Agroborealis

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School of Agriculture and Land Resources Management • University of Alaska Fairbanks

AFES and SALRM Build on Land-Grant Tradition

Seventy-five years ago on May 3, 1917, the Alaska Territorial Legislature created the Alaska Agricultural College and School of Mines. The new college's first president, Charles Bunnell, applied for land-grant status of the new school as one of his first official acts. The school became the 51st land-grant institution in the nation.

Today the School of Agriculture and Land Resources Management (SALRM) and its associated Agricultural and Forestry Experiment Station (AFES) continue the land-grant tradition of applied research, looking for practical answers to real Alaskan problems and providing this information to students.

The first faculty researchers sought better grain and vegetable varieties. We continue the search today, but we do so much more. Our scientists use their agricultural training to solve reclamation problems for Alaska's coal mines in the Matanuska Valley and at Healy. Others design revegetation plans for North Slope oil producers. Alaska's seafood industry is converting processing wastes into profitable animal feeds as a result of Agricultural and Forestry Experiment Station studies. Not only are the producers making more profits, they've reduced pollution. Previously the fish processing wastes were dumped back into the ocean, creating a multitude of problems.

Finding solutions is our tradition and our past. It's also our future. We'll continue many of the things we've done in the past, and we'll work to meet new problems. One of these is wetlands management, a developing issue that will require increasingly specific answers well into the next century. Alaskan forests are another area where we're increasing our effort. And to study both of these, and all areas of land resources management, we've dramatically increased our capabilities in geographic information systems, or GIS.

We at AFES and SALRM are proud to serve Alaska and Alaskans in managing our natural resources.

James V. Drew

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Dean, School of Agriculture and Land Resources Management

Director, Agricultural and Forestry Experiment Station

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Managing Editor .... J. Stephen Lay
Composition .... Scott L. Penwell
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ABOUT THE COVER ... *Indian paintbrush (Castilleja sp.) was photographed by Jay McKendrick on 16 July 1991 east of Umiat, Alaska, in tussock tundra previously disturbed by oil exploration and subsequently overgrown with various indigenous plants.*

Game Farm Management

Lyle A. Renecker

In recent years, commercial interest in intensive management and husbandry of wild ungulates has increased throughout North America. In Alaska, at least 12 new game farms have started in the last five years raising bison, reindeer, wapiti, and muskoxen. Several others are pending acquisition of stock. Regardless of the species, certain necessary steps, protocol, and research must be resolved before the new industry realizes maximum productivity and success. Certain basic ideas should be considered in planning a commercial game farming operation.

Development Plan

Perhaps the most important step in starting any agricultural enterprise is a perceptive view of how the operation will develop to maturity. This forces prospective game farmers to study the business, assess the infrastructure and stock required over a 15-year period, and to balance a projected budget. This basic process may eliminate potential failures. Done right, it requires both time and money. Many state and provincial governments as well as investors and lenders also require it.

Infrastructure

Developing a commercial game farm requires a farm layout (Figure 1), good fences, and functional handling facilities. A good fence defines ownership, keeps animals from escaping or trying to escape, and separates them from other stock. For example, perimeter and paddock fences for wapiti are often 8 ft. (2.4 m) high and constructed with high tensile wire netting supported by wooden or steel well casing posts spaced at least 16 ft (4.9 m) apart. Internal fences for all species can be lower but should use high tensile netting. A wire netting with smaller openings at the bottom with larger openings toward the top should be used (Figure 2). This prevents newborn calves from separating from their mothers and keeps dogs and coyotes out. Fence construction costs vary with price of materials and labor, however, an 8 ft (2.4 m) fence with 6 ft (1.8 m) of wire netting topped by three smooth wires, costs about $7,920 per linear mile ($4,950/km) in Alaska. Costs include hardware, posts, fence materials, and construction machinery rental. See Table 1 for some fence construction options for a game farm. Some high tensile wire netting suppliers include Hurricane, Cyclone, Langly Wire, Bekaert, and Stelco.

The race, a fenced area that joins the paddocks to the handling area, is a farm's high pressure area. Animal injury can easily result from a poor race design. Larger farm operations find 30 ft to 60 ft (9.1–18.3 m) widths that narrow to about 16 ft (4.9 m) at the handling facility may be desirable. An occasional curve in a long race allows animals to periodically hide from the handlers as they are being moved toward the handling facility. Animals learn and become familiar with the layout if allowed to explore and use the race and entrances to holding and sorting pens. Offering feed or water in the handling area creates a positive reinforcement and habituation to the facility and humans.

