soil was placed in trenches cut into spoil materials to establish a successful demonstration orchard near Ordzhonikidze. That innovative technique is particularly useful on old spoils for which available top soil is quite limited. Our group observed ongoing tests at the same experiment station to evaluate production of various medicinal crops on mine spoils. Examining such untraditional crops seemed appropriate since many medicinal plants are rather "weedy" members of natural flora and may be physiologically adaptable to soils too poor for ordinary crops. All plantings appeared to have been seeded. We saw no major uses of vegetative propagation on reclaimed mine spoils.

Creating public recreation areas was a notable achievement in both countries. The formation of a lake for swimming and fishing in the semiarid zone of the Ukraine was obviously welcomed by the local citizens. Remaining high walls and tree-covered spoil heaps added interest to an otherwise flat terrain. Chiatura, a village in the mountainous region of Georgia, lacked level ground; thus, forming park and other level areas on mine spoils for school playgrounds satisfied a particular local need.

In Germany, the forests resulting from plantations on mine spoils are beautiful and remarkably natural in appearance and reminded the author of a recent comment by Solandt (7): "Many of us who travel in Europe tremendously admire the beauties of the countryside where literally everything has been changed by the hand of man."

In both countries, the most beneficial results come from long-term commitments for both research and applications of technology. The joining together of engineering and biological sciences to achieve common goals is essential. The Soviet technology divides mining reclamation between "technical recultivation" and "biological recultivation" of lands (4). (Translations from Russian invariably referred to "recultivation" for the English terms "reclamation" or "revegetation.") Top-soiling and recontouring of landscapes is a major part of the technical phase; agronomic and horticultural applications constitutes the biological phase.

Soil fertility and toxicity maps of contoured terrain are most important to the biological recultivation phase. Nutrient deficiencies noted by the Soviet technicians included nitrogen, phosphorus, and occasionally potassium. Alfalfa and sanfain, two domestic legumes, are often grown on reclaimed land to build soil nitrogen supplies. Salinity and alkalinity are two problems specifically mentioned in relation to plant-growth problems. Apparently, the practice of intensive sampling to provide large-scale maps of soil nutrient status is a basic step in Soviet agriculture, according to our conversations in the Republic of Georgia and a report by Vazhenin, *et al.* (8). In contrast, soils in the United States are gener-



A recreation area surrounded by forest plantations was created in this void left by surface mining near Ordzhonikidze, USSR.

Two Soviet scientists discuss the importance of proper nitrogen and phosphorus fertilization in reclaiming mine spoils for cereal production. The stunted plants in the foreground received no nitrogen; the taller barley was fertilized with both nitrogen and phosphorus.

ally mapped only according to their genetic (formation) traits. To some Soviet soil scientists, genetic maps do not account for man's overshadowing influences on soil fertility and are thus inadequate for proper management of soil nutrient regimes.

THE COST FOR RECLAMATION

The cost of reclamation programs must be reasonable in relation to the value of the mineral resources and the resultant land use after mining. Regardless of how reclamation is accomplished, the consumer pays the price either in the form of taxes or in the price of products and services derived from the mines. Soviet operators seem to mention reclamation costs more often than their German counterparts. That may have resulted from the Soviets either sensing accomplishments in achieving reclamation economically of from being keenly aware of new cost burdens that were recently incorporated into the Soviet mining operations. Reclamation costs of one manganese mine near Ordzhonikidze, Ukraine, declined from over $8,000/acre to $2,400/acre since reclamation programs were initiated, probably reflecting a gearing-up period as the technology for reclamation was instituted.

LOCAL CONSIDERATIONS

Abiding by local considerations under the general guidance of broad national goals achieved remarkable results in Germany. That approach apparently allowed for local variations. Even though the Soviet mine reclamation projects are achieving commendable results, their approach lacks the finesse of their more-experienced, West German counterparts and resemble some of the early reclamation attempts in the United States. The central-planning approach of the Soviet government received a poor rating on environmental matters by Goldman (2).

Alaska contains an estimated 558 billion tons of coal (6). A significant portion of that could be surface mined, but presently only one commercial mine is operating. A substantial portion of Alaska's coals occur on the North Slope and into the Brooks Range (1). Climatological, biological, and demographical features comparable to most of Alaska's coal fields occur in some parts of the Soviet Union's eastern Siberian region. Reclamation goals and technical requirements should be similar in both countries. Thus, collaborating research efforts would seem to be a mutually beneficial approach. Because both countries also contain vast areas subjected to placer-mining disturbances in past years, studying those old mines would be one place to begin studies on how to manage future coal-mining disturbances. The Mineral Industry Research Laboratory and the Agricultural Experiment Station of the University of Alaska are currently collaborating on such a study on placer spoils in the Fairbanks area.

Manganese spoils and topsoil heaps in near Ordzhonikidze, USSR.

The solitary figure of a woman herding cows on unreclaimed manganese spoils near Chiatura, Georgia, USSR. These spoils may date back to the time when an English firm initiated mining in this district.

ALASKA SHOULD PROCEED CAUTIOUSLY IN DEVELOPING REGULATIONS

There are two extremes in choices for mining reclamation: 1) to proceed with minimum agronomic inputs and allow natural biological succession to reign; or 2) to proceed with maximum agronomic inputs, i.e. tillage, fertilizers, liming, etc. to achieve rapid plant cover. Both approaches have their advocates and proper places. Blending of the two techniques to fit local conditions will probably be the most desirable choice for Alaska. However, for many parts of Alaska and Siberia, the relative merits of the two extremes are largely unknown, and will remain so pending more developments and experiments. Under these conditions, it is imperative that various reclamation options not be restricted before a reliable data base has been established.□

ACKNOWLEDGMENTS

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Observations of a Grass Bug on Bluejoint Ranges

Figure 1: A sap-sucking insect feeding upon the cell contents of bluejoint reedgrass caused the light-colored spots on leaves in this photo taken on native range near Homer, Alaska, 25 July 1978.

By Jay D. McKendrick*
and David P. Bleicher**

Balancing range utilization with range production is basic for successful range management. Consequently, range researchers must be watchful for any factors affecting either the utilization or the production processes. During the 1978 summer grazing season, large numbers of chlorotic (colorless to yellow) spots appeared on leaf blades of bluejoint reedgrass (*Calamagrostis canadensis*), the dominant tall grass on ranges near Homer, Alaska (Figure 1). In heavily damaged locations, the problem appeared on every leaf of bluejoint shoots, and the plants appeared dwarfed as if suffering from drought.

Large populations of a sap-sucking insect, present on the leaves (Figure 2), were judged to be the cause. The insect was identified as *Irbisia sericans* Stal., a true bug (order Hemiptera) of the family Miridae. Records show the species is native to Alaska (2, 6, 7) with its distribution in the state limited to the southern coastal regions (Figure 3). Specimens have been recorded from St. Paul and St. George Islands of the Pribilofs (10, 11) and Umnak Island of the Aleutian Chain. Mainland collections include the southcentral coastal region and the southeastern panhandle. The total range of the insect is known to extend into the USSR at Kamchatka and on Bering Island. Southward in the Western Hemisphere, the range includes parts of Oregon and California to the San Francisco Bay area. In those southerly locations, it reportedly feeds heavily on grain crops (1, 4), wheat, barley, oats and rye. Wild mustards (*Brassica*), dock (*Rumex*), cheeseweed (*Malva*), and fiddle neck (*Amsinckia intermedia*) are weedy and wild plants that *I. sericans* is known to feed upon in those regions. At Homer we observed insect on fireweed (*Epilobium angustifolium*) but failed to find evidence of damages to that plant (Figure 4).

The insect is characterized by a dull olive-black color, a rough, wrinkled pronotum (dorsal plate behind the head), and rather dense pubescence on the head, pronotum, and hemelytra (thickened front wings).

They feed by inserting their tubular mouthparts into leaf tissues and removing plant juices. Such feeding usually results in a chlorotic spot around each feeding puncture because the plant cells die.

Similar grass bugs of economic importance in other parts of the United

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Figure 2: High numbers of the grass bug, *Irbisia sericans*, were observed on bluejoint reedgrass leaf blades on ranges near Homer, Alaska, during the 1978 growing season.

Figure 4: *Irbisia sericans* occurred in large numbers on the leaves of fireweed, above, but fireweed exhibited none of the masses of chlorotic spots noted on bluejoint as a result of *I. sericans* feeding.

States are related to this species (3, 5). Because relatively little is known about the habits of *I. sericans*, a study of its effects on bluejoint reedgrass was begun. In the summer of 1978, we attempted to measure the relative population of the insect at several sites on native rangelands near Homer and to identify possible effects on forage production and quality.

Leaf and whole-shoot samples were collected and analyzed for several forage-quality components at the Palmer Research Center's laboratory. Percentages of leaf area damaged by insect feeding were also measured. Mature leaves from bluejoint plants were ashed (8) and examined microscopically to see if there were any relationships between the patterns of silica deposited in the leaf blade cells and the insect's infestation. We presumed that high numbers of silica cells and heavy silica deposition may have discouraged insect feeding.

SURVEY RESULTS

The survey of leaves suggested that leaf weight, nonstructural carbohydrates and cell contents were lower; and that crude protein, Mg, Ca, and hemicellulose percentages were higher for leaves that had been fed upon by *I. sericans* (Table 1).

Correlation coefficients were calculated for data from the insect population survey and whole-shoot analyses of bluejoint plants (Table 2). It was noteworthy that percentages of crude protein, Mg, Ca, and hemicellulose were positively correlated with percentages of damaged leaf area and that TNC (total nonstructural carbohydrates) was negatively correlated

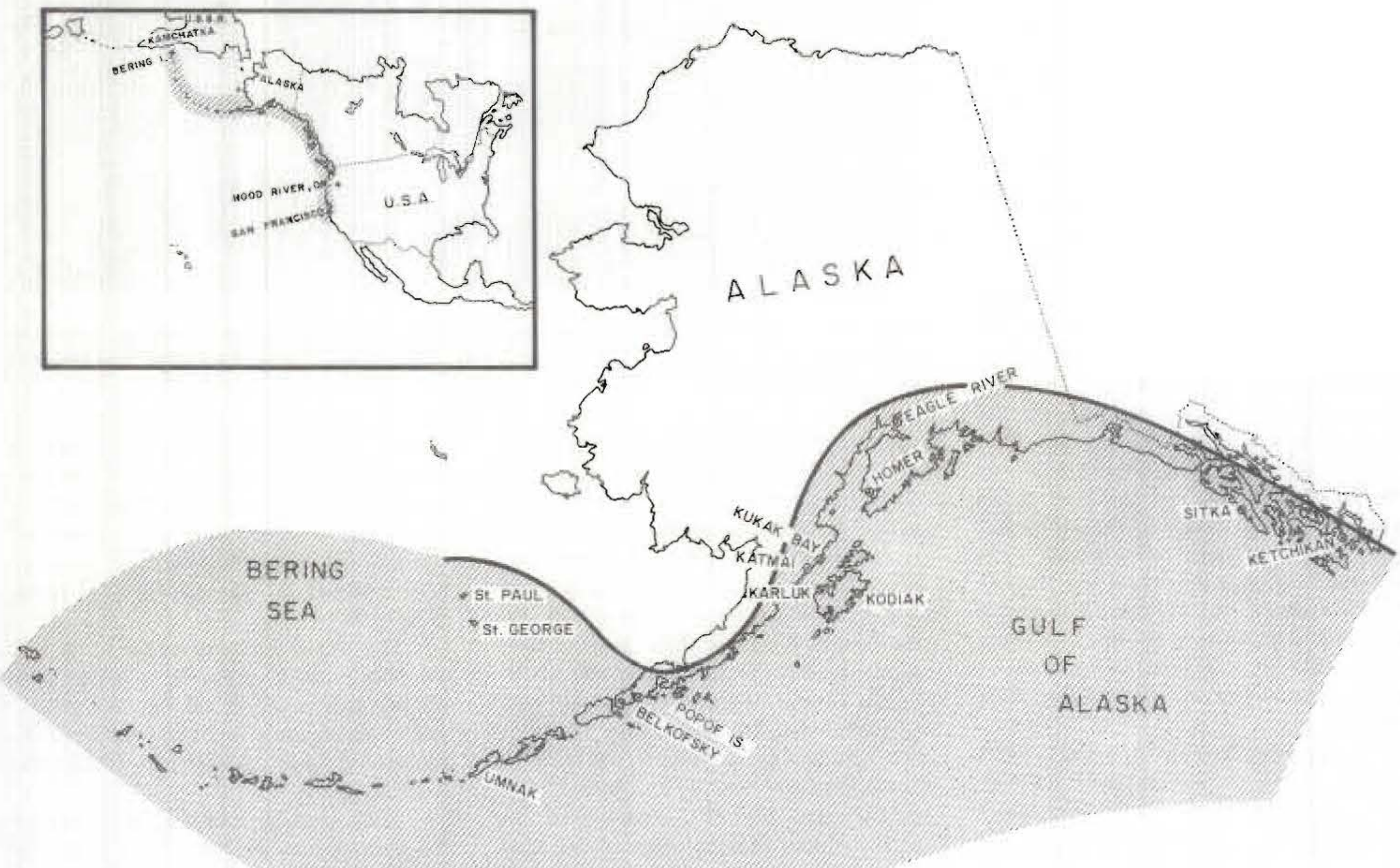

Figure 3: The known distribution of *Irbisia sericans*, in Alaska and the world.

with leaf damage. The correlation coefficient between cell content levels for whole-shoots was slightly negative but was more likely unrelated to insect damage. The reduction in cell contents noted in the leaves may have been masked in the whole-shoot data.

It would be unwise to conclude cause-and-effect relationships between the insect damage and levels of crude protein, Mg, Ca, hemicellulose, TNC, and cell contents. However, the coincidences of findings between data for the leaves and for the whole shoot suggests that future studies should include measurements of those features with respect to the insect. Either the insect selected plants with such characteristics or its feeding was actually affecting those components in the grass plants.

Correlation coefficients were negative between *I. sericans* damage and insoluble silica content of bluejoint leaves, with a trend toward higher insoluble silica levels in leaves which had little or no insect damage. Examinations of the ashed leaves revealed an array of silica cell patterns in bluejoint leaves which varied within almost as much as among sites. It was unclear whether the variation was either an artifact of the ashing technique or due to inherent plant structure. At least three structures resisted decomposition in the furnace and were believed to be silica deposits: hairs on the leaf surface (Figure 5), walls of some elongated cells in the vascular bundles (Figure 6), and parallel chains of asymmetrically oblong cells, probably surface barbs (Figure 7). Plants most heavily infested by the insect had thinner siliceous deposits and fewer and more sparse parallel chains of oblong silica cells (Figure 8). In some instances, vascular bundles (veins) in the most heavily damaged leaves seemed to be more resistant to ashing, and the interveinal areas were relatively clear after ashing compared to those of the lightly damaged plants. More conclusive evidences are needed regarding the relationship of silica deposition to insect damage. However, a study of Hessian fly resistances in wheat (9) provides reason to speculate that there may be some resistance to insect damage in grasses due to the presence of silica.

The insect and its effects on bluejoint reedgrass should be studied further to determine its impacts on Alaska's coastal rangelands. The insect's consumption of nutrients and its relationship as a competitor to livestock and wildlife for forage should be measured. Our preliminary evidences indicate several positive correlations with insect damage and desirable forage-quality factors. There is a possibility the damages lower the acceptability of the grass to livestock and other ungulates.

The geographical distribution of the insect species in Alaska should be better defined. Such questions as the following should be answered: Does the insect have a potential for becoming economically serious pests on ranges and pastures that have been altered or improved with introduced grasses? Would it affect any introduced crops? Would the insect pose problems for grass-seed growers located within the insect's natural range? What are its natural enemies? How does it disperse and how far can it migrate? Where and when are eggs laid? How does the insect overwinter?

Table 1. Average weight per leaf for the two uppermost leaves on bluejoint shoots and eleven forage quality components for those leaves on plants ranging from undamaged to heavily damaged by *Irbisia sericans* on the Alaska Agricultural Experiment Station's range near Homer, Alaska, 25 July 1978.

		Percentages												
Relative Leaf Damage	Avg. Leaf Weight (mg.)	Crude Protein	P	K	Ca	Mg	TNC[a]	IVDMD[b]	Cell Contents	Lignin	Cellulose	Hemi-Cellulose	Insoluble Silica	n[c]
Heavy	46	20.6	.20	1.49	.17	.17	6.9	63.6	42.5	3.2	22.8	30.1	1.73	262
Moderate	55	22.1	.22	1.53	.26	.18	7.5	68.8	42.9	4.0	23.5	28.8	.69	260
Light	64	22.3	.22	1.31	.14	.16	7.1	64.0	41.6	3.5	21.7	30.8	2.21	196
None	95	18.1	.22	1.42	.14	.12	8.8	65.0	45.0	3.2	23.0	25.1	2.12	86

[a]total nonstructural carbohydrates.
[b]*in vitro* dry matter disappearance.
[c]n = number of leaves in collection.

Table 2. Correlation coefficients for fourteen factors measured on nine experimental range sites sampled for insect numbers 18 August 1978 near Homer, Alaska. Forage quality components are for whole, above-ground portions of shoots

	IVDMD[a]	I. Sericans	Total Insects	Cell Contents	Hemi-Cellulose	Lignin	TNC[b]	% Leaf Damage	% Crude Protein	% P	% K	% Mg	% Ca	% Insoluble Silica
IVDMD	1.00													
I. Sericans	-.24	1.00												
Total Insects	-.23	.97	1.00											
Cell Contents	.77	-.19	-.21	1.00										
Hemicellulose	-.33	.64	.63	-.45	1.00									
Lignin	-.62	-.13	-.12	-.85	.03	1.00								
TNC	.54	-.61	-.65	.67	-.49	-.42	1.00							
% Leaf Damage	-.08	.69	.78	-.01	.52	-.27	-.34	1.00						
% Crude Protein	-.15	.73	.68	-.11	.40	-.07	-.71	.38	1.00					
% P	.04	.72	.69	-.08	.42	-.07	-.52	.36	.78	1.00				
% K	-.20	.62	.59	-.36	.40	.30	-.75	.26	.87	.83	1.00			
% Mg	-.15	.62	.66	.01	.43	-.32	-.50	.66	.61	.33	.31	1.00		
% Ca	.34	.45	.55	.41	-.12	-.46	-.23	.52	.36	.32	.19	.50	1.00	
% Insoluble Silica	-.04	-.58	-.62	.11	-.72	.23	.18	-.59	-.21	-.54	-.20	-.41	-.13	1.00

[a]*in vitro* dry matter disappearance.
[b]total nonstructural carbohydrates.

Figure 5: Fine surface hair and a few elongated cells in the vascular bundles are probably insoluble silica deposition sites. This leaf came from a site where 3% of the leaf area was affected by *I. sericans* feeding.

Figure 6: Fine surface hairs and disrupted chains of oblong cells (surface barbs) are evident. This leaf occurred on a plant heavily damaged by *I. sericans*. Fifty-nine percent of the leaf area was affected by *I. sericans* feeding.

Figure 7: Surface hairs and "barbs" appear to be more heavily silicified in this leaf compared to others examined. This leaf came from a site where 13% of the leaf area was affected by *I. sericans* feeding.

Figure 8: Fine surface hairs and "barbs" seemed to be less silicified than in others examined. This leaf came from a site where 58% of the leaf area was affected by *I. sericans* feeding.

Photomicrographs of Ash Residues from Bluejoint Leaves

If the life cycle of this insect were determined, we would be better able to control *I. sericans*, should this become necessary. Such studies would go beyond any immediate problems with the insect and touch on basic relationships between desirable and undesirable rangeland species. From our observations, it appears that there are several opportunities for productive range entomology research with Alaska's grass bug.☐

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Will Alaskan Farmers Sell the Development Rights to their Land?