Right angle corners should be

Lyle A. Renecker, Assistant Professor of Animal Science, Reindeer Research Program, University of Alaska Fairbanks.

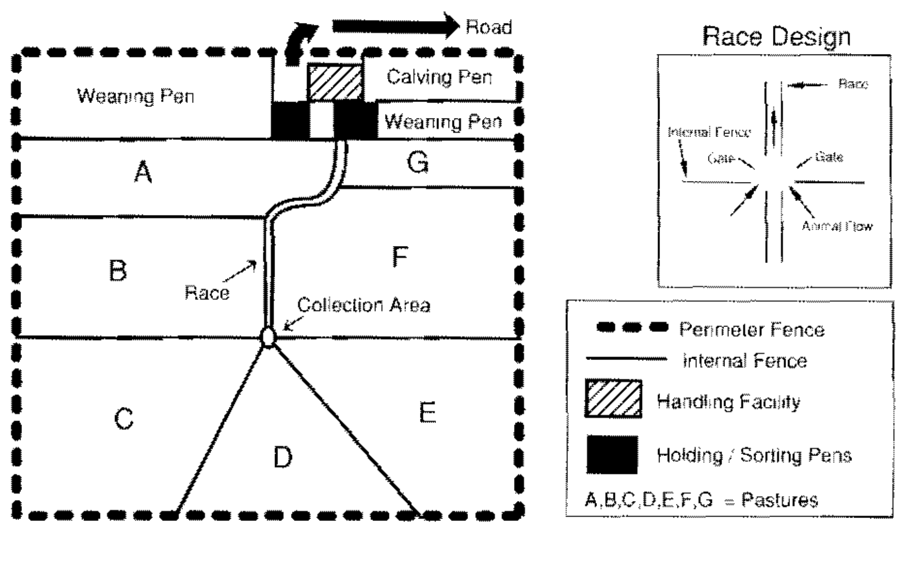

Figure 1. *An example of a farm layout.*

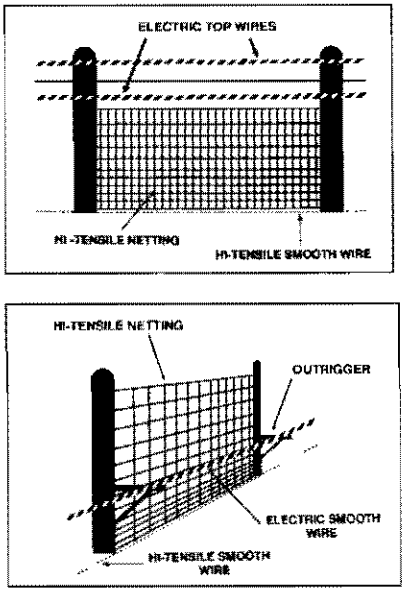

Figure 2. *Examples of game farm fences.*

Materials	Height ft (m)
Perimeter fence	
1) 12.5 ga netting plus one smooth wire at ground level.[1]	8 (2.4)
2) 12.5 ga netting 7 ft (2.1 m) high plus one smooth wire at ground level and two above 20.3 cm apart.[2]	8 (2.4)
3) 12.5 ga netting plus one smooth wire at ground level.	7 (2.1)
Race Fence	
1) 12.5 ga netting 7 ft (2.1 m) high plus one smooth on ground and two above netting. Extra cost involves visual barrier at pressure areas.	8 (2.4)
Cross Fences	
1) 12.5 ga netting 5 ft (1.5 m) high plus one smooth wire on the ground and 2-wire smooth above.	7 (2.1)
2) 12.5 ga netting plus one smooth wire on ground.	6 (1.8)
3) 12.5 ga netting 5 ft (1.5 m) plus one smooth wire on ground and two above.	6 (1.8)
Grazing Area Rotation	
1) 5-wire electric on fiberglass stays moved by hand twice per week onto new portion of pasture.	5 (1.5)

[1] Netting begins at 1 in (2.5 cm) above ground level.

[2] If the game farm is located in an area occupied by moose then three smooth wires should be above the netting with the first and third electrified.

Table 1. *Various game fence options.*

avoided in handling facilities for all game species. Animals will mill in these corners, and they often attempt to defend the area. Moving them stresses both the animal and personnel. The key to a good handling facility is a design that uses the animal's innate behavior to the farmer's advantage. Wapiti, reindeer, and bison are more relaxed and confident under subdued light conditions inside a building. Basic wall construction varies among species. Wapiti are more relaxed when aware of movements in adjacent pens rather than enclosed with solid plywood walls where sudden noises could startle them. In comparison, reindeer appear calmer when unaware of nearby pen activity. Table 2 summarizes some of these ideas.

The flow of animals varies among the three species. Wapiti and reindeer are moved from holding/presorting pens into the working area inside a building. Pens around the perimeter of the crowding pen (round drafting corral) are filled first. Reindeer need smaller pens than wapiti. Animals should be moved, one to several at a time, into the circular crowding pen through a 4 ft (1.2 m) gate. There animals should be pressured from the outside pens either by a person above the pens on a catwalk or someone entering and moving animals through an adjacent rear gate. These gates open inward to sweep the inside of the pens. This gives the handler a protective shield.

The recommended diameter of the circular crowding pen differs slightly from 12–14 ft (3.7–4.3 m) to 14–16 ft (4.3–4.9 m) for reindeer and wapiti, respectively. Animals are directed from the circular crowding pen into a chute through two drafting gates (gates that pivot on a steel pipe with a minimum diameter of 10 in (25.4 cm)). The slightly curved chute leads to a crush (device with contoured side panels made of high density foam used to physically restrain the animal). If velvet antler removal is planned in the crush, the chute wall should be designed and constructed with this in mind. Two basic types are available. One design is provided

	Wapiti	Reindeer	Bison
Wall Construction of holding pens	vertical 1 x 4 in (2.5 x 10 cm) lumber	solid plywood	horizontal 2 x 10 in (5 x 25.4 cm)
Space between boards	1 in (2.5 cm)	0 in (0 cm)	2 in (5 cm)
Wall height – outdoor pens	9–10 ft (2.7–3 m)	7–8 ft (2.1–2.4 m)	6–8 ft (1.8–2.4 m)
Wall height – inside building (for bison only chute system would be under cover)	8 ft (2.4 m)	8 ft (2.4 m)	——

Table 2. *Dimensions of wall construction for holding/handling pens for game farm species.*

in Figure 3; another type allows the animal to walk into a small 8 x 4 ft (2.4 x 1.2 m) pen with padded walls that close pneumatically. Crushes usually are pneumatically controlled. However, a manually operated crush can restrain reindeer and is recommended when installed and used under extreme cold, due to pneumatics' slower response. In contrast, a modified cattle squeeze with a stop gate in front of the head gate works best for bison. The bison squeeze needs solid steel construction and should be painted flat black on the inside. When the animal looks into the squeeze, it sees only the light coming through a ballistic Plexiglas® opening at the other end. The animal sees the light as a way out. Light entering from the working alley or side of the squeeze confuses the bison, making it reluctant to enter because it can't see an exit. With all handling facilities, animals are always released in the direction they entered (Figure 4).

Management

Regardless of the species, a management calendar is critical for maximum herd productivity and entrepreneur's eventual success. Figure 5 outlines the general annual events for a wapiti, reindeer, and bison farm.

Calving begins in mid spring (reindeer = mid to late April; wapiti = mid May; bison = late April early May). Calving places a heavy nutritional burden on females. Even with good pasture, body condition of lactating females can decline during the summer. This can have direct repercussions on ability to breed in autumn. Experienced farmers provide energy and protein supplements in addition to fresh pasture. These eliminate the problem, and at the same time, flush (ensure animal condition is good so conception will occur) animals for the autumn rut. Wapiti and reindeer velvet antler removal begins in early May and continues through mid June. Removing velvet antler for maximum profits requires careful timing. For example, the ideal time to remove wapiti velvet antlers is at the beginning of the division of the fourth tine as the antler tip flattens with a slight indent. Removal should carefully follow exact procedures to get a high grade, high value product. If velvet antlers are removed too early, they will weigh less and earn less money. After the optimal cutting time, antlers are more calcified. The antler will grade lower and get less money.