By William G. Workman*, Edward L. Arobio**, and Anthony F. Gasbarro***

INTRODUCTION

In Alaska, as in many other parts of the country, market forces are producing a change in land-use patterns that is resulting in the conversion of highly productive agricultural lands to nonagricultural uses. Property on the urban fringes of Anchorage and Fairbanks that once produced vegetables and grains or supported dairy farms appears most vulnerable to this conversion to residential or industrial sites. Within the last three years alone, for example, 27 farms have been subdivided in the Palmer-Butte area of the Matanuska Valley. Many of the subdivisions along the Parks Highway between Willow and Talkeetna are located on lands with high agricultural potential.

This displacement of farms by subdivisions, roads, shopping centers, and other nonagricultural enterprises is viewed by some Alaskans as not being in the state's best interest. Those concerned about the loss of agricultural lands argue that the areas most likely to be converted represent some of the best agricultural lands in the state and are vital to the maintenance and further development of an agricultural economy in Alaska. In addition, it is suggested that the preservation of these areas will help to maintain a much-desired way of life and to provide needed open space and other environmental amenities at the urban fringe. These concerns have resulted in actions by the

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UNIVERSITY OF ALASKA, FAIRBANKS
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School of Agriculture and Land Resources Management
Agricultural Experiment Station

August 14, 1978

Dear

The Agricultural Experiment Station at the University of Alaska is conducting a survey of Alaskan farmers. This survey is part of a study concerning the future use of agricultural lands near population centers of Alaska. We need your assistance to make this study a success.

Agricultural lands are rapidly being converted to other uses such as residential lots, airports, and shopping centers. Land is becoming more expensive and some farmland owners are convinced that it makes more sense to develop agricultural land than to farm it. Other people are concerned that we are converting too much of the farmland near cities to nonagricultural uses and that it would be wise to preserve these lands so that food can be grown close to large population centers and so that there will continue to be open space near urban areas.

Many ways are being tried to preserve agricultural lands in other areas of the United States. Some of these include tax incentives, zoning and the trading of land. Another way is for a state or municipality to purchase from the farmland owner his right to develop his land for anything but farming. For a price, the farmer would give up his option to use his land for nonagricultural purposes; the land would still be his, but he could do nothing that would impair its agricultural potential.

The principal objective of our study is to determine (1) farmers' interest in selling development rights and (2) what it might cost the State of Alaska to purchase these rights. A short questionnaire is enclosed and we would be grateful if you will fill it out and return it to us in the enclosed postage paid envelope before September 1, 1978. All information will be kept confidential. If you desire we will be happy to send you a final report at the completion of the study.

Thank you for your cooperation,

William G. Workman

Dr. William G. Workman
Resource Economist

WGW:ks
Enclosures

A division of the University of Alaska statewide system of higher education

Figure 1

state and municipal governments in Alaska to intervene in the land market to slow down or stop the loss of agricultural land. Methods employed include tax incentives (use-value assessment of farmland) and the sale of only the agricultural rights on state and municipal lands.

Recently, some state government officials have developed an interest in a new method of agricultural land preservation that is being adopted in some of the eastern states. This method involves the public purchase of nonagricultural development rights on agriculture lands currently held in the private sector. Usual development rights associated with a parcel of real property permit the landowner to develop his land beyond its current agricultural use, and because these rights can be separated from the total bundle of rights, they can be sold, thus transferring from the landowner the right to develop his land. This, then, is the concept behind the purchase of development rights as an agricultural land control device. In order that land remain in agriculture use in areas being converted to other uses, governments might purchase the development rights from agricultural lands. These lands could then be used only for agricultural purposes.

ALASKA AGRICULTURAL LANDS SURVEY

1. How many acres do you currently farm or ranch?
   Your own land ________
   Land rented or leased ________
      From other landowners ________
      From the government ________
   Total acres ________

2. What crops or livestock do you produce?

Crops	Acres: Your own	Rented from others	Leased from government
Vegetables or potatoes	____	____	____
Small grains	____	____	____
Hay or silage	____	____	____
Planted Pasture	____	____	____
Native Pasture	____	____	____

Livestock	Number of Head	Livestock	Number of Head
Dairy cattle	____	Swine	____
Beef cattle	____	Poultry	____
Sheep	____	Other (specify)	____

3. What do you estimate is the per acre market value of agricultural land:
   Your own land: Cleared ________ $/acre Uncleared ________ $/acre.
   That you rent (exclude government leases): Cleared ________ $/acre.

4. Would you be interested in selling development rights to your agricultural land? Selling such rights would mean that your land could be used for agricultural or forestry purposes only.

Degree of interest	Cleared	Uncleared
Not interested	____	____
Slightly interested	____	____
Moderately interested	____	____
Highly interested	____	____

5. At what price would you sell the development rights to your agricultural land:
   ________ $/acre.

6. Please describe the location of your farm or ranch.
   Nearest town ________ Distance from town ________
   Direction from town ________
   Thank you for your cooperation. A summary of the results of this survey will be available to you on request.

Figure 2

In June of 1978, the Agricultural Experiment Station at Fairbanks was asked by the Alaska Department of Natural Resources to evaluate such a program for Alaska. As a part of this assessment, a survey of Alaska farmers and ranchers was conducted primarily to determine their interest in such a program and to obtain estimates of the costs of purchasing these development rights. The results of this survey are reported here.

SURVEY RESULTS

During August of 1978, a questionnaire, with a brief explanation of the development rights concept in the cover letter (Figure 1 and 2), was mailed to 263 agricultural landowners in the most important farming or livestock areas of the state. Since there is no statewide, farmers' organization in Alaska, the names of landowners were obtained from the mailing lists of state and federal agencies that distribute agricultural information. Undoubtedly these lists did not include all of the people who consider themselves farmers. Of the questionnaires mailed, 18 were returned as undeliverable, leaving 245 that actually reached their destination, of which 112 (46%) were returned completed (Table 1).

Questionnaire recipients were asked to indicate their degree of interest in selling the development rights to their cleared and uncleared agricultural lands. Specifically they were asked to indicate whether they were highly, moderately, slightly, or not interested in selling these rights. Approximately 94%, 106 of 112 respondents, answered this question. The distribution of these expressions of interest can be seen in Table 2.

Most of the respondents in all regions except the Matanuska-Susitna area expressed little or no interest in selling develop-

Table 1: Questionnaire Response by Region

Region	No. Questionnaires Delivered	No. Questionnaires Returned (%)
Fairbanks	52	24 (46)
Delta	34	10 (29)
Copper River Basin	15	10 (67)
Matanuska-Susitna	106	41 (39)
Kenai-Kodiak	38	27 (71)
TOTAL	245	112 (46)

Table 2: Degree of Interest in Selling Development Rights to Agricultural Land

	Number of Respondents (%)			
	No Interest	Slight Interest	Moderate Interest	High Interest
Fairbanks	14	2	4	4
Delta	7	2	0	0
Copper River Basin	6	1	2	1
Matanuska-Susitna	13	6	7	12
Kenai-Kodiak	13	4	3	4
Statewide	54 (51%)	15 (14%)	16 (15%)	21 (20%)

Table 3: Perceived Market Value of Cleared and Uncleared Land by Number and Percentage of Respondents in Dollars per Acre

Per Acre Value	Number of Respondents (%)	
	Cleared Land	Uncleared Land
0-999	18 (26)	24 (39)
1,000-1,999	11 (16)	5 (8)
2,000-2,999	10 (14)	11 (18)
3,000-3,999	8 (12)	4 (6)
4,000-4,999	6 (9)	4 (6)
5,000-5,999	4 (6)	4 (6)
6,000-6,999	3 (4)	3 (3)
7,000-7,999	3 (4)	3 (5)
8,000-8,999	1 (1)	–0–
9,000-9,999	–0–	–0–
10,000	5 (5)	4 (6)
TOTAL	69	62

ment rights. Those respondents living in the Matanuska-Susitna region were evenly divided on the question: half indicated little or no interest and half expressed moderate to high interest. On a statewide basis, 65% expressed little or no interest and 35% indicated moderate to high interest. Over half of all those moderately or highly interested in selling development rights were from the Matanuska-Susitna region.

Questionnaire respondents were also asked to estimate the value of their farmland. Sixty-nine of the 112 respondents indicated what they perceived as the market value of their cleared land and 62 answered the same question about uncleared land. The distributions of these values are shown in Table 3. On a statewide basis, most of the respondents perceived the market values of both uncleared and cleared land to be less than $5,000 per acre. Uncleared land was valued at less than $5,000 per acre by 77% of the respondents and at less than $3,000 per acre by 65% of the respondents. Correspondingly, for cleared land 77% of the respondents valued their land at less than $5,000 per acre while 56% indicated a value of less than $3,000 per acre.

Average market values for cleared and uncleared land as perceived by the respondents were calculated for each region. These data are summarized in Table 4. Average values for cleared land ranged from $1,500 per acre in Delta to $3,900 per acre in the Fairbanks region. Three of the regions (Fairbanks, Matanuska-Susitna, Kenai-Kodiak), accounting for nearly 80% of the respondents, differed by only $200 per acre in the perceived average value of cleared land with values ranging between $3,700 and $3,900 per acre. The weighted-average, cleared-land value for the five regions was $3,300 per acre.

Uncleared land values averaged slightly lower than cleared land values and ranged from $900 per acre in the Copper River region to $3,600 per acre in the Matanuska-Susitna region. As with cleared land, the Fairbanks, Matanuska-Susitna, and Kenai-Kodiak regions accounted for nearly 80% of the survey respondents and showed a relatively narrow range of perceived land values. Average land values for uncleared land in these regions were between $2,900 and $3,600 per acre. The weighted average for all five regions was $2,800 per acre.

Questionnaire recipients were asked to assess the value of the development rights associated with their farmland. A value of development rights was reported by 39 of the 112 respondents (35%). Thirty-four of these responses were from the Fairbanks, Matanuska-Susitna, and Kenai-Kodiak areas. Nearly 70% of the respondents valued their development rights at less than $4,000 per acre. The distribution of development rights values can be seen in Table 5.

Average development rights values as perceived by the respondents were calculated for the Fairbanks, Matanuska-Susitna, and Kenai-Kodiak regions. These values are shown in Table 6. Average values were not calculated for the Copper River and the Delta regions because so few of these contacted in these areas responded to this part of the questionnaire. Average development rights values in the three areas mentioned ranged between $3,100 per acre and $3,600 per acre. Values were highest in the Matanuska-Susitna region.

Table 4: Average Perceived Market Values of Land by Region (Dollars per Acre)

Region	Cleared Value	Number Respond.	Uncleared Value	Number Respond.
Fairbanks	$3,900	13	$2,900	11
Delta	1,500	9	1,300	8
Copper River Basin	1,900	6	900	6
Matanuska-Susitna	3,800	28	3,600	24
Kenai-Kodiak	3,700	13	3,100	13
TOTALS		69		62
WEIGHTED AVE.	$3,300		$2,800	

Table 5: Value of Development Rights (Dollars per Acre)

Value	Number of Respondents (%)	Value	Number of Respondents (%)
0-999	6 (15)	5,000-5,999	3 (8)
1,000-1,999	8 (21)	6,000-6,999	2 (5)
2,000-2,999	7 (18)	7,000-8,999	–0–
3,000-3,999	6 (15)	9,000-9,999	1 (3)
4,000-4,999	2 (5)	10,000	4 (10)

Table 6: Average Development Rights Values (Dollars per Acre)

Region	Value	No. of Respondents
Fairbanks	$3,200	5
Matanuska-Susitna	3,600	21
Kenai-Kodiak	3,100	8
TOTAL		34
WEIGHTED AVERAGE	$3,400	

Table 7: Farm Distance from Nearest Community Related to Degree of Interest[a]

Distance Category	Percentage of Respondents Reporting	Moderate to High Interest	Little or No Interest
0-5	41	39	43
6-10	24	29	21
11-15	16	12	19
16-20	7	5	9
21+	12	15	9

[a]Based on 111 farmers reporting.

Average development rights values were also calculated by degree of interest, again using data from the Fairbanks, Matanuska-Susitna, and Kenai-Kodiak regions. Calculations showed that those with a moderate or high interest in a development rights program on the average valued these rights at $2,145 per acre. Those not interested in the program put a much higher value on these rights, $4,662 per acre. Respondents in the moderate-to-high interest categories accounted for 63% of the total acreage represented in the survey responses.

Additional analysis of the survey data was undertaken to determine whether or not a landowner's interest in a development rights purchase program and/or his perceived value of these rights were related to the distance between his farm and the nearest population center. Table 7 presents a summary of the data relating to the interest/distance question. One can observe that the distributions of responses are similar between the moderate-or-high and low-or-no interest categories and are, therefore, similar to the pattern shown for all responses.[1] This close relationship suggests that farmers' interest in selling development rights is not significantly influenced by the location of his farm relative to a population center. When data for just those farm owners living near Palmer and Wasilla were broken out and analyzed in the same way, the identical conclusion was drawn.

We also addressed the issue of whether a landowner's perception of the value of the development rights to his property was influenced by the location of the farm relative to a population center. The expectation was that the closer the farm was to a town or city, the more attractive would be that land for development purposes and that this relative attractiveness would be reflected in the perceived value of the development rights. Unfortunately the quality of the data obtained through the survey did not allow a rigorous test of this proposition on either a local or statewide basis.

The data in Table 8 are presented to show the nature of the relationship or lack thereof between distance and development rights value as perceived by farmers near Palmer. No clear pattern emerges but, again, this conclusion must be qualified by recognizing that the data are not taken from a random sample. The fact that the expected relationship did not occur may perhaps also be explained by the existence of unrealistic expectations on the part of some landowners regarding the development value of their property. Consequently, these perceived values may not represent the minimum payments that these landowners might be willing to accept to forego their development options.

[1]Using the chi square test for independence with the data on which Table 7 is based, we were not able to reject the hypothesis of independence of interest and distance at any reasonable level of significance. One must recognize, however, that these data were not obtained through random sampling. Thus, any inferences about the views of farmers in Alaska must be regarded with caution.

Table 8: Relationship Between Development Rights Value and Distance from Palmer

Distance (Miles)	Stated Values
0-1	$10,000
	7,700
1	3,000
2	10,000
	3,500
	1,500
3	3,500
	1,000
	5,500
4	2,000
5	600
6	—
7	3,000
8	500
9	—
10	850
11	1,000

CONCLUDING REMARKS

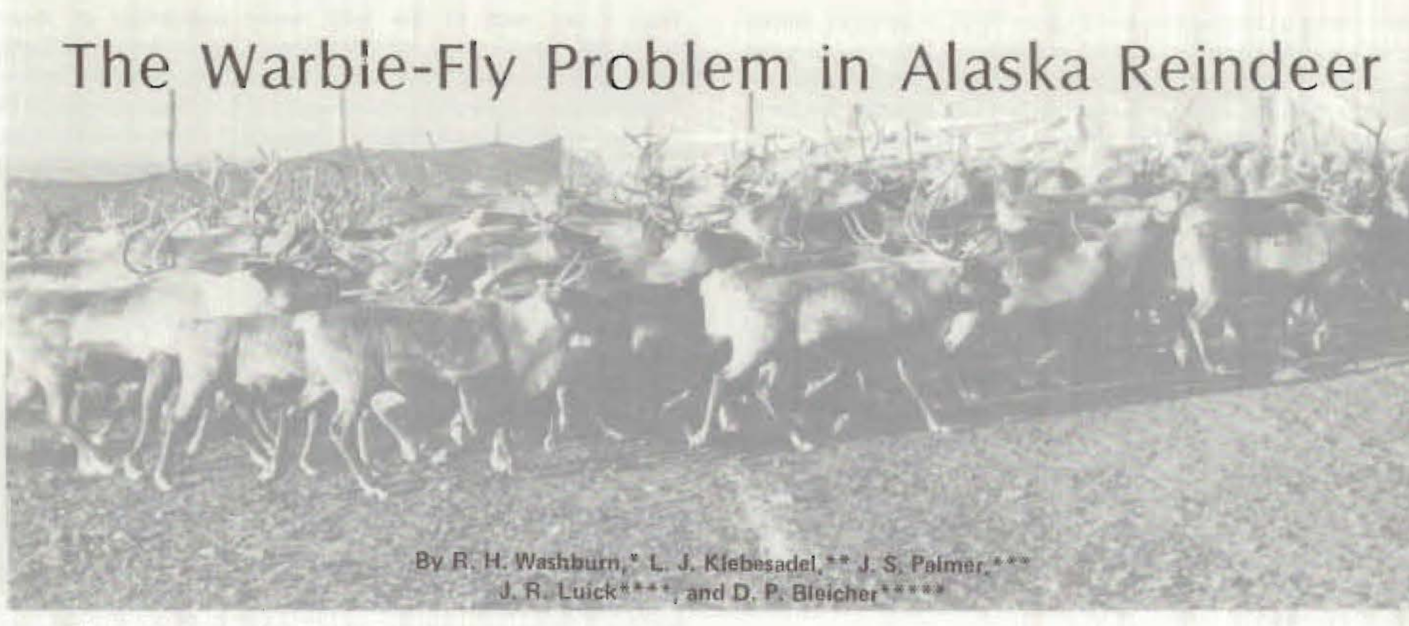
The survey described here was designed to assess Alaska farmers' interests in participating in a development rights acquisition program for preserving agricultural lands and to provide an estimate of the cost to the state of purchasing these rights. While agricultural landowners in the Matanuska-Susitna Valley areas appeared the most receptive to this land use control concept, farmers surveyed statewide were generally not interested in selling the development rights to their farmland. When faced with the hypothetical proposition of selling these rights, nonetheless, farmers on the average valued the development options at $3,400 per acre.

While it would be difficult to state confidently why farmers lack enthusiasm for the development rights purchase concept, several explanations appear plausible. First, as reflected in written comments on the returned questionnaires, some landowners may feel this approach to be just another invasion in their lives by "big government." Also, questionnaire respondents may have felt it to be a wise strategy, considering possible future price negotiations, to appear initially uninterested in disposing of their development rights.

Another possible explanation is that agricultural landowners might not be interested in selling development rights now since they anticipate that these rights will be worth more at some later date. This explanation, however, is not entirely satisfactory, since land prices and, therefore, development rights values presumably reflect the discounted value of future development benefits. Thus, in order for this reasoning to offer any promise, one must also argue that these farmers view the market as presently failing to accurately anticipate future development patterns.

The results obtained in this survey should be viewed with caution. Although a high percentage (46%) of delivered questionnaires was completed and returned, the sampling technique and the fact that some respondents did not answer all questions may have biased the results. Also, the concept of purchase of development rights was new to many farmers and this lack of familiarity may account for some of the negative interest shown by farmers. Still, the conclusion that must be drawn from this survey, keeping in mind the preceding caveats, is that Alaskan farmers at this time show little enthusiasm for the idea of selling their farmland development rights and place a significant value on these rights *vis-a-vis* the total market value of their agricultural land.□

The Warble-Fly Problem in Alaska Reindeer



By R. H. Washburn,* L. J. Klebesadel,** J. S. Palmer,***
J. R. Luick****, and D. P. Bleicher*****

The reindeer is perhaps the only large animal which can be herded in large numbers and which is capable of converting vast areas of tundra rangelands of Alaska into products useful to humans. An expanded, healthy, reindeer industry could have a very beneficial social and economic impact in western Alaska. However, the reindeer industry in Alaska is similar to several other facets of Alaskan agriculture: it has a great potential for development as well as several problems that must be resolved before that potential can be fully realized.

REINDEER INDUSTRY PROBLEMS

Problems requiring resolution before the reindeer industry can move forward on a sure footing are several, some political and others biological (2, 4), not the least among which is the need for effective, approved controls for certain parasites that infest reindeer, causing serious practical considerations and economic losses (1, 3, 7, 8). One of the most economically significant of these parasites, the warble fly (*Oedemagena tarandi* L.), has been the subject of intensive study in recent years.

However, to place the warble-fly problem in proper perspective, it may be helpful to summarize the colorful history of the reindeer industry in Alaska. Moreover, an appreciation of the former magnitude of the industry in Alaska can perhaps provide an indication of how large it could again become and, therefore, how important to the reindeer industry are solutions to such reindeer problems as the warble fly.

REINDEER HISTORY IN ALASKA

The reindeer is not native to Alaska, but it is closely related to the native caribou that is common over much of the western and northern areas of the state. Dr. Sheldon Jackson, first superintendent of education in Alaska, secured private and public funds to underwrite costs of importing 1,280 reindeer into coastal areas of Alaska from 1891 to 1902 (2). The reindeer were brought from Siberia and were landed at several points from Unalaska Island to the Seward Peninsula. Between 1892 and 1898, a number of Lapps familiar with reindeer husbandry were brought to Alaska to assist in the care of the reindeer and to instruct Eskimos on reindeer management.

Originally, the reindeer were imported to provide food and industry for Alaskan Eskimos to compensate for the depletion of their traditional food sources due to uncontrolled hunting of walrus, whales, and other animals in coastal areas of western Alaska by white men interested in oil, whalebone, and ivory (2). Establishment of a reindeer industry for the Eskimos, therefore, was seen as a solution to food shortages.

The industry started from relatively unstructured beginnings—in 1911, 60 per cent of Alaskan reindeer were owned by native Alaskans, 15 per cent by Lapps, 14 per cent by missions, and 11 per cent by the United States federal government (4). By 1911, there were over 33,000 reindeer in Alaska, and the first shipment of meat, 125 carcasses, was sent to the "states." In 1914, a private Nome organization, Lomen Bros., was set up to produce and export reindeer meat on a large scale. The company purchased 8,600 reindeer between 1914 and 1921 and constructed warehouses, corrals, and slaughter and cold-storage facilities. Since the Alaskan tundra ranges, both winter and summer, seemed limitless in the first third of this century, reindeer numbers in the territory were allowed to increase dramatically. About 20,000 hides and 2,500,000 pounds of reindeer meat were shipped from Alaska in 1930.

A United States Reindeer Service was created in 1907. In 1920, the United States Biological Survey (later the Fish and Wildlife Service) established a reindeer research program which headquartered successively at Unalakleet, Nome, and, finally, Fairbanks, but which terminated in 1935. Supervision of the Alaskan reindeer industry was given to the Governor of Alaska in 1929. A Reindeer Council was formed in 1931 to administer reindeer affairs, but a year later it was reduced to advisory capacity only.

In 1932, the Alaska reindeer population peaked at 641,000 head, a figure which remained fairly stable for about five years, until the start of the "Alaska reindeer crash," a dramatic decline in numbers over a short period of time. Between 1936 and 1940, the reindeer population was roughly halved. By 1945, there were approximately 100,000; by 1948 there were only about 30,000 (2, 4).

Numerous problems have been cited as contributing to the decline of the reindeer numbers and industry in Alaska. These include overstocking, which led to overgrazing and deple-

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tion of ranges, destruction of range by fires, inadequate winter (lichen) range, predation by wolves and bears, poor herding and management practices, competition in trade, trespassing and conflicts in range allotments, and neglect (4). Another problem, common even today, is that reindeer join passing caribou herds and are not recovered. Also, changes in the agencies concerned, inexperience, and lack of information and understanding on the part of those who administered the industry probably contributed to the decline.

In 1937, the United States Congress passed the Reindeer Act restricting ownership of reindeer to Alaska Natives, and that law still remains in effect. Administration of the reindeer industry in Alaska has been by the Bureau of Indian Affairs of the Department of the Interior since the 1930s. Since 1970, the Northwest Alaska Reindeer Herders Association and, now, Kawerak, Inc., the nonprofit arm of Bering Straits Native Association, have provided services to reindeer operators on the Seward Peninsula and adjacent areas under contract with the Bureau of Indian Affairs. On Nunivak Island, Bering Sea Reindeer Products operates the herd and facilities under contract with the bureau.

During the past thirty years, there has been little change in the Alaskan reindeer population, and the industry is concentrated in the vicinity of the Seward Peninsula (Figure 1). Current estimates place Alaska's numbers at about 26,000 head, less than 1 per cent of the total world population of about 4,500,000. Most of the world's reindeer are in the circumpolar areas of Europe and Asia, with the greatest concentrations in Scandinavian Lapland and northern U.S.S.R. Approximately 75 per cent of the world reindeer population is in the Soviet Union, with the greatest concentrations in northern European Russia and in northeastern Siberia (8).

The Alaska Native Claims Settlement Act of 1971 will result in transfers of land title that may have some effects on reindeer grazing rights and leases; however, the effects of those transfers, if any, on the reindeer industry are not clear at this time.

REINDEER WARBLE LIFE CYCLE

In order to appreciate the problems created by the reindeer warble fly and strategies for its control, one must first understand the life cycle of the insect (Figure 2). Its life cycle is completed in about one year and involves four distinct life stages or forms that differ greatly in duration: (a) egg: six days from ovipositing to hatching, (b) larva: ten to eleven months, (c) pupa: three to eight weeks, and (d) adult fly: six to eight days before dying.

The adult fly is about the size of a worker honeybee and its dark thorax and abdomen are densely covered with blond-to-orange hairs. Present on the tundra from about May 20 to

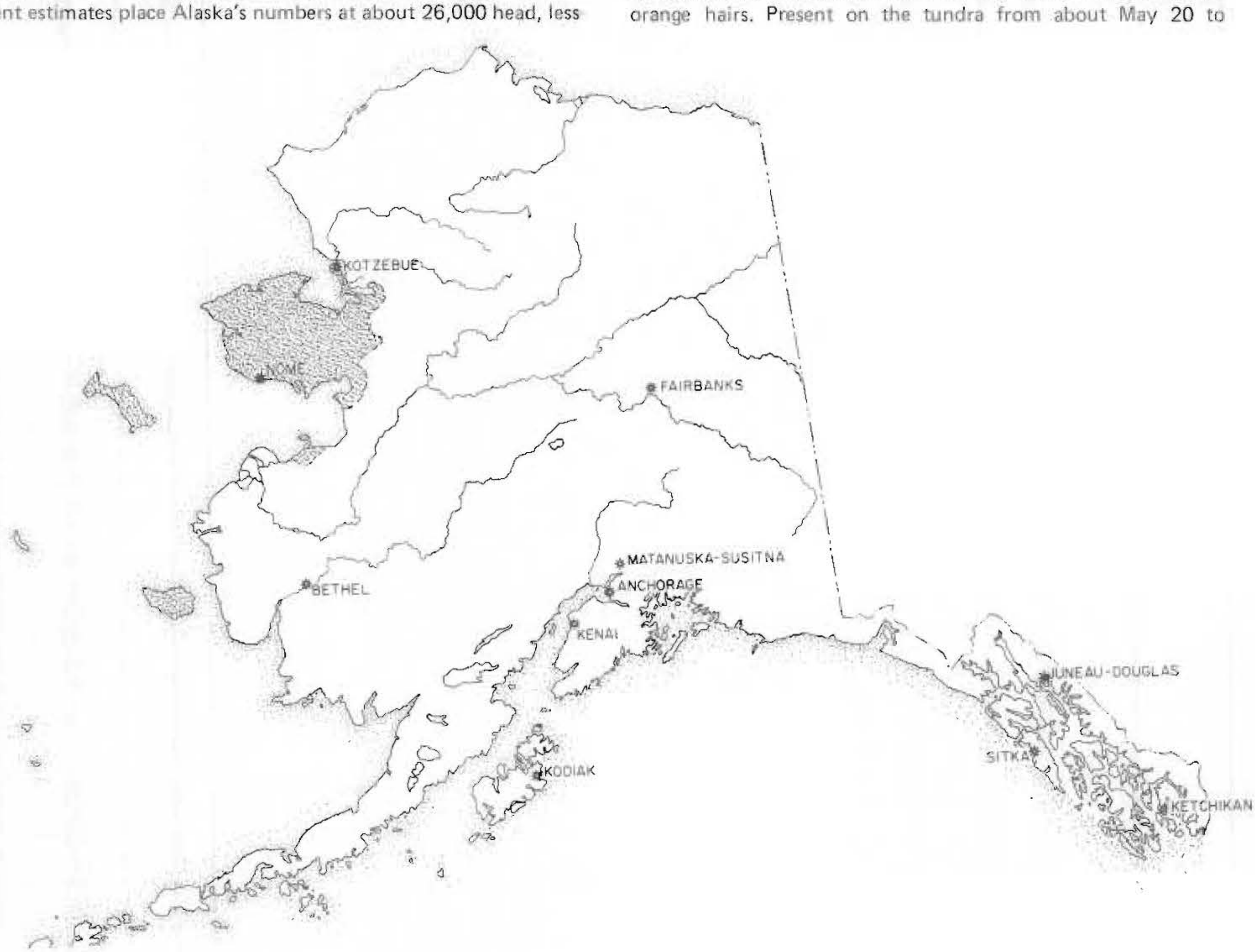

Figure 1: The shaded areas in the above map show the location of current reindeer leases and herd ranges in Alaska; concentration is primarily on the Seward Peninsula and Nunivak Island.

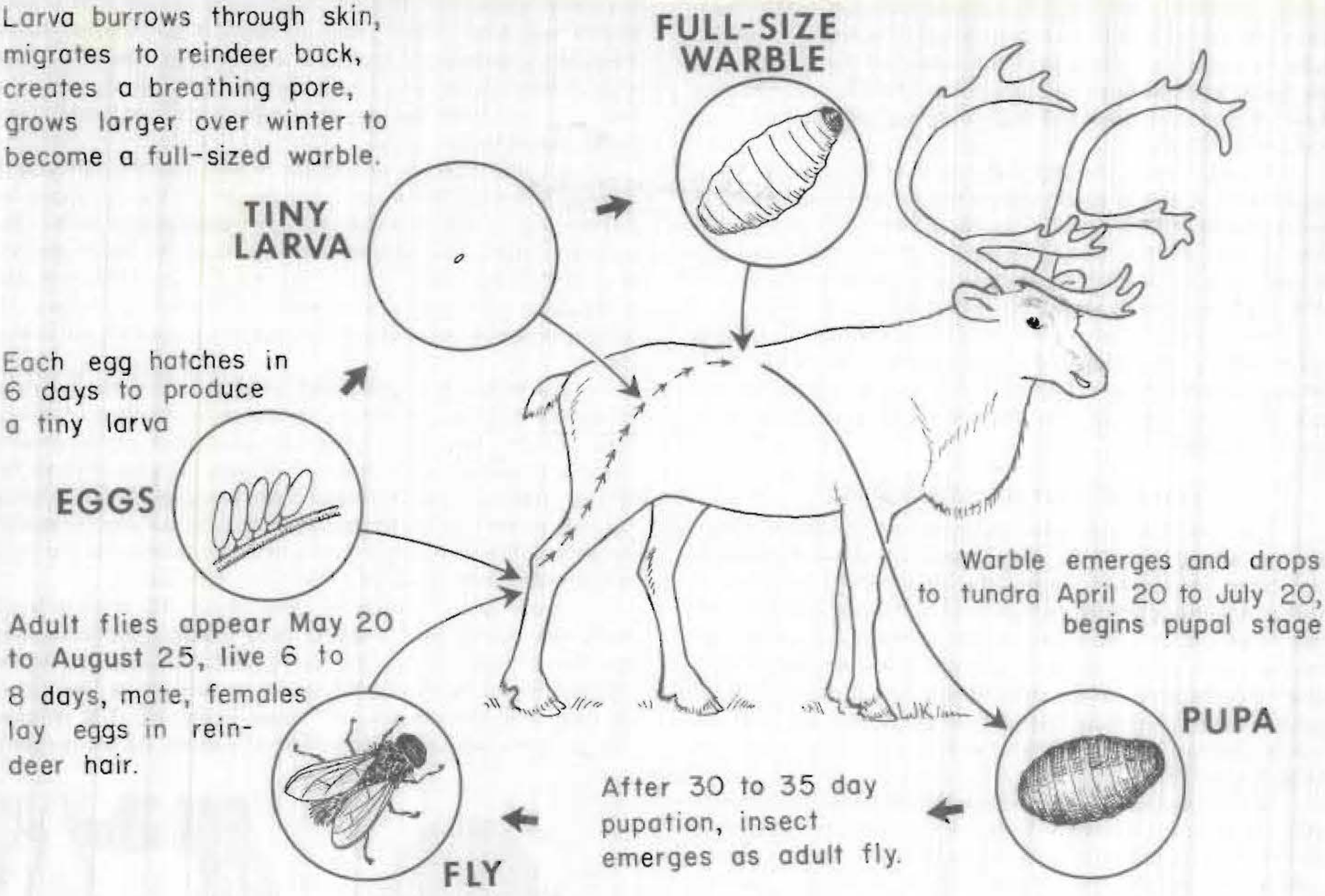

Figure 2: The life cycle of the reindeer warble fly as it affects Alaskan reindeer.

August 20 (3), the adult flies are most active on sunny days. The flies do not feed during their short lifetime. During this time they mate, and females devote the remainder of the time before they die to depositing eggs. They deposit eggs on any area of the reindeer body, but usually on the upper portions of the legs and on the flanks, sides, or back. The female fly burrows backward into the reindeer hair coat and extrudes the eggs from its ovipositor in a manner that cements one end of each whitish egg onto the shaft of the reindeer hair, usually at the base. Eggs are deposited in row-like clusters of three to fifteen. Reindeer body heat apparently is required for egg incubation, for eggs deposited near the outer tips of the hairs do not hatch. Eggs that hatch do so in six days, producing an almost microscopic larva (Figure 2).

The tiny larvae soon burrow through the skin and enter the reindeer body. This is the beginning of the truly parasitic portion of the insect's life cycle, during which it feeds on the blood and lymph of the reindeer (8). During this stage, the larvae migrate along muscle sheaths and connective tissues from the point of entry to a location under the skin along the reindeer's back. The greatest concentrations are found over the loin and rump areas. At the point where each larva comes to rest, a cyst forms, consisting of a sack-like capsule of connective tissue. By late September or later, the larva pierces the reindeer skin to make a hole, or fistula, through which it can breathe. Within the cyst, the larva proceeds through a succession of moults, shedding its outer skin with each. Over winter, the larvae grow larger and eventually become full-sized, grub-like warbles just over an inch long.

During late winter and spring, when warble growth is most rapid, and particularly when numbers are high, infested reindeer show increased emaciation. Some warbles die within the cyst, and others perish later in the process of emerging through the breathing pore in the reindeer skin (3). Either event retards healing of the cyst and the skin opening. Warbles that emerge successfully from the reindeer skin do so between April 20 and July 20. When they emerge, they drop to the tundra where they become pupae in one to three days (Figure 2). Duration of the pupal portion of the life cycle is conditioned by temperature and ranges from three to eight weeks (8); during this period the pupa undergoes metamorphosis to become an adult fly. The fly makes an opening at the fore-end of the pupal shell, called a chrysalis, from which it emerges to complete the life cycle.

ECONOMIC SIGNIFICANCE

The principal economic returns within the reindeer industry in Alaska have traditionally derived from the meat and hides, which are used for subsistence or sold for cash income. Beginning about 1963, however, another significant source of income has developed from the summer harvest of immature antlers. The upper portions of the antlers are severed in the velvet stage and are sold in several Far East countries for medicinal purposes (6). In Lapland and the Soviet Union, reindeer are more domesticated, and, in addition to being a source of meat and hides, they are also used as draft animals. There, also, more use is made of reindeer "wool" and "down" (8).

The warble fly is of significance to the reindeer industry from several standpoints. A major concern is the drastically lowered value of the hides from damages inflicted by the insect. Scars left by the warble cysts and the actual openings cut in the hides by the larvae reduce both the value and the usefulness of the hides, especially as fine leather. For example, a single hide from an adult reindeer may have from several hundred to as many as 2,000 scars.

Another major, undesirable effect of the warble fly is impairment of animal health due to the parasite load, as well as harmful anaphylactic response to the presence of foreign proteins in the reindeer body. Reindeer that are debilitated and weakened by these effects undoubtedly are more susceptible to other diseases, climatic stress, and predators.

The warble fly also contributes to difficulties in herding and managing the reindeer. Because reindeer fear the fly, their behavior becomes erratic as they seek to avoid them; in this bedeviled, anxious state they become vastly more difficult to herd and manage.

WARBLE CONTROL STRATEGIES

The warble fly has been recognized as a problem in reindeer for a long time (1, 3), and numerous and varied attempts have been employed to control the insect. Early strategies in Alaska included artificial shelters to provide shade on the reindeer range (3), an idea based on the observation that reindeer seek whatever natural shade is available to escape warble flies, which are characteristically most active in full sunlight. Provision of artificial shelters for reindeer to escape the flies is an old, popular method used to a limited extent in certain areas of the Soviet Union (8).

Other, unadopted warble-control techniques suggested in 1929 (3) included treatment of reindeer with a pour-on application of an unnamed insecticide dissolved in gasoline or oil and a fumigant applied to the reindeer with a pressurized sprayer. Another warble-fly control strategy, reported to be helpful in the Soviet Union (8), involves avoidance of the adult fly, based on close monitoring and control of herd migration. By this procedure, the herd is driven in spring, after calving, 30 to 55 miles away from the place where the larvae emerged and dropped to the ground to pupate. The reindeer are then kept away from those areas until mid-September. Ideally, the adult flies are thereby not able during their short lifetime to find reindeer on which to lay their eggs. However, since the shedding of larvae continues over a long period, that control procedure has limited effectiveness (8).

The senior author of this article began to investigate the warble-fly problem about twenty years ago. An early attempt to pour or spray an insecticide-water solution onto the reindeers' backs as they passed through chutes proved unsatisfactory. The natural water-repellancy of the reindeer coat and the propensity of treated reindeer to shake themselves vigorously shortly after treatment resulted in poor penetration and retention of the insecticide, as well as unacceptable contamination of those working with the animals.

Another treatment evaluated was esophageal insertion of a tablet or capsule containing a systemic insecticide. This treatment, which was relatively difficult to administer, was judged unsatisfactory because many reindeer managed to regurgitate the tablet or capsule by coughing before it could dissolve and release the insecticide for absorption in the reindeer body.

The most promising treatment evaluated was intramuscular injection of a larvicide into temporarily restrained reindeer. One such material, famphur[1] (5, 7), was developed as a control for cattle grubs, the parasitic larval stage of heel flies (*Hypoderma* sp.) that infest cattle throughout the United States. Famphur is commonly applied as a pour-on treatment for control of cattle grubs. It is also approved and routinely used as a systemic insecticide for reindeer warble control in Lapland and in the Soviet Union.

A major concern in the use of any systemic larvicide in animals intended for meat is the length of time required for breakdown of the chemical and its disappearance within the animal's body. This information is needed to determine the chemical's fate, to secure legal approval for the treatment, and to establish how soon after treatment the meat and organs can be consumed by humans without danger of ingesting the chemical.

The first step in evaluating famphur as a systemic control of warble flies was, therefore, to slaughter reindeer at several intervals after injection of the material. Tissues of fat, muscle, liver, and kidney were removed (Figure 3) and sent to the United States Livestock Insects Laboratory at Kerrville, Texas (5), for determination of residues. No famphur was detectable in tissues other than fat at five weeks after treatment, and none was detected in fat at seven weeks after treatment.

Therefore, in October of 1976, about 300 reindeer bulls, cows, and fawns were injected with famphur following herd roundup at Kotzebue. In the spring of 1977, about half of the treated animals were recaptured and checked for determination of treatment effectiveness. Of those examined, 120 reindeer (76 per cent) were found to be free of warbles, 33 (21 per cent)

Figure 3: A slaughtered reindeer is eviscerated in order to obtain organs and tissues for insecticide residue analysis.

[1] Chemical name: o-[p-(dimethylsulfamoyl) phenyl] o, o-dimethyl phosphorothioate.

Figure 4: After being weighed in order to adjust dosage, a released reindeer plunges from chute toward waiting hands of herd owner Larry Davis, there to be wrestled to the ground for injection of systemic insecticide.

Figure 5: An identifying eartag is affixed to treated animal by Alaska Division of Agriculture Marketing Specialist E. D. Kern while herd owner Larry Davis holds reindeer.

had 1 to 5 warbles, and 2 had about 25 warbles. Untreated animals examined at the same time had the following numbers of warbles: One had 8, 5 had about 30, 15 had nearly 50, 6 had roughly 75, and 66 were estimated to have between 100 and 300 warbles.