Yields vary with the animal's nutritional plane. Under good management, wapiti will yield about 3.3 lb (1.5 kg) of velvet antler per year of age until they reach eight years old. For example, a five-year old wapiti bull produces about 16.5 lb (7.5 kg) of velvet antler. At about age eight, production stabilizes or declines as teeth become severely worn and animals cannot properly chew and digest food consumed. Highly-prized wapiti antlers currently bring about \$87-\$110/lb (\$190-240/kg) worth about \$2,070-2,600 a year from a mature bull. Three-year old reindeer bulls yield about 5.5 lb (2.5 kg) velvet antler/yr worth \$41-\$55/lb (\$90-120/kg) in today's market. Mature female reindeer produce antlers about 1.5 lb (0.7 kg). Each mature reindeer pair can earn \$363 per year.

The autumn rut for wapiti begins in early September and continues until about November 1. Breeding activity peaks between September 14 and October 10. For plains bison, rut begins in late July, peaks in mid August, and is completed by early September. Reindeer rut extends from early September to October with a late September peak. Wapiti calves are weaned in late August when animals are sorted into breeding groups. Mature females are separated from 15 month old females and maintained at lower bull:cow ratios than younger cows (e.g., 1:20 vs 1:7, respectively). The selection criteria for breeding heifers must be rigorous and based on target body weight. Wapiti females, for example, should be at least 408 lb (185 kg) to ensure at least 85% fe-