The sequence of events involved in treatment of the reindeer with intramuscular injection of famphur is shown in Figures 4 through 7 (page 28). This treatment would fit into reindeer managment practices and the insect life cycle as follows:

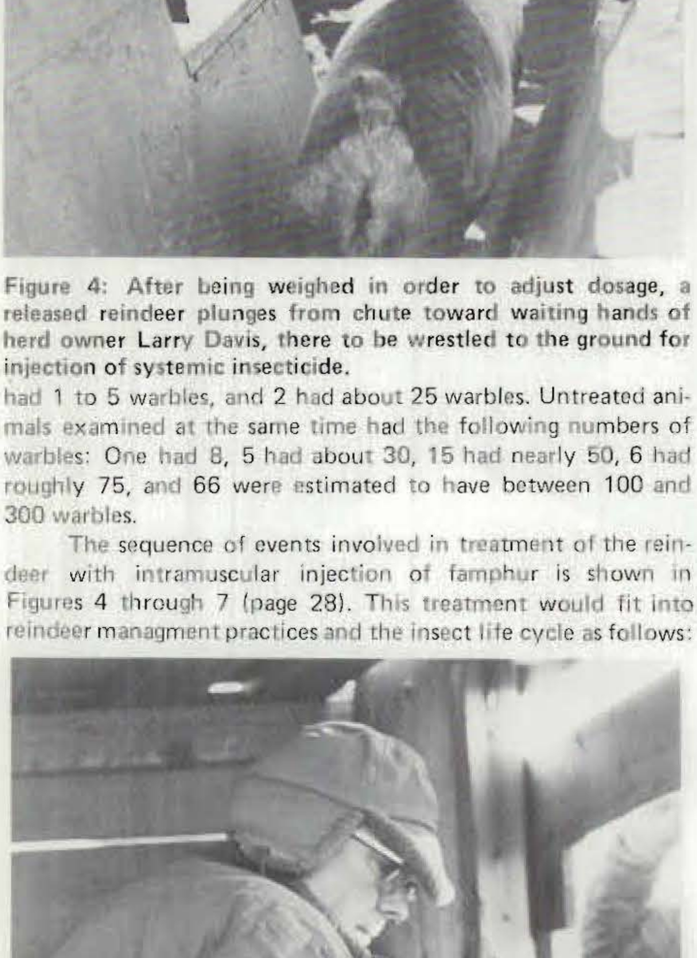

Figure 6: The late Dr. Richard Washburn records reindeer weight, insecticide dosage, and identification number for each treated animal.

Reindeer are corralled in October (animals are then in top physical condition) for annual selection of slaughter stock; those not slaughtered would be injected before release. Thus, both round-up and treatment would be timed to coincide with freeze-up, which terminates the warble-fly flight for the year. The systemic treatment therefore would kill the larvae within the reindeer before most of them had formed larval cysts and before they pierced the hides to make breather holes. Effective control of the warble-fly in Alaskan reindeer will result in increased reindeer health, easier herding and management of more docile animals, and improved quality of hides returning greater profits to the reindeer industry.

The control of warble flies with famphur discussed here represents a report of research only and does not constitute a recommendation by the United States Department of Agriculture nor the University of Alaska. Use of famphur as an injectable treatment for reindeer warble control in the United States has not yet been approved by the Food and Drug Administration.□

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Figure 7: An unusually spirited reindeer, incensed by capture and handling, conveys its displeasure.

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For generous cooperation and assistance in the work reported here, we gratefully acknowledge American Cyanamid Co.; Larry Davis, president, Northwest Alaska Reindeer Herders Association; cooperating personnel of the Livestock Insects Laboratory, Kerrville, Texas; Drs. William Burgoyne and Richard Stokes, State of Alaska Division of Environmental Conservation; Ed Kern, marketing specialist, State of Alaska Division of Agriculture; Richard E. Barrett, biologist, Veterinary Services, United States Department of Agriculture; Dr. Robert Dieterich, University of Alaska Institute of Arctic Biology; Sigmund Restad, assistant director, and Terry Wighs, herdsman, Agricultural Experiment Station, University of Alaska; Lee Ellis, Edward Nygard, Richard Birchell, and Joe Chase, United States Department of Interior Bureau of Indian Affairs; Fred Goodhope of Cape Espenberg; and reindeer herders of Nunivak Island, Nome area, Selawik, and NANA Corp. of Kotzebue.

Does it Work?

Barley, Potato and Bromegrass Chemical Composition Unchanged by Use of a Multipurpose Wetting Agent

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

Nonfoaming wetting agents, marketed for use with herbicide and insecticide sprays, are also credited with increasing crop yields when applied to the soil. These increases have been attributed to increased solubilization of nutrients in the soil, providing the basis for more uniform nutrient distribution throughout the root zone and enhanced uptake of these nutrients by plants (2).

We have evaluated one of these wetting agents, WEX—a chemical formulation the active ingredients of which are alcohol ethoxylates, propylene glycol, and dimethylpolysiloxane. Following application techniques recommended by those reporting crop response, we used WEX with barley in 1976 and with barley, potatoes, and bromegrass in 1977.

EXPERIMENTAL PROCEDURE

Barley

A uniform area of Knik silt loam (Typic Cryorthent) on the Matanuska Experiment Farm was selected for a block barley experiment with eight replications. WEX treatments of 0, 3, and 10 ounces per acre were applied on May 10, 1976, by adding the appropriate amount of WEX to water at the rate of 484 gallons per acre, mixing thoroughly, and applying the entire amount uniformly to each 6 by 15-foot plot. The area was then disked and planted to Weal barley with a grain drill and fertilizer attachment. After planting, the area was cultipacked. Commercial 10-20-20 fertilizer at 200 pounds per acre supplied 20, 40, and 40 lb N, P_2O_5, and K_2O, respectively.

On May 6, 1977, in another area of Knik silt loam on the Matanuska Experiment Farm, we repeated the barley experiment at the same fertilization rate using 0, 16, and 32 ounces per acre WEX. On August 9 in both 1976 and 1977, four 10-foot rows of barley were cut from the center of each plot with a hand sickle, placed in a sack, dried for 1 week, and then threshed. Straw, grain yields, and test weights were obtained.

Potatoes

On May 17, 1977, a uniform area of Bodenburg silt loam (Typic Cryorthent) at the Palmer Municipal Airport was selected and rototilled for a similar replicated block experiment with Bake King potatoes using 20- by 3.2-foot plots. Furrows were opened and 800 pounds per acre of 8-32-16 were uniformly applied in the bottom of the furrows and covered with 1 inch of soil. Then the WEX treatments (0, 16, and 32 ounces per acre) were applied, using the method recommended for barley, to the bottom of the 20-foot rows. Forty uniform seed pieces were planted in each row; these were covered with soil and the entire area cultipacked. On May 31, dinitro-0-sec-butylphenol was applied uniformly over the experimental area for weed control. On August 30, the vines were removed from the plants, the tubers dug, and yields of both vines and tubers (U.S. No. 1 and small) determined. The specific gravity of the tubers from each plot was determined on August 31 and dry-matter percentages calculated.

Bromegrass

On May 3, 1977, a block experiment was established on a uniform stand of bromegrass on Bodenburg silt loam 3 miles south of Palmer and replicated eight times. All 6- by 15-foot plots were top dressed at the rate of 120 pounds per acre N (with ammonium nitrate), 100 pounds

Table 1. Effect of WEX on Weal barley yield, test weight, and grain/straw ratio. 1976 and 1977. Knik silt loam. (means of 8 measurements)

WEX oz/A		Yield (tons/acre) Straw		Grain		Total		Test weight lb/bu		Grain/straw ratio	
1976	1977	1976	1977	1976	1977	1976	1977	1976	1977	1976	1977
0	0	.58	1.03	.70	1.30	1.28	2.33	48.4	50.5	1:24	1:26
5	16	.58	1.07	.68	1.31	1.26	2.38	49.0	49.4	1:23	1:22
10	32	.55	1.08	.70	1.27	1.25	2.35	49.1	50.4	1:29	1:18
C.V.[1]		15.3%	16.3%	12.0%	10.4%	10.5%	7.2%	1.1%	4.8%	15.6%	16.7%

Table 2. Effect of WEX on Bake King foliage and tuber yields and tuber specific gravity and dry matter. 1977. Bodenburg silt loam. (means of 8 measurements)

WEX oz/a	Vines Foliage T/A	Tuber Yields Tons/yield US No. 1	Small	Tubers Specific gravity	% dry matter	T/A dry matter
0	15.98	21.55	1.50	1.085	22.0	5.06
16	16.18	22.20	1.73	1.084	21.8	5.19
32	16.56	22.23	1.77	1.082	21.6	5.19
C.V.[1]	18.7%	11.8%	23.9%	0.5%	4.2%	9.9%

Table 3. Effect of WEX on bromegrass yield, Kjeldahl-N and NO_3-N percentage, and N uptake. 1977. Bodenburg silt loam. (means of 8 measurements)

WEX oz/A	T/A oven-dry Cut. 1	Cut. 2	% Kjeldahl-N Cut. 1	Cut. 2	% NO_3-N Cut. 1	Cut. 2	lb/A Kjeldahl-N Cut. 1	Cut. 2	lb/A Total N
0	3.14	1.65	2.47	2.54	.15	.07	155	82	113
16	3.08	1.59	2.34	2.48	.13	.08	143	79	106
32	3.11	1.55	2.34	2.57	.14	.09	144	80	107
C.V.[1]	11.4%	7.7%	14.0%	5.6%	50.1%	34.8%	10.8%	7.5%	9.0%

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per acre P_2O_5 (with treblesuperphosphate), and 100 pounds per acre K_2O (with sulfate of potash). After fertilization, 0, 16, or 32 ounces per acre of WEX were applied to the appropriate plots as described for barley. An additional 100 pounds per acre N as ammonium nitrate were applied after the first cutting. Just after the emergence of seed heads on June 23 and again on September 18, forage from all plots was harvested with a small sickle-equipped mower, leaving a 2-inch stubble. Green and dry weights were recorded, and representative samples from each plot were ground to pass a 40-mesh, stainless-steel screen.

Soil analysis

A composite soil sample was taken each year before planting each crop. After barley and the second bromegrass harvest each year, soil samples were taken from each plot at 2-inch increments to a 6-inch depth. We determined the pH and analyzed these samples for NO_3-N, P, and K using a modified Morgan's procedure with sodium acetate buffered at pH 4.8 (3).

Plant analysis

Plant tissue analyses were conducted as follows: N, using a modification of the Kjeldahl method by collecting the distillate in boric acid (1); NO_3-N with the nitrate electrode (5); K, Ca, and Mg, using an atomic absorption spectrophotometer following a perchloric acid digestion (4); P, using the molybdate procedure with a Technicon Auto-Analyzer II (6); and S, with an automatic sulfur analyzer (7).

RESULTS AND DISCUSSION

Weal barley

Yield, bushel test weight, and grain/straw ratios were not influenced significantly by WEX (Table 1).

Bake King potatoes

Yield, specific gravity, and dry-matter percentages were not influenced by WEX (Table 2).

Bromegrass

Yield, Kjeldahl-N, NO_3-N, P, K, Ca, and Mg concentrations, and N, P, K, Ca, Mg, and S uptake by both cuttings were not influenced significantly by WEX (Tables 3, 4, and 5). The first-cutting S concentration also was not influenced by the WEX treatment, although second-cutting S concentration was significantly increased by the heaviest (32 oz/A) WEX application (Table 4). By chance, this value could occur five times in a hundred. At the 1% level of probability no significance occurred.

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

WEX application had no significant effect on the soil pH or the available NO_3-N, P, or K in either the Knik or Bodenburg silt loam (Table 6).

In August, the top 2 inches of both soils was more acidic and contained more available P and K than soil at the two lower sampling depths. The top 2 inches of the Knik silt loam had more NO_3-N than did the lower depths. Bodenburg silt loam was less acidic at 4 to 6 inches than at the 2- to 4-inch depth. Significantly less available K in the Knik silt loam was found in soil samples from the 2- to 4- and 4- to 6-inch depths than in the top 2 inches.

CONCLUSIONS

The results from these four experiments showed no crop response to WEX application. The uniformity of yield results is reflected in the extremely low coefficients of variability. Our results resemble those of Fornstrom (2) with sugarbeets in Wyoming.

Potato specific gravity and dry-matter percentages, barley test weights and grain-straw ratios, bromegrass chemical composition, and soil analyses show no consistent effect of WEX application.□

Table 4. Effect of WEX on percentages of P, K, Ca, Mg, and S in bromegrass forage. 1977. Bodenburg silt loam. (means of 8 measurements)

WEX	% P		% K		% Ca		% Mg		% S	
oz/A	Cut. 1	Cut. 2	Cut. 1	Cut. 2	Cut. 1	Cut. 2	Cut. 1	Cut. 2	Cut. 1	Cut. 2
0	.36a[2]	.25a	2.90a	1.84a	.182a	.284a	.131a	.186a	.187a	.187a
16	.36a	.25a	2.85a	1.82a	.176a	.271a	.128a	.189a	.183a	.192ab
32	.34a	.25a	2.69a	1.79a	.178a	.277a	.128a	.192a	.184a	.199a
C.V.[1]	8.2%	5.6%	4.4%	6.9%	8.0%	13.5%	8.1%	6.2%	10.9%	4.5%

Table 5. Effect of WEX on P, K, Ca, Mg, and S uptake by bromegrass. 1977. Bodenburg silt loam. (means of 8 measurements)

WEX	lb/A P		lb/A K		lb/A Ca		lb/A Mg		lb/A S	
oz/A	Cut. 1	Cut. 2	Cut. 1	Cut. 2	Cut. 1	Cut. 2	Cut. 1	Cut. 2	Cut. 1	Cut. 2
0	22.5	8.2	181.4	60.3	11.4	9.3	8.2	6.1	11.7	6.2
16	22.2	8.0	173.9	58.0	11.1	8.6	7.9	6.0	11.2	6.1
32	20.9	7.9	164.5	55.6	11.1	8.6	7.9	6.0	11.4	6.2
C.V.[1]	14.6%	11.4%	9.0%	12.3%	15.1%	11.8%	8.5%	9.2%	11.2%	10.7%

Table 6. Effect of WEX on soil pH and available NO_3-N, P, and K at three soil sampling depths. August, 1976 and 1977. (means of 24 measurements)

	Knik silt loam				Bodenburg silt loam			
	pH	lb/A available			pH	lb/A available		
	water	NO_3-N	P	K	water	NO_3-N	P	K
WEX (oz/A)								
0	5.69a[2]	6.3a	9.4a	135a	5.70a	14.8a	4.7a	46.8a
16	5.68a	5.9a	8.8a	137a	5.66a	16.9a	5.8a	43.1a
32	5.63a	6.7a	9.4a	141a	5.66a	13.6a	4.5a	40.7a
Sampling depth (in)								
0-2	5.59b	8.3a	11.2a	196a	4.83c	15.3a	10.1a	101.7a
2-4	5.68a	5.6b	8.9b	121b	6.01b	20.7a	3.4b	15.5b
4-6	5.74a	5.4b	7.5b	95c	6.19a	9.3a	1.4b	13.4b
C.V.[1]	2.4%	40.8%	31.4%	35.5%	3.4%	120%	69.8%	53.4%

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

[2]According to Duncan's multiple range test, column means followed by the same letter are not significantly different at the 5% level.

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Editor's Note: Cooperative investigation of the SEA-FR, USDA, and the Alaska Agricultural Experiment Station. To simplify terminology, the trade name of the produce (WEX) is used in this report. The use of this name is intended for the reader's benefit and implies neither endorsement nor criticism of this or of other products not mentioned.

Forest Regeneration of Upland Areas
following
Logging in Interior Alaska

By John Fox*

The spruce, birch, and aspen forests of interior Alaska uplands provide Alaskans with recreation, building material, fuel, berries, game, clear water, a place to live, and a way of life. In addition, for those who choose to experience these rewards first hand, the forest provides an imprint on the senses that kindles the spirit that abides in Alaska's heartland.

Appropriately, Alaska's state constitution mandates that this forest resource be managed on a basis of sustained yield—that which a forest can produce continuously at a given intensity of management. In addition, the recently passed forest practices act requires that forest resource utilization be compatible with water and other resource management objectives.

Unfortunately, there is no guarantee that sustained-yield and water-quality objectives will be achieved where utilization without management or management without information exists. The fact that forests are renewable resources does not imply that they will be renewed or renewed in a form considered desirable for the sustained production of value. In addition, one cannot specify utilization methods most compatible with water resource objectives without first identifying problem situations and understanding cause-and-effect relationships.

In 1976, the Alaska Agricultural Experiment Station at Fairbanks undertook a reconnaissance study of post-harvest revegetation on selected upland areas between Fairbanks and Nenana on the Parks Highway. The primary objective of the study was to determine the stocking levels of commercially desirable tree species. ("Stocking level" is an indication of the number of existing trees or sample plots containing trees compared to some desirable number for best results, e.g., maximum productivity of wood.) The results of this study are reported here.

Characteristics of the four timber sale units studied are given in Table 1. These study units were identified and mapped using small-scale, high-altitude, infrared photography. Study units were divided arbitrarily into subunits, with 30 sample plots systematically distributed over each subunit. A total of 220 sample plots were used, each divided into four subplots. Field observations of plant occurrence, percentage of coverage (by species), and nonliving ground coverage were made on one quarter of each sample plot while tree seedling counts were made on all four quarters. Additional data on plot slope and aspect were taken.

Table 1. General Description of the Four Timber Harvest Areas Studied

Study Unit	Years of Harvest	Area Cut (acres)	Total Volume Harvested (Thousand Board Feet)
1	1973-75	200	3887
2	1969-75	308	2547 plus poles
3	?	5.5	?
4	1971-75	42	416 plus poles and cordwood

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Table 2. Results of Regeneration Survey: Frequency of Sample Plots Containing at Least One Tree (percent stocking); Trees per Acre (stocking density); and Percentage of the Area Having Unoccupied Mineral Soil

Study Unit	White Spruce Frequency %	White Spruce Density (trees/acre)	Birch Frequency %	Birch Density (trees/acre)	Aspen Frequency %	Aspen Density (trees/acre)	All Trees Frequency %	All Trees Density (trees/acre)	Unoccupied Mineral Soil %
1	13	370	20	693	15	404	43	1487	6
2	41	1841	57	5413	18	516	73	7787	4
3	50	1518	50	6981	10	607	60	9106	*
4	13	352	37	4604	17	384	48	5340	2

*No data available.

RESULTS OF REVEGETATION SURVEY

A summary of data obtained from sample plots is presented in Table 2. Variability between study units and subunits is evident.

The frequency distributions of seedlings per sample plot for the subunits of each study unit were compared and determined to be from the same population (Kolmogorov-Smirnov test at the 95% confidence level). Therefore, subunit data from a particular study unit were pooled for analysis and presentation in this report. Variability among and within the four study units can be seen in the results presented in Table 2. Major nontree species found in the sample plots are presented in Table 3.

Table 3. Major Nontree Species Found in the Four Study Areas

Study Unit	Most prevalent species: Average % Cover		% Frequency	
1	horsetail	25	horsetail	84
	bluejoint grass	15	fireweed	79
	wild rose	10	wild rose	54
	fireweed	9	raspberry	40
	raspberry	6	bluejoint grass	38
2	bluejoint grass	21	fireweed	79
	fireweed	11	bluejoint grass	61
	horsetail	8	horsetail	57
	twin flower	6	wild rose	47
	wild rose	5	twin flower	22
3	bluejoint grass	14	fireweed	90
	highbush cranberry	10	bluejoint grass	60
	fireweed	9	twin flower	60
	twin flower	5	wintergreen	60
	blue bells	3	horsetail & wild rose	50
4	bluejoint grass	26	fireweed	72
	horsetail	9	horsetail	70
	fireweed	7	bluejoint grass	44
	twin flower	5	raspberry	44
	raspberry	5	wild rose	40

White spruce seedlings were found on 13% of the sample plots in unit 1, while birch and aspen frequencies were 20% and 15%, respectively. Total frequency of plots stocked with either spruce, birch, or aspen was 43%. The major nontree species were fireweed, horsetail, rose, and bluejoint grass. An view of the area is provided in Figure 1. An average of 6% of the existing seedbed was "stockable," i.e. unoccupied mineral soil.