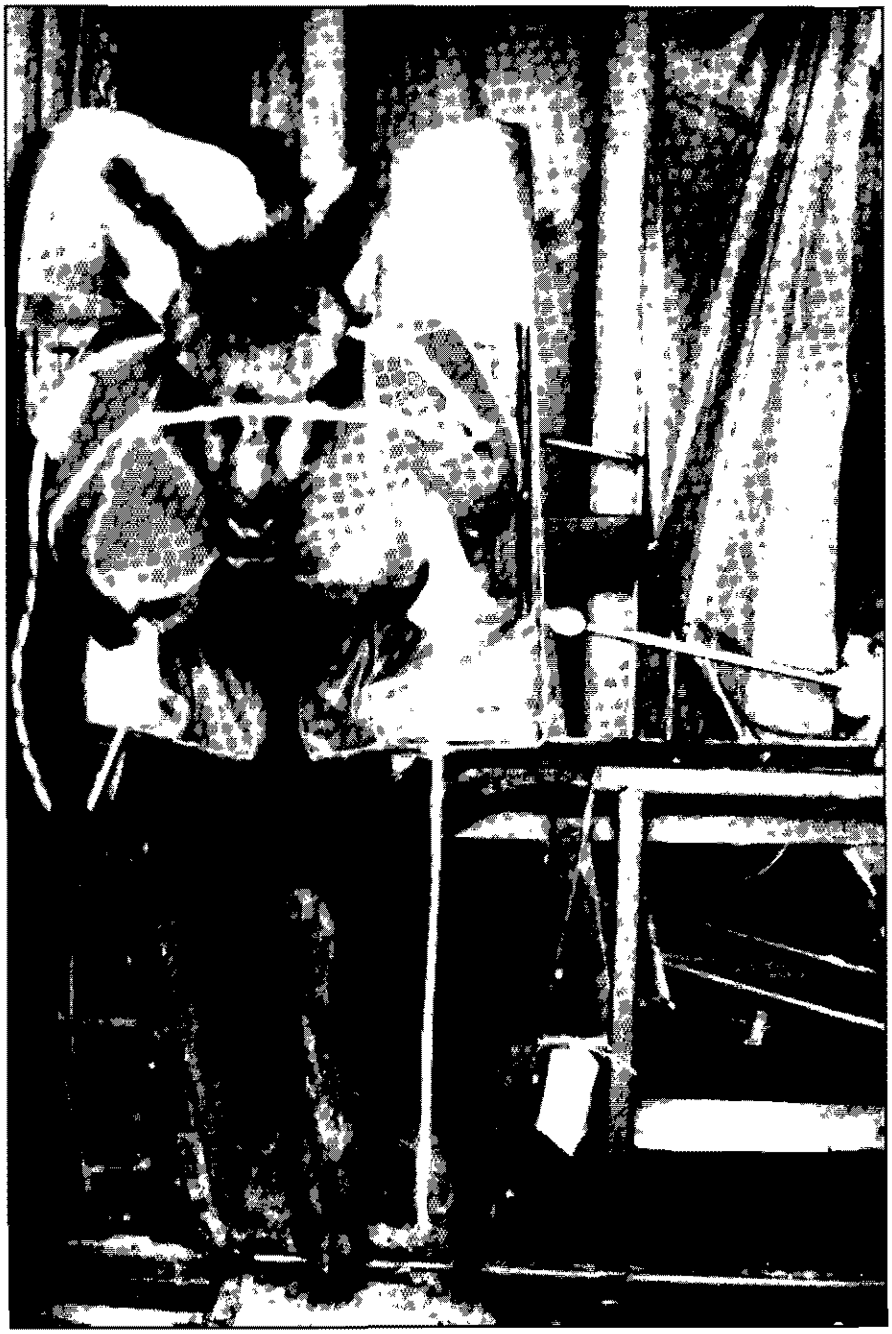

***Figure 3.** A pneumatic, foam-padded crush for handling reindeer or wapiti.*

cundity. Wapiti not meeting this weight threshold should not be bred that year. Work in Norway suggests that autumn weights of female reindeer calves must exceed 110 lb (50 kg) to ensure 90% conception at one-and-a-half years age. This threshold must be determined for farmed reindeer in Alaska. The UAF Reindeer Research Program has begun studies to determine optimal breeding weights and how they are influenced by nutrition in farmed reindeer. High quality feed is necessary for weaned calves of all game farm species to obtain their body target size by the following year.

A winter feeding program is based on animals age and production status. An overwinter weight loss of 10% is advisable for pregnant cows. This takes advantage of good compensatory gains in spring and minimizes calving difficulty common to overfed cows. A natural adaptation of northern wild ungulates is an inherent decline in food intake and metabolic rate during winter. This natural adaptation of a wild species gives the farmer an economic bonus. During winter, mature wapiti—peak autumn weight of 660 lb (300 kg)—reduce daily dry matter food consumption from about summer's 16.5 lb (7.5 kg) to 9-10 lb (4.0-4.5 kg) dry matter of alfalfa/day. There is also a concomitant metabolism reduction during the winter low period. The animal burns less energy, therefore, it needs less food. Lower feed consumption reduces costs. With high quality pastures during late spring and supplemental ration, the farmer can capitalize on native ungulates excellent inherent characteristic of compensatory gain. Studies show that wapiti given full high quality feed over winter do not have similar spring weight gains. Farmers control overwinter weight loss through their winter feeding program. Program planning must be based on actual measurement of peak autumn weight.

For example, a 10% loss of peak weight may be acceptable for females. If peak autumn weights are lower than expected, then winter feeding nutritional adjustments should be planned to maintain lower weight loss. Weight gains expected over the summer are reflected in the minimum spring weight. Good weight records let farmers estimate individual animal weight gains by autumn and the nutrition required to reach goals.

Every game farm must have a health management plan. All game animals should be treated at least once in late autumn for endo and ectoparasites. In summer, pasture rotation reduces feces accumulation in paddocks and animal contact with feces which can happen on overgrazed pastures. A larger number of smaller paddocks, instead of fewer but larger paddocks, is the most efficient rotation method.

Conclusions

Game farming of wapiti, reindeer, and bison offer a potentially profitable alternative to or diversification of conventional agriculture. However, basic considerations are similar to other livestock operations. Good planning and management are essential. There is no substitute for good handling facilities. A handling system and series of pasture fences that reduce injury and stress protect the considerable investment required for breeding stock.

Record keeping of animal production parameters is extremely important. Body weight is essential and provides a reliable guide to reproductive status, and body condition, and gives information needed for supplemental feeding programs. Feeding programs should change with the annual management calendar, animal growth, and production goals.

The entrepreneur must realize that the commercial game farm industry, like any other livestock industry, must eventually be based on the price of meat. For cervid species, velvet antler production should not be ignored. However, it's important to remember that the world velvet antler market is volatile. Returns should be considered supplemental income. For a successful industry in Alaska, research must continue to explore production and management strategies of commercial game species as they apply to both extensive and intensive northern settings. ❑