Study unit 2 displayed a higher level of reforestation. Stocking percentages average 41 for white spruce, 57 for birch, and 18 for aspen. Total tree stocking percentage was 73. Major nontree species were fireweed, horsetail, bluejoint, and twin flower. Current available mineral soil seedbed represented 4% of the area.

Study unit 3 exhibited a 50% stocking for white spruce, 50% for birch, and 10% for aspen. Overall tree stocking was 60%. Nontree species occupying greatest coverage and occurring most frequently were horsetail and bluejoint grass. Data on mineral soil are not available for the site.

Study unit 4 averaged 13% for white spruce stocking, 37% for birch, and 17% for aspen, while overall tree stocking was 52%. Major nontree species were the same as in unit 1. Available mineral soil seedbed average 2% of the total area.

Frequency distributions of seedlings per sample plot were tested against the Poisson probability distribution and were found significantly different at the 95% confidence level using a G-test statistic. Coefficients of dispersion were all much greater than 1.0 indicating "clumping." This phenomenon was visually evident as indicated in Figure 2 for white spruce. The effect of exposed mineral soil on spruce and birch revegetation can be seen in Figure 3 of an old road bed.

Figure 1: Overview of study unit 1 shows the low stocking level for trees and the dominance of bluejoint grass.

Figure 2: White spruce regeneration is often found in clusters.

Figure 3: Both white spruce and birch regeneration can be quite prolific on mineral soil seedbeds.

DISCUSSION OF REVEGETATION RESULTS

Some ecological implications: Satisfactory regeneration of a forest requires the presence of trees in the vicinity, an adequate production of seed by these trees (or a viable vegetative reproduction structure), sufficient and suitable seedbed and, finally, successful seedling establishment and growth. As in many human endeavors, success is basically a matter of being at the right place at the right time, with the resources to capitalize on an opportunity and the capability to compete, grow, and prosper in the new situation.

The opportunity provided by the forest is simply the availability of growing space or, considering regeneration by seed, the availability of a suitable seedbed. Accordingly, low tree regeneration following timber harvest may be simply related simply to a small amount of mineral soil seedbed exposed by the harvest operation. Secondly, our data indicate that herbaceous and small shrub species can occur with high frequency and represent a very high percentage of ground cover (Table 3). Not only can these nontree species colonize or proliferate on the mineral soil when tree seed is sparce, but once established may restrict or prohibit the germination and growth of subsequently abundant tree seed.

This pattern, which was particularly evident in study unit 1, has been referred to as the inhibitory pathway of plant succession (10). Other examples of such "arrested" succession in the interior forests are discussed by Hegg (8) and Neiland and Viereck (9). According to this theory, early successional species invade and/or proliferate in a disturbed area and modify the environment so it is less suitable for entry of other species. As long as individuals of these early colonists persist undamaged and/or continue to regenerate vegetatively, they exclude or suppress subsequent succession. This situation may be particularly prevalent where the original "disturbance" is extensive in area but mild in intensity (10).

Study units 2 and 3 display moderate stocking levels of all three tree species and have thus regenerated to a mixed, even-aged stand. This situation is also unlike the classical model of succession, where only early successional species are established after a disturbance and subsequently modify the environment to facilitate entry of late successional species. Rather, both early (birch and aspen) and late (white spruce) successional species enter the area immediately after disturbance. Here "succession" refers to changes in the dominance among species rather than simply the sequence of colonization. The slower-growing but longer-lived spruce is able to tolerate a subordinate position in the birch or aspen stand. Eventually, the vigor of birch and aspen will decline and the spruce will overtop the decadent hardwood canopy.

The lack of favorable seedbed conditions is a potential problem for all three tree species discussed here. However, the situation for white spruce is particularly critical since it does not have the capabilities to reproduce vegetatively that birch or aspen possess (12). Furthermore, white spruce may produce abundant seed crops as infrequently as once every 10 to 12 years (14). Thus, the probability that seed availability coincides with the brief period between initial disturbance (logging or fire) and complete colonization by other species must be very low. Considering that seed availability requires the presence of mature spruce within some seed-disseminating distance as well as the production, by these trees, of abundant, viable seed, it is not an unlikely proposition that continued, periodic disturbance of an area fully stocked initially with spruce will result in a progressive decline and/or exclusion of spruce from the area. This outcome of periodic disturbance on spruce would be particularly likely where the "disturbance" mechanism resulted in a low frequency of exposed mineral soil.

Some Management Implications: Having discussed some possible ecological implications of the forest regeneration data, what implications exist for forest management? First, rational management activities can only exist in relation to an objective or policy statement. Thus, if the manager's concern is only for prompt revegetation as opposed to reforestation, little management effort appears necessary. If, however, reforestation is the objective, then seedbed preparation accomplished at the time of timber harvest may be effective, assuming tree seed will be available within the subsequent two- to three-year period.

If the manager wishes to promote white spruce, seedbed preparation at the time of harvest may not be effective, but may rather facilitate entry or spread of herbs, shrubs, and other trees. Two alternatives seem possible: (1) prepare seedbeds only prior to or during years of abundant spruce seed production, or (2) rely on artificial regeneration by planting or seeding after harvest and seedbed preparation. A potential problem with the first alternative is the increased difficulty of seedbed preparation due to interim growth of other vegetation. Controlled burning might prove useful in this case. Although the latter option has not been available in the past, the new tree nursery at Palmer is now operational and planting trials have been initiated.

Having stated an objective and observed the results of our study, do the data in Table 1 indicate a satisfactory or unsatisfactory situation? If the objective were revegetation only, the data certainly indicate successful colonization by plants of all but an average of 3.7% of the areas studied. If, however, the objective is reforestation or white spruce regeneration, there is some uncertainty and room for discussion. First, what represents a satisfactory stocking of trees or of a specific tree species? Theoretically, a 100% frequency on plots of the size used in this study would represent full stocking of approximately 1000 trees/acre of "well distributed" trees (2). This density is characteristic of 90-year-old white spruce stands in interior Alaska (site index* 70), 50-year-old birch stands (site index 55), 60-year-old aspen stands (site index 55), or an approximately 60-year-old mixed stand (5, 7). In all cases the number of stems per acre decreases from younger to older stands. This rate of decrease (i.e. mortality) is largely due to competition and is, itself, decreasing with increasing age. Thus, the density that represents "full stocking" for a seedling stand, allowing for future mortality, might be considerably higher than for a rotation-aged stand. Even on intensively managed plantations, more stems per acre are usually planted than will ultimately reach rotation age (harvestable age or mature stand). The "excess" above full stocking allows some genetic and microsite variation to be expressed by the trees and recognized by the manager. Subsequent thinnings will salvage this excess such that optimum tree spacing and tree quality is achieved.

A point worth noting, however, is that the decrease in stems/acre with increasing stand age, is a density-dependent mortality and would be expected to be less significant at initially low densities. Secondly, in mixed stands, white spruce may bear proportionately less of the density-induced mortality than either birch or aspen because of its tolerance for shade. Finally, the growth of spruce in mixed stands may be improved over that of pure stands by virtue of better light, nutrient, and soil temperature conditions.

Zasada, *et al.* (13) notes that, in other parts of North America, minimum requirements for adequate milacre (0.001 acres) stocking range from 40 to 60%. They also report results of a previously unpublished study on white spruce regeneration following timber harvest in interior Alaska. Stocking values were lower than those reported here, ranging from 6 to 30%. They note that inadequate white spruce regeneration has also been reported in Canada by Wagg (11) and Dobbs (4). The results of our study indicate that two of the areas do meet this criteria while two areas do not.

Another point worth noting is the apparent discrepancy between percent frequency and density with respect to stocking levels. For example, in study unit 2, spruce has an average density of 1841 stems/acre which is more than twice the density needed for full stocking of spruce at 90 years of age. Yet the area is considered understocked since only 41% of the plots had any spruce seedlings at all. Furthermore, the latter value still does not reveal the spatial distribution of those plots constituting the 41%. If the data for all trees on study unit 2 are considered, we get 73% frequency and a total of 7787 stems/acre which gives more allowance for mortality and probably represents satisfactory achievement of a reforestation goal.

SUMMARY

Our study of four timber harvest areas in interior Alaska indicates that revegetation has occurred on all areas while regeneration of commercial tree species is quite variable. Herbs, shrubs, and grasses appear to offer significant competition for available seedbed if adequate tree seed is not available during or immediately after timber harvest. Entry of tree species during subsequent good seed years may be inhibited by the lack of a mineral soil seedbed. When both seed source and seedbed conditions are favorable, regeneration of mixed or pure, even-aged stands of birch, aspen, and/or white spruce is possible. Occurrence of such conditions favorable to white spruce regeneration are thought to be somewhat rare.

Thus, achievement of a specific regeneration goal can be viewed as a matter of chance. However, as has been demonstrated by others (1, 3, 6), management activities affecting seedbed preparation, timing of harvest, methods of harvest, or planting can increase the probabilities of success. The role of research is to provide relevant information and identify feasible management alternatives and their consequences. Undoubtedly, further research is needed in many areas including identifying adequate stocking levels, investigating controlled burning as a means of seedbeed preparation, performing planting trials, and determining the soil erosion hazard associated with widespread seedbed preparation.

In essence, more intensive forest management appears necessary if the values of our interior forests are to be sustained. If the perceived values do not justify the added expenditures implied by more intensive management, the responsibility falls on the individual user of the resource, from berry picker to logger, to understand the forest system and harvest its products with care and respect.□

*Site index: an index of site productivity. Defined as average height of dominant trees in the stand at age 100 for spruce and age 50 for birch and aspen.

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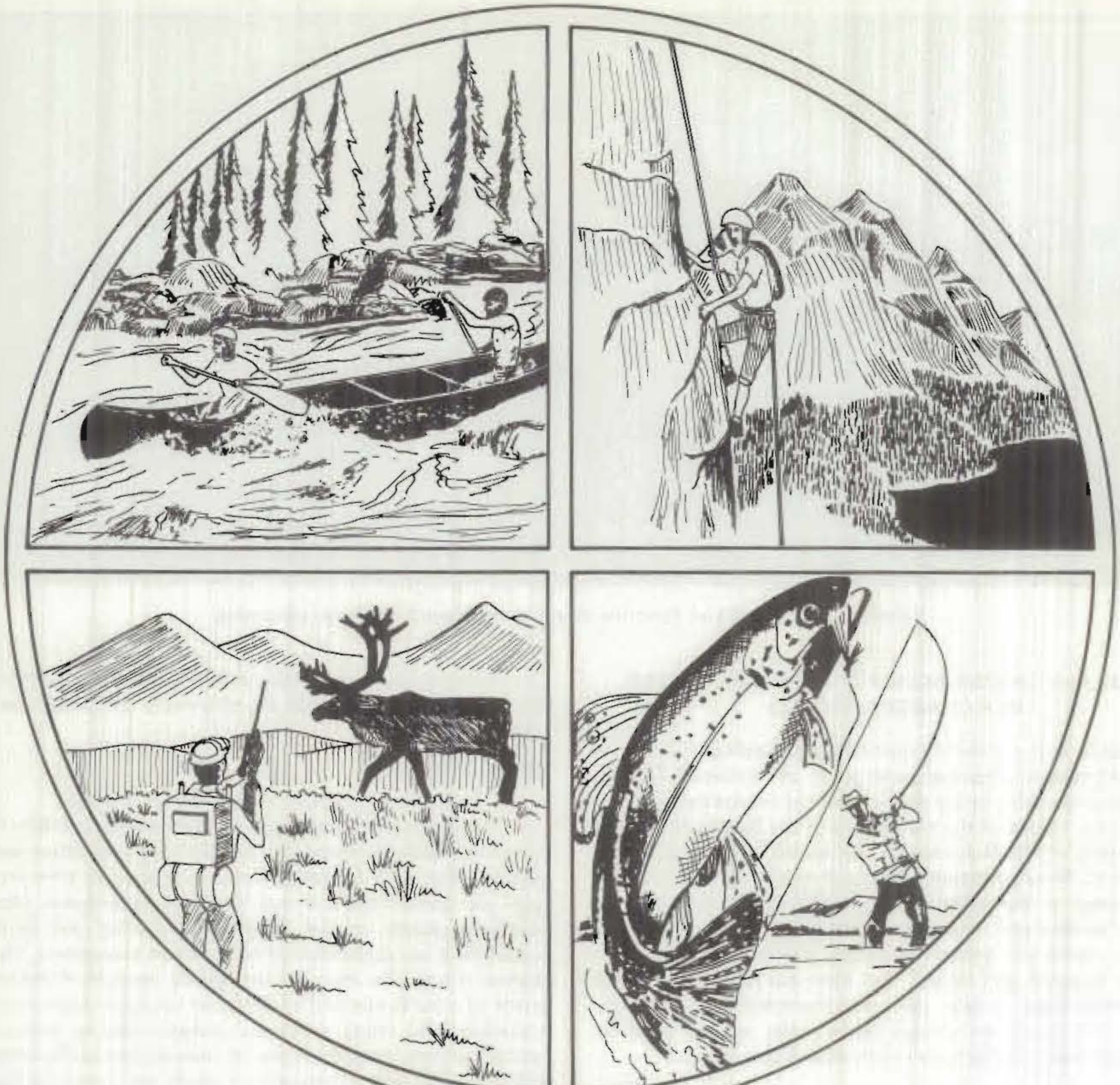

Outdoor Recreation in Alaska

A Problem Analysis

By Alan Jubenville*

INTRODUCTION

While much of the use of the Alaskan landscape has been recreation oriented, very little research has been done on this portion of the Alaskan lifestyle, its effect on the economy, or its ties to the past. Nor has anyone thoroughly reviewed the potential of the various geograpical locations for providing recreational opportunities. These types of studies would have helped decision-makers in their deliberations over the Alaskan lands controversy. Certainly, with the passage of legislation for national-interest lands in Alaska, more federal development and intensification of management will take place on these lands, and more people will be visiting Alaska. Increased income and leisure time will also contribute to the expansion of recreation participation. Alaska will probably continue to increase in population, and these people will spend as much, if not more, time recreating on the Alaskan landscape, particularly as access is increased. Consequently, more decisions are going to have to be faced in the future about recreation as a competing use of the landscape, the quality of that use, and the management of delivery systems providing those opportunities while protecting the landscape. While the need for recreation research has long been with us, it will intensify in the future because of the resource allocation decisions, increased recreation participation, fragility of the environment, and the uniqueness of the people and the geography of Alaska that would (or should) prevent wholesale importation of management strategies from other regions.

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Alaska's 34,000 miles of shoreline offers many opportunities for clamming.

ALASKA—A UNIQUE BLEND OF LAND AND PEOPLE IN A CHANGING WORLD

Alaska is not a simply man-land relationship; there is no single land type nor homogeneous group of "natives." There is tremendous diversity in the state—from the coastal forest to the south to the tundra of the north slope of the Brooks Range and from heights of Mt. McKinley to the depths of the outer continental shelf. The population is just as diverse—from the urbanite in Anchorage to the native whaler in Barrow and from the outfitter in the Wrangell Mountains to the placer miner at Chicken. However, there are groups of people who have similar backgrounds, interests, and tastes,* and there are regions within the state which have similar resource characteristics. However, beyond this, there are unique factors that appear to affect patterns of leisure in the state which should be explored.

Population

Population is one of the most significant variables on recreation participation in Alaska. The state's population has grown dramatically from 300,382 in 1970 to 418,658, a 40 percent increase. This is only part of the story—the greater Anchorage area, with nearly 50 percent of the entire state's population, is increasing at a faster than is the state as a whole. This is also true for Fairbanks but it has been influenced by the cyclic nature of the Interior's economy. The greater growth of urban centers has been the result of immigration into the state and an influx of residents from rural areas. Population as shown in Table 1 will continue to increase, and the urban centers of Anchorage and Fairbanks will continue to absorb most of state's new residents in addition to transplants from the "bush" areas. Thus, the majority of Alaskans will become urbanites—probably producing a dichotomous lifestyle, on the one hand demanding municipal services while on the other attempting to hold onto some of the unique values of Alaska like hunting, fishing, hiking, and skiing. Assuming that is true, the obvious future problems facing the land manager will focus on those lands adjacent to urban centers, or which are reasonably accessible from those centers.

Roles of Research

There are three levels of emphasis of research:

1. **Recreation Information Management (RIM)**—Recreation information management is a system of collection and analysis of data by a managing agency for specific sites (intensive use) and areas (dispersed use) for planning purposes. Many recreation research studies would be classified and conducted under RIM yet accomplished by scientific researchers. There are several reasons for this: (a) the agency involved in the management of a particular site or area does not have in-house research capacities, (b) many university research facility and staff are geared to providing this type of support more efficiently, and (c) a comprehensive management study can eliminate the indiscriminant proliferation of surveys and other kinds of data collection.

2. **Applied Management**—Management oriented studies are important to the effective delivery of recreation programs to the public. Programs can vary from auto-oriented campgrounds to wilderness hiking opportunities, sport hunting, and outlying cabins. The intent of such studies is to develop a broad base of scientific knowledge to help the management community, not necessarily to solve a specific problem on a specific site.

3. **Basic or Esoteric**—Basic research is done out of specific scientific interest on the part of the researcher without any predetermined application of study results in assisting the management community. Its sole purpose is the furtherance of knowledge in that specific academic area. Yet, where there is a concerted effort in basic research, spin-offs from the findings usually benefit management even though there may be some time lag. Because of the limited body of knowledge pertaining to outdoor recreation under Alaskan conditions and the need to improve management, very little basic research will probably be done in the near future. However, to dismiss or discourage basic research would be a disservice to management and academic communities since much management and RIM research is based on techniques and theories developed through basic research.

* The Alaska Division of State Parks is currently conducting a study to develop user profiles.

Table 1. Statewide Population Projections for Alaska*

Age	Male	Female	Total
		1979	
0-14	63,434	61,235	124,669
15-19	20,313	17,875	38,188
20-24	32,692	21,296	53,988
25-44	71,074	63,208	134,282
45 and over	35,784	31,747	67,531
TOTAL	223,297	195,361	418,648
		1985	
Age	Male	Female	Total
0-14	74,050	71,533	145,583
15-19	22,465	20,085	42,550
20-24	34,684	23,504	58,188
25-44	87,548	77,498	165,046
45 and over	43,391	41,289	84,680
TOTAL	262,138	233,909	496,047

* Institute of Social and Economic Research, University of Alaska.

Transportation Systems

Because of Alaska's location on the Great Circle air routes and the lack of good interstate transportation, the state is served by international, domestic, and intrastate commercial air carriers, plus air taxi and charter service in most communities. Thus, movement of people over long distances is usually by air, a trend which seems to be increasing.

There is one railroad—from Whittier to Anchorage, thence north to Fairbanks—which is being used less with the opening of the Parks Highway. There is some interest in extending the track to the new barley project at Delta, which would increase the backhaul to Anchorage. Southeastern Alaska and the Prince William Sound, Kodiak, and Anchorage areas are served by a state ferry system. Foot travel is limited because of distance, hardships, and hazards. And the use of the rivers for movement of cargo and people is limited except on a local basis.

The highway system is limited to the interior (Fairbanks) and southcentral (Anchorage) regions with land access via the Alaskan Highway and the Haines Cutoff ferry connection. The total highway length maintained by the state is probably no more than 3,000 miles. Use of the James Dalton Highway, the oil pipeline construction haul road to Prudhoe Bay, is limited to permitted commercial traffic, but it is being studied for public use. Many road corridors have been considered for expansion into nonroaded areas, but there does not appear to be any present commitment to their development.

Interior Alaska has a limited road network that connects the urban centers and, in turn connects them to the portals or access to the points of such visitor attractions as boating, hiking, or off-road vehcile (ORV) use. Thus, it appears that the majority of recreational use will be auto oriented and concentrated along the highways nearer the urban centers. One exception to this may be the influence of the opening of the Dalton Highway which could influence participation patterns of Fairbanks residents. Even then, the change may only reflect new summer and fall opportunities like fishing, hunting, and river floating. Of course, access from the urban areas to the bush will be the airplane, primarily air taxi services. For the coastal areas, other than the Kenai peninsula, the primary transportation will continue to be the boat or the airplane, and recreational use will be limited to those areas having reasonable boat or plane access from the coastal cities and towns.

Beyond these residential units is bush Alaska—an area which will continue to be dependent on the airplane as the primary transportation for long-distance movement. Local transportation will likely continue to be the boat, ORV (including snowmobiles), or small planes.

Alaskan Economy

The economy has continually shifted, first from gold to furs and salmon, and, more recently, from government to oil and gas. While the economy is described by economists as cyclic, the layman simply calls it "'boom or bust." The employment outlook of the economy is shown through 1985. Table 2.

Table 2. Total Projected Annual Average Employment in Alaska (Nonagricultural)

1979	173,000
1980	182,500
1981	193,900
1982	205,800
1983	218,500
1984	232,255
1985	245,900

*Institute of Social and Economic Research, University of Alaska.

Although unemployment is presently high in interior Alaska, employment statewide seems to be fairly high. Even then discretionary income used for recreation is fast being consumed by inflation which would either reduce recreation participation or change the patterns of present use. Probably, the immediate effect will be to change patterns of use. The preliminary results of a study by Jubenville, Thomas, and Workman indicate that Alaskans will attempt to ameliorate costs of recreating by changing patterns of use.

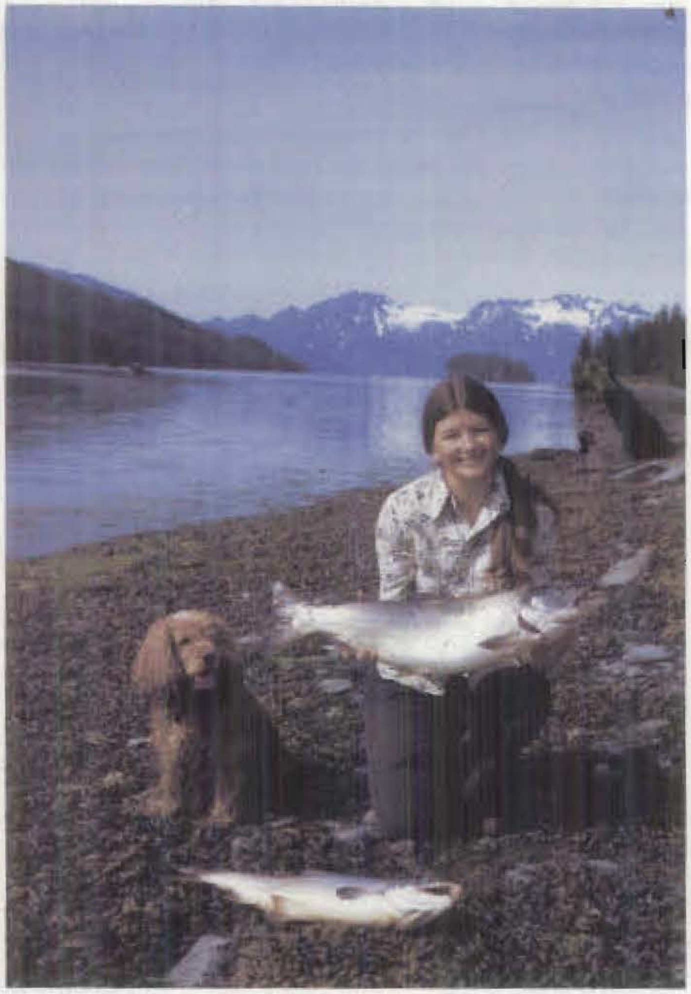
Resources for Recreation

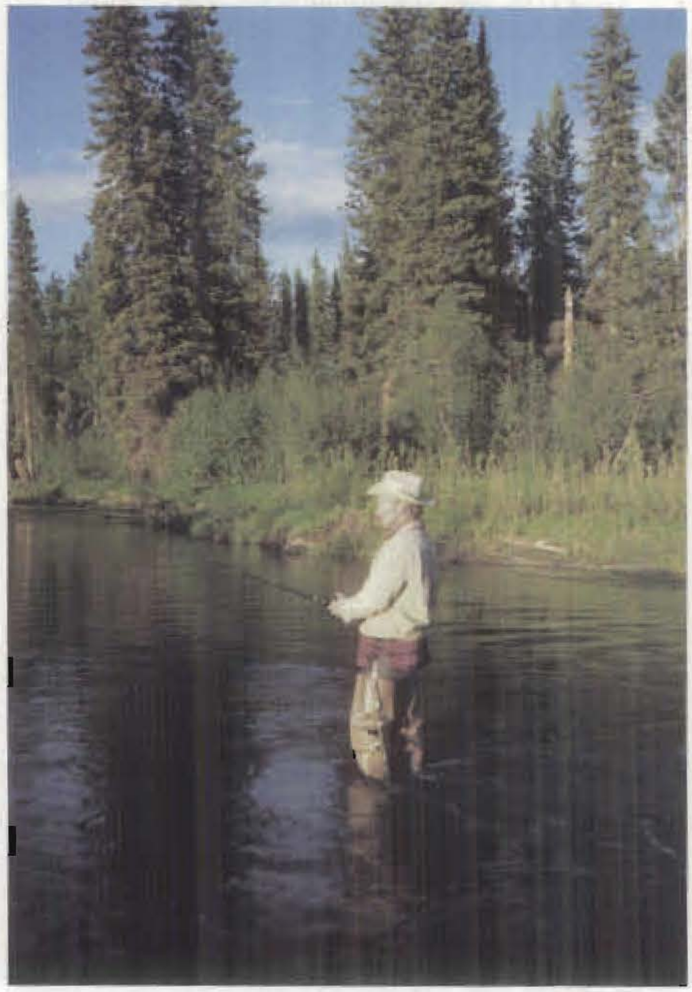
Opportunities for various outdoor recreational experiences in Alaska are exceptional. Many hiking, fishing, skiing, and other opportunities are available near towns and urban centers. The state park system is the largest in the United States, containing over 1.5 million acres and including some of the state's outstanding landscape features. Development of facilities to encourage use of the parks is increasing.

There are also excellent opportunities on federal lands for both highly dispersed activities like wilderness hiking or sheep hunting to such intensive uses as that in the campgrounds on the Kenai Peninsula. Mt. McKinley National Park, accessible by automobile, has continued to show a dramatic increase in visitor use and, subsequently, has pioneered some of the more intensive recreation management within the state. The Bureau of Land Management has conducted recreation studies, increased facility development, and intensified management of the landscape for recreation. Reasonably high use is occurring on the existing trails in both winter and summer, in the Chugach National Forest. Also, the outlying cabins in both the Chugach and Tongass National Forests are used fairly heavily in both summer and winter.

A number of lodges and related commercial developments are scattered throughout the state, with the high percentage of tourist use centering around hunting and fishing. And, of course, such related businesses as the many air taxi services cater primarily to the recreationist. River guiding has more recently become a recognized commercial recreation industry, along with the more traditional game and fish guiding.

Alaska's fish and game resources are some of the most unique aspects of the state and prime recreational attractions for both residents and nonresident alike. The prominent big-game and hunting locations are:





Alaska's interior streams and rivers provide excellent fishing opportunities.

Dall Sheep—located primarily in the Wrangell Mountains, Chugach Mountains, Alaskan Range, and Brooks Range.

Mountain Goat—located along the coastal mountains from B.C. to Kenai Peninsula.

Caribou—loated throughout the state, with the prominent herds in the Arctic-Brooks Range and Alaska Peninsula.

Alaskan Moose—throughout most of Alaska.

Brown Bear-Grizzly—throughout most of Alaska, the larger brown bears occurring on Kodiak Island and the Alaskan Peninsula.

Others are important, such as the wolf, but are diffused throughout the state, or are of more local importance such as the Sitka blacktail deer. Also, the state is blessed with a variety of marine mammals such as whales, seals, sea lions, walruses, and polar bear. Obviously these species offer rare opportunities for consumptive and nonconsumptive uses. While they are important, they are also very isolated and are used almost solely for subsistence by indigenous peoples.

Big game numbers built up to a peak in the middle 1960s and individual populations have generally either stabilized or crashed. Dramatic reductions in moose and caribou have been noted statewide. Many variables (including man's activities, climatic patterns, fire suppression, etc.) have led to these severe losses in big-game populations. But more importantly, Alaska, in general, has a very low natural productivity; and large numbers of animals occur in conjunction with large acreages, very little competition with man for the landscape, and the relative unaccessibility of the prime habitat.

The coastal areas and river bottoms provide prime waterfowl, raptor, and shore bird habitat (breeding grounds). Plus, upland areas provide habitat for ptarmigan, grouse, and a myriad of nongame birds.

In terms of fishery, the anadromous fish such as salmon, char, and sea-run trout are found in most coastal areas, and many interior rivers. Some interior streams afford quality grayling and trout fishing, while lakes offer lake trout, northern pike, and landlocked salmon. Some stocking of lakes has occurred at points of reasonable access near population centers.

Activities related to some of the wildlife discussed above will probably change as more national-interest legislation is considered by the federal government. The general effects of such legislation will undoubtedly be more emphasis on preservation and nonconsumptive uses, possibly more developed opportunities and intensified management, a reduction in traditional recreational uses of many parts of Alaska, reduced mobility in areas because of transportation restrictions, and lack of access to some lands. In sum, recreational use will probably become less consumptive and more restrictive under intensified management, as a result of the congressional mandate.

Many of the unique geographic features of the state are also recreational attractions for both resident and nonresident. Examples of these attractions are Mt. McKinley, the highest point in North America at 20,320 feet, the 34,000 miles of shoreline of which only a fraction is near the population centers, the 5.2 million acres of lakes of which only 0.5 million acres are in the southcentral region (near Anchorage), and the 7.7 million acres of rivers of which only 1.6 million acres are in the southcentral region.

Mt. McKinley, the highest peak in North America, is one of Alaska's major attractions.

RECREATION RESEARCH OPPORTUNITIES

The research opportunities are really unlimited because so little has been done. Muth and Fitchet (4) summarize the literature related to recreation in Alaska: of their 257 listings, only 16.7% were included under the heading, Research-Based Material. Yet, a more detailed evaluation of these 43 listings shows that most of the publications contain limited data or the analyses were limited because of specialized interests of management. Only three were published in refereed journals; and only one of these is aimed specifically at the recreationist. Most of the 43 were management oriented and the largest contribution was in wildlife management (16 listings). Other contributions to the literature on outdoor recreation have been through the Bureau of Land Management and the Alaska Division of State Parks (1). The last official act by the Federal-State Land Use Planning Commission (2, 3) was the publishing of *Outdoor Recreation in Alaska*; yet, ironically, the executive summary of that document (the one manager/planners and policy makers read) never once, implicitly or explicitly, focuses on the need, the role, or responsibility in research related to outdoor recreation. Certainly research plays a significant role in Alaska because information is needed for intelligent decision-making, yet so little has been done.

There are three primary subsystems that are integral to any outdoor recreation planning effort: visitor, resource, and management services. We need a great deal more research in all three subsystems; however, the visitor (or social) subsystem needs the primary emphasis because the other two only take on meaning as recreation actually occurs. Yes, we need to be able to measure use, behavioral patterns, and isolate those social and environmental factors which are important to each particular experience. We also need to know what impacts, social and environmental, a particular pattern of recreational use is causing. What effect does this have on the regional economy? What about the future? What are the potential effects of particular management programs, keeping in mind the fact that there are often systemic effects between subsystems?

As indicated above, outdoor recreation research has to be broad based, encompassing many academic areas, and will require a variety of expertise in the full development of any research program. The ensuing discussion is intended to strengthen the idea that there is a broad array of research topics, not Jubenville's Shopping List for Outdoor Recreation Research in Alaska. It is deliberately divided into topical areas to show the breadth of research needs and the discussion in each is kept general to give an overview of possibilities while avoiding the shopping-list appearance. The next section, Priority Focus, will offer the reader assistance in developing research priorities within the structure of the general topics listed below.

1. Techniques for Measuring Recreation Participation—Little baseline data on use is available and that which is available does not have well-established reliability limits. Consequently many managers faced with important decisions have very little information on which to base these decisions. Many techniques for measuring recreational use under Alaskan conditions may be needed: observation, contrived observation (that using instrumentation), erosion and accretion, diary, and indirect counting (measuring some variable directly correlated to use). Ideally, study techniques should be easily implemented in the field without necessitating personal contact between manager and participant. The manager needs to know two things: the reliability of the data emanating from a collection technique and the costs involved. Some examples might be time-lapse photography to measure use at trail heads, remote sensing to measure small-boat use along remote coastlines, diaries to measure behavioral patterns in isolated areas, or other such collection devices.

2. Patterns of Use—Survey research can certainly help to describe existing use, improve management feedback, and provide the basis for follow-up studies. Ideally, these types of studies would not only show patterns of activity participation, but would also tie them to a specific site or area. Some studies have already been made on how people use specific sites in Alaska. However, no attempt has been made to synchronize recreational use studies in order that the results will be comparable and integrable and the resultant patterns of use can be generalized. Possibly the use of standardized questionnaires and observation forms and standardized units of measures would help to make survey results comparable, and consequently the data could be integrated to make better generalizations about how Alaskans use the landscape for recreation. Modeling of behavioral patterns, using descriptive, probablistic, or integrative paradigms, certainly would provide a solid foundation for future management and additional research.

Much of the recreational use in Alaska is road oriented and requires immediate research attention. Yet, at the same time, use of roadless areas offers a greater management and research challenge because of the dispersed nature of the activities and greater potential increase in popularity. However, beyond simply modeling behavior, it is also important to know the interrelationship between behavior and the resource. Are the patterns of use random on the landscape or highly predictable based on the specific activity? Or are patterns more affected by facility development? This might be more properly called the ecology of the recreationist under specified conditions. This type of research is important not only because it fully develops the behavior but also because it ties that pattern to specific types of landscape variables. Pattern statistics developed by geographers can help in the full development of the relationship of man the recreationist and the land.

Certainly, the study of basic patterns of leisure is also important in terms of time budget, available supply in relation to available leisure time, and travel in relationship to leisure. What are the patterns of such special populations as the elderly, the unemployed, the physically handicapped? Is there a great desire by Alaskans to change these existing patterns?

3. Economics of Outdoor Recreation—There is no limit to the study possibilities relating to economics of outdoor recreation. Demand studies are needed to predict future use (consumption). If we could relate demand in terms of activities to specific landscape requirements as suggested above, the allocation of the resource base and the development of specific facilities would become a more efficient process. Beyond that, supply needs also to be studied in terms of what constitutes a reasonable unit of supply? Why are some sites and areas overly used and others completely ignored?

What role does outdoor recreation play in the regional economy from the perspective of the resident? Nonresident? Do Alaskans allocate more of their personal income to various recreational pursuits than do other Americans? What is the potential for the intensive development of international tourism? Answers to these and similar questions can give us a better idea of the economic significance of outdoor recreation and improve the regional resource allocation process by government and the private sector.

In the future, substitution of activities within some defined range could be important in Alaska. What are the ranges within which substitution is acceptable? What specific activities are directly substitutable for other activities?

Another area of economics needing attention is concessions within the public sector. What unique role should concessions play in the recreational use of Alaskan lands? What type of concession arrangements would best suit Alaskan conditions? What unique role should commercial transportation play in the use of public land? Finally, one has to ask, What changes in transportation will take place because of energy shortage and subsequent increase in cost of petroleum products? and, ultimately, What affect will the shortage have on the Alaskan leisure lifestyle?

4. Recreational Experiences—If recreation participation in Alaska is truly unique, what are the parameters that describe the experiences people seek? What are attitudes, interests, or opinions about the available opportunities? About the management of those opportunities?

User preference studies can help give guidance to the management community. Beyond that, how do specific user types make choice decisions? Are these simple, unidimensional or multidimensional decisions? How are tradeoffs made by the user?

In a place as large as Alaska, do people tend to segregate themselves naturally into specific use or experience patterns? Are there places where there is no physical or psychological competition, thus providing a mecca for the study of recreational experiences in their purest form?

What are the psychological or physical barriers to recreational use of Alaskan lands and waters? Can manipulation of these barriers signficantly change use patterns? What are the effects on the recreational experience?

Probably as important as any research on recreational experiences is the focus on the more unique Alaskan activities and cultures. Big game hunting (sheep, goat, walrus, big bear), glacier climbing, mountain climbing, salmon fishing, dog mushing, berry picking, ski touring, and so on, are examples of unique recreational experiences. Many of these are reasonably common in Alaska, but we do not have good descriptions of these experiences and subsequent programs to maintain them.

5. Management Studies—Many of the opportunities for research already discussed would also benefit management directly, but there are other management studies needed to help implement programs.

a. Policy evaluation—What techniques would be appropriate to evaluate policy? Under Alaskan conditions, is it possible to test the effects of policy change on recreational use without a field trial-and-error process?

b. Management coordination—This is essential in Alaska with the large roadless areas, confusion of boundaries, and diversity of agency roles. But we need to answer the questions: when, where, how, and under what conditions?

c. Special programs—Special programs such as access for the handicapped, new wild river proposals, and mass transit will need to be evaluated fully before consideration.

d. Management roles—Research can help to define management roles more adequately for each level of government and the private sector.

e. Redistribution of use—How do people make choices and how can the manager affect choice? Redistribution on a voluntary basis is certainly going to be a primary challenge of future management.

f. Information, education, and communication—Management programs require some level of communication with the public. In Alaska, what are the best methods for specific conditions? How do Alaskans respond to various methods of communications?

g. Public safety—With increasing use, greater access, and more intensive management, safety will become a primary concern.

h. Visual resource management—What are the important elements of the landscape to the viewer? Are basic visual perception models applicable to Alaska? What kinds of programs are needed?

i. Career development/continuing education—What are the specific continuing educational needs of the practicing professional in order to improve his present management skills and/or adapt them to Alaska?

6. Impact Analysis—We need to understand the impact of specific recreational use on specific landscape types in both the terrestrial and aquatic ecosystems. We have little information on the impact of the recreationist and his technology on the Alaskan environment—an environment which is not very durable and which probably cannot sustain intensive use without rapid deterioration of flora, fauna, geology, water, or air. We need to identify the threshold levels of these environmental components. Possibly, indicator plant species can be isolated to indicate prethreshold levels and the need for immediate site renovation, rather than crossing the threshold and encountering the subsequent rapid environmental deterioration.

There are also social and economic impacts associated with any program; these need to be enumerated. Computer simulation modeling could possibly help assess these before implementation of a major recreation management program. As important as any potential impact is that of the development of oil and gas and such renewable resources as timber on the recreational use of a particular landscape. One must also consider the impact of increased access and intensive recreational development on more traditional use patterns. With limited road access and expanding use, severe impacts may result. Research is needed to assess these impacts both in the short and long runs. Short-run effects may be a boon to the user, such as greater moose harvest with better access, and yet the long-run effects may take such devastating forms as overkill, destruction of moose habitat, or major conflicts between users.

PRIORITY FOCUS

Rather than simply trying to rank the research opportunities into some artificial priorities, we will attempt to give some focus to research through four principles of priorities.

1. Problem Oriented—Each agency should develop and continually reevaluate its own management priorities and locate the gaps of knowledge within those priorities, thus helping to reduce crash research programs. Often crash-type campaigns are expensive with few results and have little carryover in terms of evaluating future problems.

Most use and most management problems appear to be directly proportional to the ease of access. Consequently, problem-oriented research should focus geographically on the reasonably accessible lands in the southcentral, southeastern, and roaded portions of the interior zones. Other known problem areas are points of intensive oil, gas, and mineral development and the development of better access into some of the outstanding natural wonders of the state.

Based on the fact that many of the attractive, uniquely Alaskan activities are tied very closely to specific resource areas, and, assuming little opportunity for substitution (sheep and bear hunting, walrus watching, climbing Mt. McKinley, salmon fishing, etc.), each of these activities and its accompanying resource is a prime target area for problem-oriented research.