Acknowledgements

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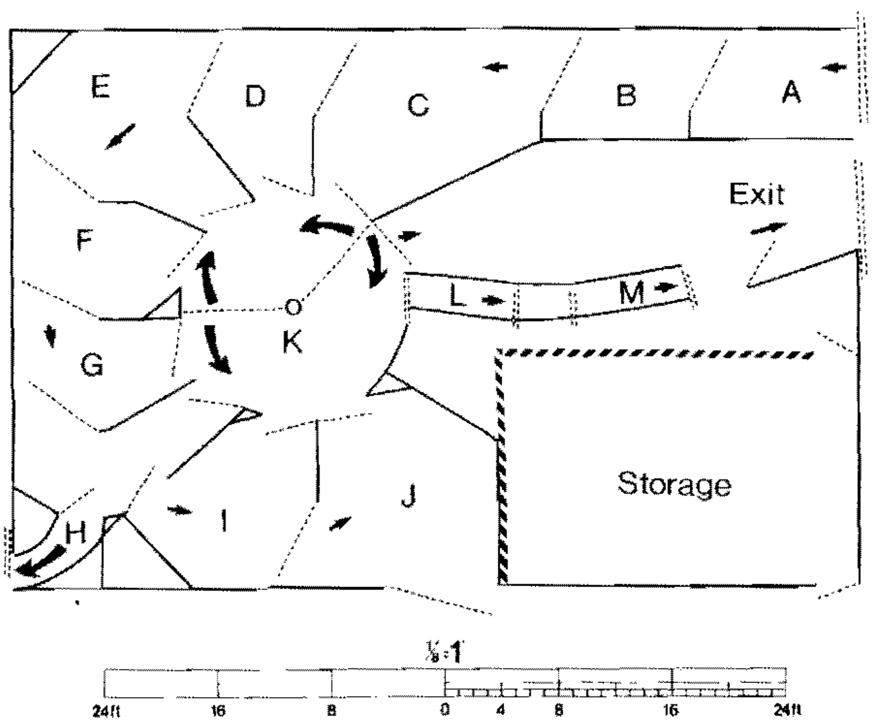

A,B	= ENTRY PENS
C,D,E,F,G,I,J	= HOLDING PENS
H	= LOADOUT
K	= DRAFTING CORRAL
L	= SCALE
M	= CRUSH
::::::::::	SLIDING GATE
----------	SWINGING GATE

Figure 4. *A handling facility design for reindeer or wapiti (facility constructed inside a standard straight-wall equipment shed).*