2. Policy Oriented—Not only should the focus be on problems, but also on policy related to those problems. Many of the decisions made in the next ten years relating to recreational use of the Alaskan landscape will take the form of broad-based policy, even though we will also have our share of "brush fires." This is a new era in recreation management in Alaska and the nucleus of these new policies will carry forward for an even longer period, so research aimed at evaluation of policy is deemed essential to the development of proper management posture.

The recognition of this principle is important because Alaska is just not another playground. It has unique resources, people, opportunities, and problems—and policies need to reflect these unique characteristics. One can not simply import policy strategies which include an organizational framework and expect them to work automatically.

Policy also has to be coordinated between agencies and levels of government in order to be effective; one does not "do his thing" in Alaska based on some vague cognizance of the political boundaries of management units but, rather, he does it with a realization that there may be some inherent legislative constraints on coordinating policies between two agencies.

3. Multiplier Effect—Because so much research needs to be done, it is imperative that researcher and manager alike stretch the dollar as far as it can go—focus research attention where it is most needed, collect only what is necessary, and try to build in some multiplier effect.

The multiplier effect can be developed in three ways:

a. Some research has automatic multiplier effects. One of the primary research needs in Alaska is the development of simple baseline data that are reliable. Research that tests various techniques for measuring use, including costs and reliability of the data produced, should have a tremendous multiplier effect because the managers can then collect and analyze the data using the "proven" technique.

b. Replication of research studies helps to define the level of external validity of the results (how well the results hold from case study to case study). If we design a study so that it can be replicated in several places or at different points in time, there is a much stronger base for generalization to a region, physiographic province, or whatever large unit one chooses to use.

c. Controlled experimental design, although somewhat difficult, can yield better results for generalizing than can simple surveys.

4. Regional Economy—Research related to the regional economy is essential in an emerging state. We have to determine the real value (price) of recreation in the market place because it will be necessary for it to compete; otherwise, it may always be downplayed in any resource allocation decision. Tradeoffs will be made and recreation can lose in that type of strategy, sometimes to an entity of a lesser value in the market place, because we were reluctant to place a value on recreation. Armed with the above knowledge, Alaskans may choose to shift greater emphasis to recreation and tourism in the regional economy.□

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Impatient for spring to arrive, the catkins of thinleaf, or streambank, alder swell and pollinate during the initial warming periods, often when the ground is still frozen.

Using Phenology to Characterize Spring Seasons in Alaska

By Wm. W. Mitchell*

Weather is still a favorite topic for conversation, and comparing current experiences with those of previous years is a pastime that engages many venturesome minds. Agreement on past history is not always readily obtained; but certain years, generally the ones that have dealt us the most severe blows, stand out. These may be associated with particular events that are indelibilized in the mind. Charlie Russell immortalized the winter of '88 on the Montana plains with his report to an absentee owner on the fate of his cow herd—a postcard sketch of a starved cow, the last of 5,000, waiting for a chinook.

Without a written record, however, it becomes difficult to recall the details of specific years. One means of characterizing seasons of the year is through phenological observations. Phenology deals with periodic occurrences, often first appearances of designated events during a season. Flowering times are a favorite subject, but any number of events are subject to phenological interpretation—the first bud opening, the first robin, the first mosquito bite, etc. Phenological observations can heighten one's interest in one's surroundings. A phenological study is currently underway to compare growing seasons in different regions of Alaska (1).

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I started to record spring flowering dates in the Palmer area in 1964. The record is most complete for three shrubs that span the spring season through May, covering fifteen years for American red currant (*Ribes triste*) and highbush cranberry (*Viburnum edule*) and twelve years for thin-leaf alder (*Alnus incana*). Less frequent observations have been made on other plants. This record can tell us a great deal about the character of spring seasons for the last fifteen years in southcentral Alaska.

EARLIEST SPRING EVENTS

Thinleaf alder is a tall shrub (or small tree) that generally grows on bottom lands along water courses. It is one of the first plants to flower when the thaw period commences (Figure 1). Alder is a catkin-bearing plant, like willows and cottonwood, and flowering occurs when the male catkins open and commence shedding pollen (Figure 2). The pollen is disseminated by wind, some of it falling on small, pistillate cones that eventually bear the seeds. Some willows that appear to flower earlier than thinleaf alder have only shed their bud scales, thus exposing the swelling catkin. Willow catkins sometimes are exposed during a warm spell in midwinter. They are not actually in flower, however, until the catkins open and commence pollinating.

Thinleaf alder is not the same species as the later-flowering American green alder (*Alnus crispa*) commonly found in thickets on hillsides and as outliers above and beyond the timberline. Thinleaf alder may flower so early as to signal a false spring, its flowering triggered by an unusually early thaw period that may be followed by more winter weather. Some willows (*Salix* sp.) and quaking aspen (*Populus tremuloides*), also catkin bearers, closely follow the alder in flowering times (Figure 1). These are plants that flower while their feet are still frozen.

PREVERNAL PHASE

One of the earliest, non-catkin bearing shrubs to flower in the spring is American red currant. It inhabits the understory and edges of open, mixed woods. The small, reddish-to-purplish flowers occur in drooping racemes (Figure 3) that develop into clusters of red berries cherished for jellies and syrup making. The flowers are insect pollinated, probably by flies that emerge early in the spring before other flying insects are about. Some spring plants of the more showy kind also commence flowering about this time. This may be considered the beginning of the prevernal phase in this region of Alaska.

In the midwestern states and eastward, a distinctive group of plants flower in the understory of the hardwood forests prior to the appearance of leaves on the trees. These plants comprise the prevernal flora. *Hepatica* (or liverwort) is a prominent member of this group in the Midwest. It was so named because of its three-lobed leaves, resembling the shape of the liver, and because of that, was once thought to have therapeutic value for liver ailments.

Alaska's prevernal flora is not as rich as the Midwest's. Among the showy ones to look for here are the delicate, pink ladyslipper (*Calypso bulbosa*)—a hard-to-find orchid that occurs on the mossy beds of spruce woods—the gaudy, undeniable dandelion (*Taraxacum officinale*), and the yellow anemone (*Anemone richardsonii*).

The local cottonwoods (*Populus balsamifera*) also flower and shed their pollen about the time the red currant flowers (Figure 1). Later, in the summer, the long-haired seeds of cottonwood drift passively about as cottony nuisances. Some non-flowering plants initiate their reproductive process, often unnoticed, during this phase. Meadow horsetail (*Equisetum pratense*) is very common and abundant in the woods and some fields throughout much of Alaska. Its underground, over-wintering organs produce pale brown shoots with cone-like structures at the top which open and shed spores about the same time the red currant flowers. The single-celled spores initiate a somewhat involved process for reproducing the plant. The cone-bearing shoot subsequently branches and becomes vegetative. In some species, the cone-bearing shoot may die after shedding its spores while developing other shoots that are vegetative.

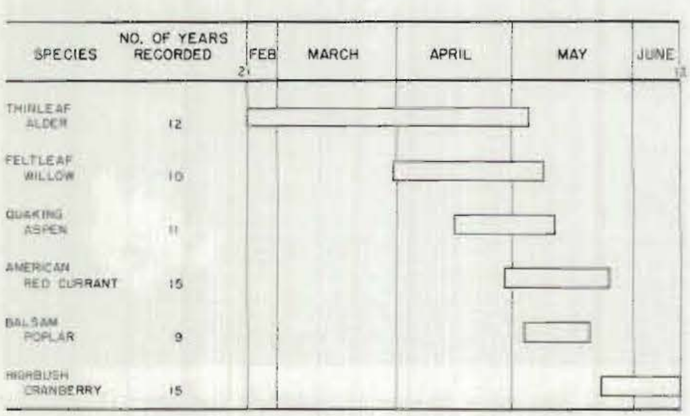

Figure 1: Ranges of flowering times over 9- to 15-year periods for selected native plants.

Figure 2: Male and female catkins of thinleaf alder (*Alnus tenuifolia*) just prior to flowering (when pollination occurs). The long, male catkins drop off after the pollen is shed. The small, female catkins on the upper left enlarge into hardened burrs that contain the winged seeds..

A number of plants flowering in this phase of spring require sufficient warming of the soil to permit shoot development from underground parts. Some plants are precocious because of the benefits of a particular location, such as the south side of a house or a particularly favorable niche on a south slope, and thus flower sooner than those subject to normal warming action.

THE VERNAL PHASE

Highbush cranberry commences flowering near the end of May or early June, when the birch and cottonwood trees are leafing out. This marks the vernal phase, a short period that rushes headlong into summer. The tight, white, flower clusters of highbush cranberry (Figure 4) elongate during the summer into an upright cluster of red berries, also used for jellies and syrups.

A number of plants are impatient to begin the reproductive process at this time. Bluebells (*Mertensia paniculata*), wintergreen (*Pyrola* sp.), lowbush cranberry (*Vaccinium vitis-idaea*), and bunch berry (*Cornus canadensis*) commence flowering when highbush cranberry appears. Flowers of the pretty, low-growing Jacob's ladder (*Polemonium pulcherrimum*) adorn many of our roadsides followed shortly thereafter by the wild, prickly rose (*Rosa acicularis*). The ever-present dandelion continues in its determined effort to populate the world. Soon summer is ushered in with its fireweeds, parsnips, daisies, asters, etc.

Figure 1 summarizes the range of flowering times of those plants for which the longest records are available. The earliest to flower are tall, woody materials whose catkins are exposed to ambient temperatures. They respond to sporadic thaw periods in late winter and early spring and flower prior to the initiation of vegetative growth and leaf production. Their flowering dates occur in a wide range, reflecting the highly variable occurrence of early thaws, which may be interrupted by some belated winter efforts. The range of flowering dates narrows for the later-flowering plants.

When the red currant flowers, things begin to appear that depend upon some warming of the soil as well as the air. The field horsetail has produced both vegetative and reproductive shoots from underground storage organs by this time. The soil in wooded areas may be thawed only about three to four inches. Other plants also emerge from the soil about this time. These events would appear to signal more truly the start of our "growing spring," or prevernal phase, than the earlier flowering events.

Over the last fifteen years, our prevernal phase has begun from late April to late May. In some years, the prevernal phase has been, indeed, a short period. The flowering of highbush cranberry appears to signal the final flush of spring growth and flowering leading to the onset of summer. Plants that have not flowered must do so hurriedly now if they are to complete their reproductive process. The appearance of yarrow (*Achillea borealis*), fireweed (*Epilobium* sp.), and others in late June to early July mark this headlong rush to complete the summer flowering season.

CHARACTERIZING THE YEARS

By gathering together the flowering dates of the three plants for each year, we gain a picture of the character of our springs for the last fifteen years (Figure 5). Although data are not available on alder for the first three years, the flowering times of currant and highbush cranberry define the prevernal phase, or growing spring. On this basis, three years clearly bear the distinction of having afforded us our latest springs: 1964, 1971, and 1972. The earliest springs are more difficult to denote, but 1969, 1974, and 1978 appear to qualify (and 1979, not tabulated, could be added to the list). The earliest start on our prevernal spring was obtained in 1965, but periods of cold weather intervened to slow its progress. Some long gaps between the flowering times of thinleaf alder and American red currant indicate how misleading the initial stirrings of spring can be in our north country. The average flowering date for the currant was May 11 and for highbush cranberry, May 31. From this

Figure 3: The small saucer-shaped flowers of American red currant (*Ribes triste*) develop in early spring with the unfolding of the leaves, which occur at alternate positions on the stem. The ovary of the flower swells into a red berry during midsummer.

Figure 4: The white flowers of highbush cranberry (*Viburnum edule*) appear in a cluster bracketed by a pair of leaves that occur opposite each other on the stem. The flowers mature into a cluster of red berries.

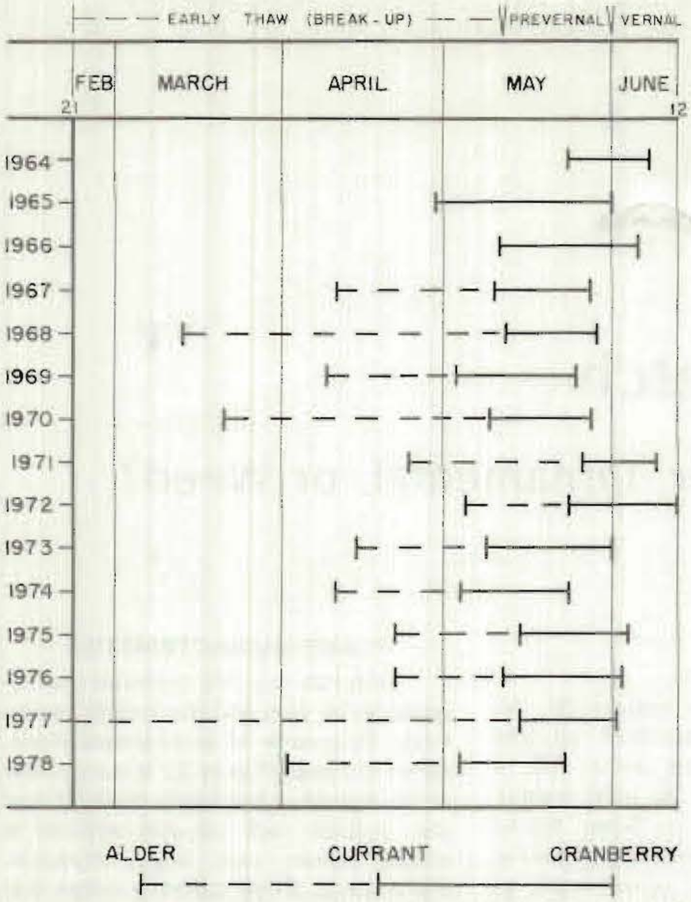

Figure 5: Flowering times of shrubs characterize spring periods of the last 15 years.

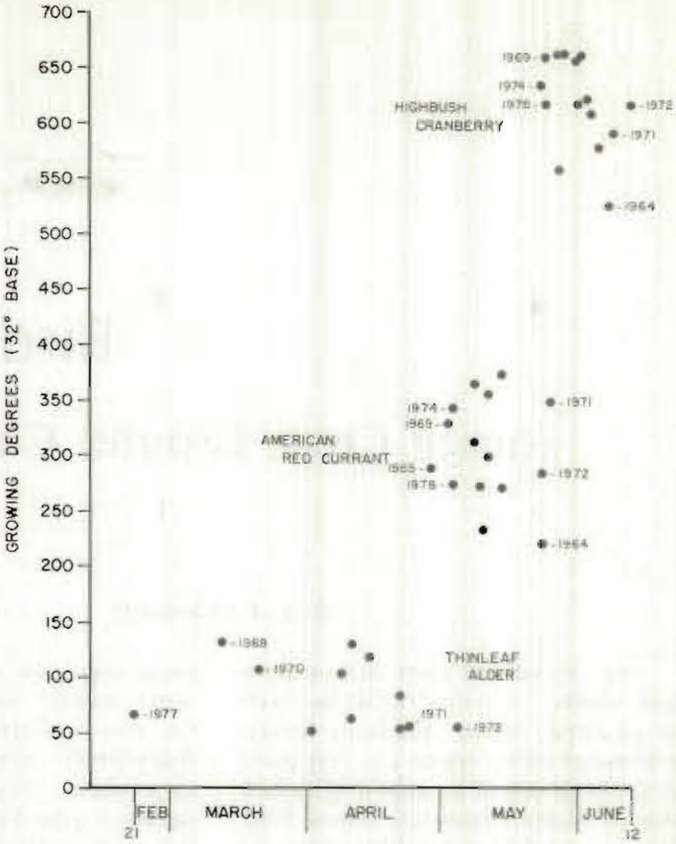

Figure 6: Number of growing degrees required for flowering of three shrubs over a 12- to 15-year period.

record, then, these dates may be considered to be delimiting the normal prevernal, or growing spring (Figure 5). On this basis, 1976 most closely approximated a normal spring.

Further affirmation is gained on the character of the different years with the use of temperature data to determine the accumulation of growing degrees (or growing degree days) over the season. The number of growing degrees for a given day equals the amount the average of the daily minimum and maximum temperatures exceeds a predetermined threshold or base figure. In this case, 32°F is used as the base figure, thus, (maximum + minimum) ÷ 2 − 32 = number of growing degrees for each day, which are added throughout the season. For agricultural crops in Alaska the base figure of 40° is used to determine the accumulation of growing degrees (degree days) during the season (2, 3). With 32° as the base temperature, the average accumulation of growing degrees required for our spring plants to flower equal:

Thinleaf alder	85°
American red currant	304°
Highbush cranberry	620°

By graphing accumulated growing degrees against their respective flowering dates (Figure 6), three clusters are readily delimited representing the three plants. Furthermore, by attaching years to some of the dots on the graph, we note that 1964, 1971, and 1972, indeed stand out as cold, late springs; and 1964 was one of the coldest. That spring has other distinctions as well. Many will remember it for the Good Friday earthquake on March 27. Also, a particular Alaskan family can remember it for the extremely late break up of the Nenana River, enabling that family to be the last individual winner of the Nenana Ice Pool—and their guess wasn't even on the right day! One of the early springs, 1969, is also a memorable year for Alaska. The Prudhoe Bay oil lease sale thrust Alaska into the limelight that year. And in 1974, another early-spring year, construction on the trans-Alaska oil pipeline finally began.

SUMMARY

In summary, flowering of some of the catkin-bearing trees and tall shrubs begins in southcentral Alaska in response to warming air temperatures, but with the soil still frozen except at the surface. These initial spring events may be interrupted by some dying charges of winter. The flowering of American red currant and emergence and sporulation of some horsetails mark the beginning of our prevernal phase, which is conducive to growth from a warming soil. This generally occurs in early-to-mid May in the Palmer area. The prevernal phase ends with the leafing out of the hardwood trees. Highbush cranberry flowers about this time, marking the beginning of the vernal phase, which, in Alaska, telescopes into summer. This occurs in late May to early June. An average prevernal phase determined from fifteen years of record of flowering times in the Palmer area extends from May 11 to May 31. The years 1964, 1971, and 1972 have been distinctively late springs, and 1969, 1974, and 1978 early springs. The current year's spring, not included in the record, also was early.☐

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Birdvetch

Forage Crop, Ground Cover, Ornamental, or Weed?

By L. J. Klebesadel*

Few introduced plant species seem more ideally "at home" in Alaska than the perennial legume commonly known as birdvetch (*Vicia cracca* L.). This plant continues to extend its range in disturbed areas of Alaska increasingly distant from the points at which it was introduced.

The world range of birdvetch in temperate and subarctic regions of the Northern Hemisphere is considerable, extending from Western Europe to Far Eastern Asia (7). It is common in eastern Canada and the northeastern U.S. Although some authors (3, 4, 6) consider the possibility that birdvetch is native to North America, most authorities (1, 2, 7, 9, 11) agree that the species is native to Eurasia and was introduced early to the Western Hemisphere. Polunin (9) conjectures that birdvetch was introduced to Greenland by Norsemen about 1,000 years ago.

VETCHES IN GENERAL

There are about 150 species worldwide within the genus *Vicia*, and about 15 of these are native to the United States (5). With numerous introductions from Europe and Asia, about 35 species are now found in North America (6). There are both annual and perennial species of vetch, but most of those used in cultivation are annuals. Vetch species most used in American agriculture are hairy vetch (*Vicia villosa*), common vetch (*V. sativa*), and purple vetch (*V. benghalensis*). In the 48 conterminous states, these are often planted in autumn and grown as winter annuals for a variety of purposes, including hay, silage, pasture, cover crop, and green manure (5). All vetch species are considered valuable for their nitrogen-fixing ability (6), a characteristic common to most leguminous plants (Figure 1). Some Alaska dairymen grow common vetch in association with small grains, usually oats, or awnless barley, for an annual forage crop for silage.

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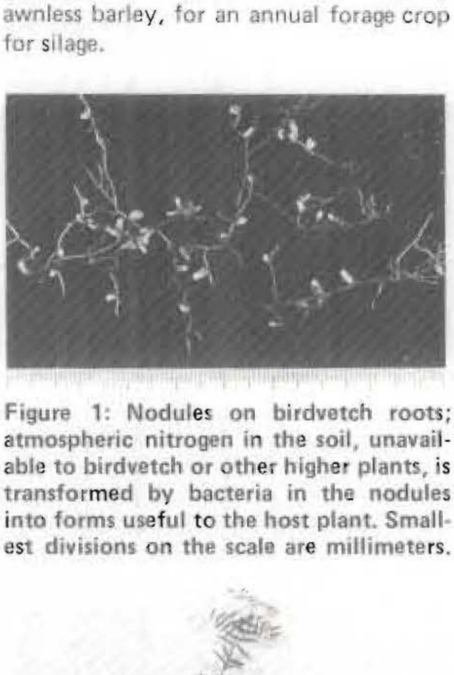

Figure 1: Nodules on birdvetch roots; atmospheric nitrogen in the soil, unavailable to birdvetch or other higher plants, is transformed by bacteria in the nodules into forms useful to the host plant. Smallest divisions on the scale are millimeters.

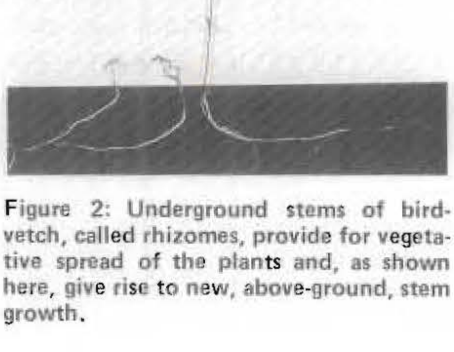

Figure 2: Underground stems of birdvetch, called rhizomes, provide for vegetative spread of the plants and, as shown here, give rise to new, above-ground, stem growth.

PLANT CHARACTERISTICS

Birdvetch is a viny perennial that reproduces by seed and also spreads vegetatively by growth of underground stems, called rhizomes (Figure 2). It is a member of the legume or pea family of plants that also includes such valuable relatives as alfalfa, clovers, peas, beans, lespedeza, and peanuts. Other common names that have been applied to birdvetch include cow vetch, tufted vetch, crow vetch, and Canada pea.

The stems of birdvetch are weak and viny and grow nearly prostrate unless they are supported by other vegetation or fences. The leaves are composed of many (10 to 30) small leaflets borne on both sides of a midrib (Figure 3). The midribs terminate in branched tendrils that curl around whatever they touch, thus providing support to the vines. Birdvetch vines supported by bushes, small trees, or high fences may ascend to heights of 4 to 6 feet.

The small but very attractive, blue-violet-to-purple flowers are crowded along many-flowered stems, called racemes (Figure 3). In Alaska, birdvetch flowering begins in July and continues into September.

The seed pods are somewhat flattened, 2 to 3 cm long (Figures 4 and 5), and usually contain 4 to 8 seeds. The seeds are round, dark grayish-brown, and 2.5 to 3 mm in diameter (Figure 5). The seeds number about 40,000 to the pound, and a bushel of seed weighs 60 pounds (5).

HISTORY IN ALASKA

Birdvetch has a longer history in Alaska than might be suspected. Records reveal that it was first planted in Alaska at the now-closed Rampart Experiment Station on the Yukon River in 1909.

Table 1. Seeding-year forage yields, percent winter survival, and forage yields the subsequent year, of various biennial and perennial legumes in two separate field tests at the Matanuska Research Farm.

Legume	Seeding-year yield (T/A)			Percent winter survival			Forage yield, second year (T/A)		
	8 Oct 69	8 Oct 71	2-yr mean	1969-70	1971-72	2-yr mean	17 July 70	27 July 72	2-yr mean
Vetch (*Vicia* spp.):									
Birdvetch (*V. cracca*)	*	*	*	**	**	**	1.236	1.934	1.585
Alfalfa (*Medicago* spp.):									
M. falcata	*	0.470	0.235	100	98	99	1.469	1.688	1.579
A-syn. B	0.669	0.855	0.762	42	82	62	0.744	0.751	0.748
Teton	(not incl.)	1.807	***	(not incl.)	12	***	(not incl.)	0.090	***
Rhizoma	(not incl.)	1.234	***	(not incl.)	5	***	(not incl.)	—	***
Sweetclover (*Melilotus alba*):									
A-syn. 1	0.836	1.467	1.152	30	64	47	1.385	1.152	1.269
Polara	(not incl.)	1.887	***	(not incl.)	2	***	(not incl.)	—	—
Cumino	(not incl.)	1.859	***	(not incl.)	1	***	(not incl.)	—	—
Red Clover (*Trifolium pratense*):									
Alaskland	0.257	1.026	0.642	0	15	8	—	1.011	0.506
Altaswede	0.101	1.025	0.563	0	1	1	—	—	—
La Salle	(not incl.)	1.607	***	(not incl.)	0	***	(not incl.)	—	—
Kenland	(not incl.)	1.770	***	(not incl.)	0	***	(not incl.)	—	—
Alsike Clover (*Trifolium hybridum*):									
Kurir	0.514	1.387	0.951	0	0	0	—	—	—
Aurora	0.594	1.833	1.214	0	0	0	—	—	—
White Clover (*Trifolium repens*):									
White Dutch	(not incl.)	1.343	***	(not incl.)	0	***	(not incl.)	—	—
Ladino	(not incl.)	1.192	***	(not incl.)	0	***	(not incl.)	—	—
Birdsfoot Trefoil (*Lotus corniculatus*):									
Cascade	0.884	1.017	0.951	0	0	0	—	—	—
Empire	0.619	1.085	0.852	0	0	0	—	—	—
P-15456	0.531	1.273	0.902	0	0	0	—	—	—
Crownvetch (*Coronilla varia*):									
Emerald	*	0.067	0.034	0	0	0	—	—	—
Penngift	*	0.028	0.014	0	0	0	—	—	—
Strawberry Clover (*Trifolium fragiferum*):									
Commercial seed lot	*	0.761	0.381	0	0	0	—	—	—
Sainfoin (*Onobrychis viciifolia*):									
Onar	1.009	1.595	1.302	0	0	0	—	—	—
Viva	1.181	1.204	1.193	0	0	0	—	—	—
M-1678	0.377	0.946	0.662	0	0	0	—	—	—
P-15596	0.385	1.052	0.719	0	0	0	—	—	—
Krasnodar	(not incl.)	2.278	***	(not incl.)	0	***	(not incl.)	—	—
Eski	(not incl.)	1.656	***	(not incl.)	0	***	(not incl.)	—	—
Melrose	(not incl.)	1.743	***	(not incl.)	0	***	(not incl.)	—	—
Milkvetch (*Astragalus* spp.):									
A. harringtonii	*	*	*	100	100	100	1.058	1.638	1.348
P-498 (*A. cicer*)	*	0.096	0.048	0	28	14	—	0.051	0.026
Eskimo Potato (*Hedysarum alpinum americanum*):									
Native Alaskan bulk sel.	*	*	*	100	94	97	0.415	0.912	0.664

* Insufficient seeding-year growth to obtain a harvestable yield.
** Rhizomatous nature of the plant did not permit counts of percent winter survival.
*** Two-year mean not available; included in one test only.

Many later plantings were made there and at the Fairbanks and Matanuska experiment stations where it was evaluated for forage (8).

From the plantings at all three of these locations, birdvetch has spread and persists today mixed with the local vegetation. With increased land disturbance and development in the Fairbanks and Matanuska Valley areas, birdvetch has spread considerable distances away from the experiment stations and has become a conspicuous element of the local flora. It is most evident along roadsides and railroad tracks and at the edges of farm fields. On abandoned fields, birdvetch has spread as a ground cover to become the dominant species (Figure 6). However, it is most evident on fences where the abundant and vigorous vine growth rises and intertwines, often concealing the fences (Figure 7).

BIRDVETCH USES

Birdvetch grows well on silt loam soils well supplied with moisture, though not persistently wet. It grows poorly on shallow, sandy, or gravelly soils, especially where insufficient moisture limits its growth.

Forage Crop

Irwin (8) notes that birdvetch is "slow in establishing itself" but grows vigorously during the second and subsequent years. Curing for hay and winter survival of birdvetch were improved when the crop was seeded along with grasses. Irwin reported that birdvetch hay yields for the several Alaskan experiment stations ranged from just over one ton per acre to more than four tons.

To derive more current information on the potential of birdvetch for use as a forage crop, and how it compares agro-

Figure 3: Closeup of leaves and flowers of birdvetch.

nomically with other forage legumes in southcentral Alaska, a seed supply was harvested from roadside stands for experimental field tests. Two tests, using randomized complete block experimental designs with three replications, were planted at the Matanuska Research Farm, one on 19 June 1969 and the other on 16 June 1971. Both included several other herbaceous forage legumes, each planted alone. All plots were broadcast seeded after appropriate bacterial inoculants were added. The two tests were planted in field areas leeward of a forested area, leaving plots relatively sheltered from maximum velocities of strong northeasterly winter winds that usually remove insulating snow cover from more exposed field sites. Legumes in both tests were harvested on 8 October of the planting year, and again in July of the following growing season. Forage yields are reported (Table 1) in tons of dry forage per acre with drying at 140°F. Neither test was continued beyond the second year.

Both tests were influenced adversely by a soil moisture deficit engendered by three consecutive years of markedly below-normal precipitation. Normal annual precipitation at the Matanuska Research Farm is 15.43 inches. In 1968, 1969, and 1970, precipitation was below normal by 3.96, 3.80, and 3.55 inches, respectively. Due to this cumulative dry spell, legume forage yields were lower than would be realized in years with nearer normal precipitation.

Although both tests were planted near mid-June and most of the other legumes produced a harvestable yield in the seeding year (Table 1), birdvetch seedling development was too limited to provide a harvestable seeding-year yield in either test. These results agreed with Irwin's (8) earlier observations for birdvetch. The late agronomist A. L. Hafenrichter of the Soil Conservation Service, U.S. Department of Agriculture, found that slow growth during establishment is considered characteristic of all rhizomatous, perennial vetches (personal communication).

Figure 4: Individual viny stem of birdvetch, showing arrangement of leaves and seed pods. Photo taken 3 October near the end of the growing season.

Over a dozen legume species, some with several named varieties, were included in these tests. Where winter survival of varieties varied within a species (alfalfa, sweetclover, red clover), there is evidence of an inverse correlation between seeding-year forage yields and subsequent winter survival (Table 1). Those producing the smallest seeding-year yields tended to be more winterhardy than higher-yielding entries and vice versa. This trend agrees with similar results found in other experimental field tests conducted at the Agricultural Experiment Station at Palmer.

Winter survival of birdvetch was adequate in both tests. However, no actual counts of winter survival of plants could be made in the rhizomatous birdvetch because, unlike most of the other legumes, it does not possess identifiable crowns of individual plants. The high winter mortalities of the several varieties of red, alsike, white, and strawberry clovers, birdsfoot trefoil, crownvetch, sainfoin, and some alfalfas and sweetclovers included in these tests emphasizes how few adapted, winterhardy legumes are available for use in Alaskan agriculture.

The actual cold tolerance of each legume is governed by genetically controlled, environmentally mediated, physiological characteristics within the plant's overwintering tissues. Additionally, however, the subterranean location of the overwintering organs (buds and rhizomes) of birdvetch confers an added physical protection on this species not possessed by the other legumes compared here. The

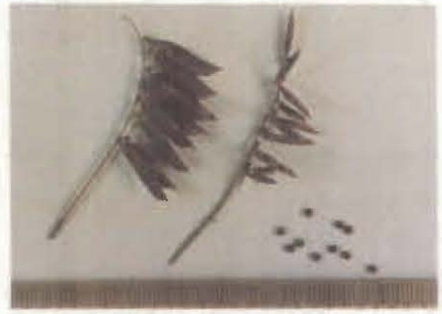

Figure 5: Intact and opened seed pods of birdvetch, and mature seeds. Smallest divisions on the scale are millimeters.

overwintering tissues (crowns, buds, stolons) of the other legumes tested are at or very near the soil surface, and are thus much more exposed to harmful winter stresses, such as dehydrating winds and low air temperatures.

Birdvetch oven-dry forage yields in the year after planting (about 1.6 tons per acre) equalled those of Siberian alfalfa (*M. falcata*) and exceeded the yields of all other legumes compared. Only Alaskan breeder selections of sweetclover, Alaskland red clover, native Alaskan milkvetch, and Eskimo potato produced appreciable second-year forage yields.

The greatly entangled growth of clasping tendrils and interwoven vines makes harvesting and handling of birdvetch forage rather difficult. Irwin (8) noted that birdvetch is "hard to cure as hay; vines mat together." This problem would be circumvented if birdvetch were pastured or harvested with a forage chopper.

Concerning the palatability of birdvetch to livestock, little information is available in the literature. No feeding trials were conducted with these tests, but we have observed Holstein heifers actively grazing birdvetch foliage at the Matanuska Farm.

At the present time, there are no known commercial seed sources of northern-adapted birdvetch. A range plant handbook (10) reported that this species "is not infrequently cultivated in various parts of New Mexico as a fodder or soiling crop;" however, that 40-year-old reference implied only that there were seed supplies available then. Anyone desiring to plant birdvetch in Alaska must harvest seed from existing stands of the plant. To obtain the seed used in the field tests reported here, we pulled vines from fence-rows, dried them on canvas in a heated room, and then separated the seed with a small thresher. The canvas caught that portion of the seed that dropped as pods opened during drying of the vines.

Figure 6: A small, abandoned field overgrown by dense growth of birdvetch. Photo taken 23 August.

Figure 7: A barbed-wire fence overgrown by birdvetch. Photo taken 17 August when plants were in full bloom.

Ground Cover

Birdvetch can serve as a very effective ground cover, either alone or mixed with other vegetation such as grasses (Figures 6 and 7). As a ground cover, it may find increasing application in Alaska if seed sources can be developed. Used as a ground cover to stabilize and protect soils, the abundant vine growth shields the soil from wind or direct raindrop impact, and the mass of roots and underground stems provide an effective soil-binding effect.

Ornamental

Grown as a ground cover, as along roadsides, birdvetch becomes unusually attractive when the flowers appear (Figures 3 and 7). The rich green, hedge-like appearance of fences covered with birdvetch are also aesthetically pleasing, becoming more beautiful when the blue flowers appear.

Other Uses

In addition to the above, birdvetch vine growth creates an effective habitat for small forms of wildlife, some of which undoubtedly consume the seeds that are dropped as the pods open at maturity. When it blooms, birdvetch also serves as effective "bee pasture" (1, 4), providing nectar for both domestic honeybees and wild bees.

UNDESIRABLE CHARACTERISTICS

One of the characteristics that contributes to the usefulness of birdvetch as a forage crop or ground cover, namely its vigorous vegetative spread by underground stems, also can cause it to be a tenacious weed.

Birdvetch growing in vegetable gardens or small-grain fields can be a problem weed that is extremely difficult to eradicate. Although the topgrowth may be hoed off completely and removed, new vines will grow repeatedly from any of the underground stems (Figure 2) that remain in the soil.

Birdvetch should not be planted in or near gardens or in places that may later be developed for vegetable or small fruit production. Nor should birdvetch be introduced into yard plantings with other ornamentals because its vigorous growth and rapid spreading would be objectionable there. Moreover, fences overgrown with birdvetch can alter winter wind flow, and the "snowfence" thus created can sometimes cause unwanted snow drifts to accumulate on roads or fields.

SUMMARY

Birdvetch is well suited to the climate and growing conditions of central and southern Alaska, as evidenced by its vigorous seasonal growth as well as the persistence with which it has spread here for well over half a century. It proved more winterhardy in two field tests than most introduced legumes compared. Although seedling growth was relatively nonvigorous and provided no harvestable yield during the planting year, birdvetch did provide modest forage yields in the year after planting, during a time of lower-than-normal precipitation. More research is warranted to establish more precisely the potential of birdvetch as a forage crop in Alaska, alone and in mixture with grasses. Effective control techniques also should be identified for eradication of birdvetch from areas where it is not wanted.

Although birdvetch can be a serious weed problem in gardens, it nonetheless is an attractive and effective ground cover, and provides food for wildlife and nectar for bees.

The question raised in the title of this report is perhaps best answered by saying that birdvetch can fulfill all of the categories mentioned. The main limitation to more widespread beneficial use of birdvetch is lack of commercial seed sources.☐

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Staff Notes

Alaska's Agricultural Experiment Station has gained two new staff members: one at Fairbanks and one at Palmer.

Dr. Alan Jubenville

At Fairbanks, we welcome Dr. Alan Jubenville, Associate Professor of Resources Management. Dr. Jubenville received his B.S. degree in Forest Management from North Carolina State University in 1962, his M.S. degree in Forest Ecology in 1964, and his Ph.D. in Wildland Recreation from the University of Montana in 1970. He has a strong background in teaching and curriculum development as well as a long list of publications including two major textbooks in the areas of outdoor recreation and management.

Our Palmer station welcomes Dr. George Mitchell, Jr., who comes to us as an assistant professor from the Department of Agronomy at the University of Georgia Coastal Plain Experiment Station. Dr. Mitchell received his B.S. and M.S. degrees in Soil Science from the University of California at Riverside, where in 1977 he received his Ph.D. in Soil Fertility and Plant Nutrition. Dr. Mitchell is actually returning to the Palmer station, having previously been with the staff in 1973 and 1974.

While at Georgia, Dr. Mitchell developed a comprehensive research program in the area of soil fertility and soil chemistry for the Coastal Plain region at South Georgia.

Dr. George Mitchell

His duties at Palmer will include supervision of the Soil and Plant Testing Laboratory, development of a research program in the area of soil fertility and soil chemistry with emphasis on some of the new agricultural lands in the state, and cooperative research in the area of coal spoil reclamation and revegetation.

Dr. Wayne Thomas, Associate Professor of Economics, who has been on the staff of the Agricultural Experiment Station since 1971 in the area of agricultural economics has been named a Senior Fulbright Research Scholar for 1980. Dr. Thomas was granted a sabbatical leave by the University of Alaska to go to the University of New England at New South Wales, Australia, where he will be a visiting professor in the Department of Agricultural Economics. He will pursue his Fulbright research in Australia.

The thrust of Dr. Thomas' research will be an investigation of the development and implementation of agricultural policy in the United States and Australia at both the state and national levels using a case-study approach.

Of particular interest is the perceived greater role of Australian state governments in the formulation of Australian national agricultural policy. Information gained from a comparative analysis of Australian and American agricultural policy systems should provide a better understanding of the role American states could play in national policy formation. Greater knowledge of this situation should aid the political decision-making process in one American state, Alaska, which is going through a lengthy process of refining its agricultural policy to direct the expansion of its agriculture.

As of FY79, Sigmund H. Restad of Palmer became Assistant Director of the Agricultural Experiment Station, University of Alaska. He assumed the duties of Dr. Charles F. Logsdon who has retired as Associate Director of the Experiment Station (see above). From his office in Palmer, Mr. Restad will assist the Director of the Agricultural Experiment Station in the administration of Research Centers at Fairbanks, Palmer and Homer. Mr. Restad has served as a County Agricultural Extension Agent in Minnesota, as manager and dairy husbandman of the Experiment Station at Fairbanks, as Director of the Alaska State Division of Agriculture, and as Executive Officer of the Alaska Agricultural Experiment Station. He holds bachelor's and master's degrees in dairy science from the University of Minnesota and has taken graduate work in public administration at the University of Alaska. He has served as an officer in a number of agricultural organizations within Alaska.

Two long-time members of our Palmer staff have retired:. Dr. Charles E. Logsdon has left the experiment station after 26 years to go into a private consulting business. While with the station, he conducted numerous research projects as a professor of plant pathology and in 1970 was named Associate Director.

Active in the community affairs of the Mat-Su Borough, Dr. Logsdon has also served as Mayor of the City of Palmer in addition to several other positions in the community.

Dr. Wayne Burton served the Alaska Agricultural Experiment Station as an agricultural economist for 16 years, having come to the station in 1963 from the University of Nevada.. His research and publications contributed to identifying and developing Alaska's agricultural potential. In addition, Dr. Burton taught courses at the Mat-Su and Anchorage community colleges.

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