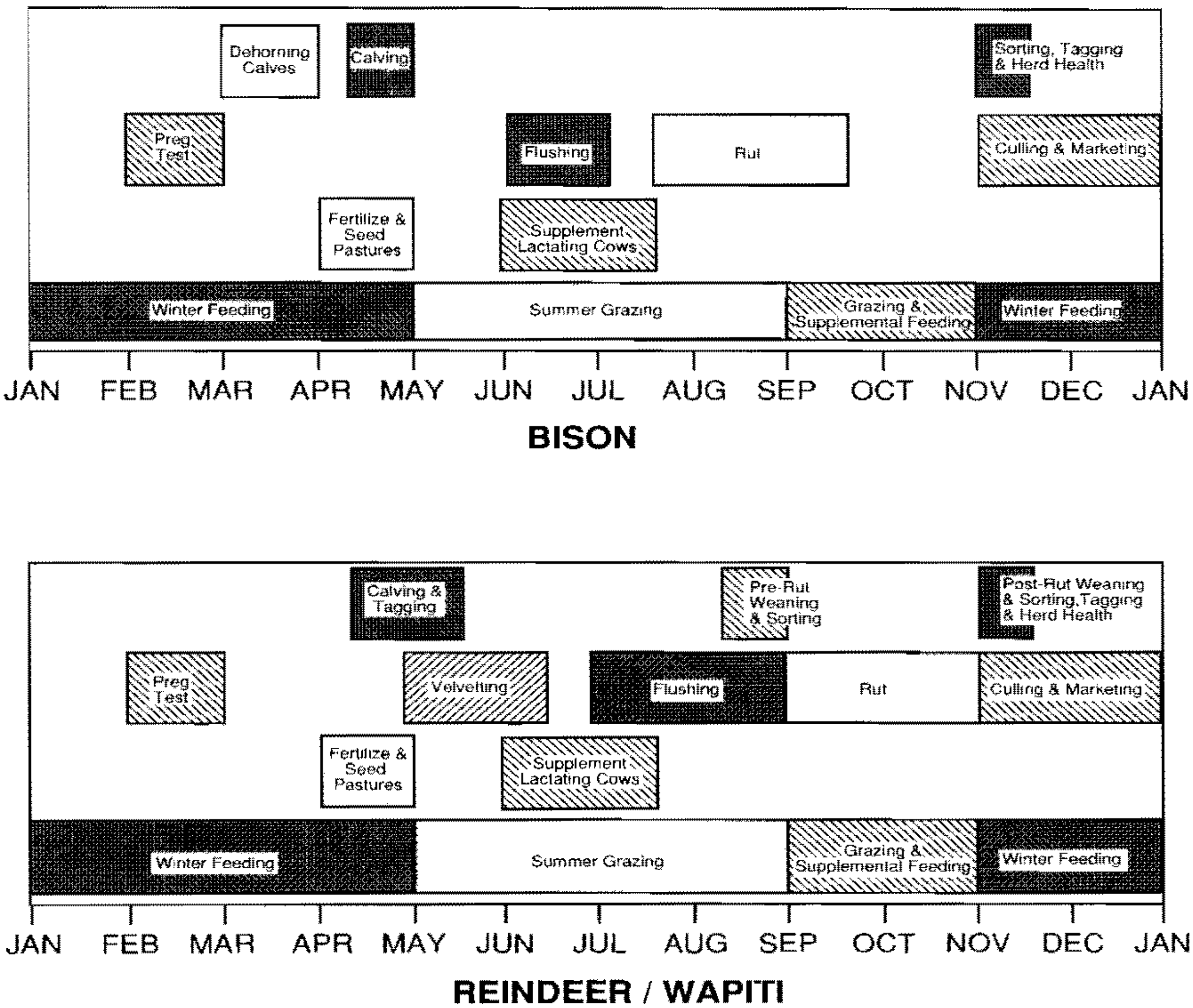

Figure 5. *Calendar of management events for reindeer, wapiti, and bison farms (all events may not pertain to each species).*

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Restructured Steaks —
A Potential Product from Alaskan Reindeer ?

Ruthann B. Swanson and Marjorie P. Penfield

REINDEER IS A LOW-FAT, HIGH-protein meat produced commercially in western Alaska (Renecker, 1991). The meat is sold or exchanged for labor in local villages. Sales also occur in regional centers in western Alaska. In these traditional markets, meat from the forequarter is preferred because stewing is the typical method of preparation. Some Alaskan reindeer meat is also sold in urban centers of the United States. Interested buyers from foreign markets have also inquired about its potential export. In developing game meat markets worldwide, meat cuts from the hindquarter are preferred (Pattison, 1988). Consumers in these markets have complained that cuts from the forequarter are less tender (Jones, 1988). If Alaskan reindeer production is increased to meet the potential demand for these hindquarter cuts in the developing game meat market, a surplus of reindeer forequarters may result. Forequarter sections comprise nearly half of the carcass weight (Zhigunov, 1961).

Restructuring is a processing technique that can add dollar value to less desirable but nutritionally valuable cuts of meat. Processors have more control over shape, texture (tenderness and juiciness), fat, moisture, and flavor of the restructured meat products than they have when the meat comes from intact muscles. Thus, it is possible to "design" a meat product to meet consumer wishes for a nutritious, low-fat, flavorful, juicy, and tender product. That product is also uniform in size, totally edible, and designed for fast cooking (Field, 1982). Restructured products are described by Mandigo (1982) as "high-value consumer cuts with intermediate price and eating quality."

The process

In restructuring technology, meat is first deboned. In some cases, connective tissue and external fat are removed. The boneless muscle is chunked followed by slicing into thin, individual meat flakes (Figure 1). These flakes are then mixed with fat or additives such as phosphate, salt or other flavoring agents, and tumbled to extract the protein. The extracted protein forms a sticky coating on the meat flakes that enables the flakes to bind together. The addition of salt or phosphates aids in the extraction of these proteins and helps in the binding of the meat flakes (Schmidt, 1986). Salt also serves as a flavor enhancer in many food products (Gillette, 1985). The desired product—chops, steaks, and even roasts — are then formed under pressure. The formed products are typically vacuum-packaged and held frozen. When cooked, the meat proteins coagulate and the restructured product holds together. Texture of the restructured product is influenced by flake size. Smaller flakes create a product more like ground beef whereas larger flakes result in a product more like intact muscle cuts (Cardello et al., 1983). When compared to steaks cut from the same intact muscles, restructured beef steaks have been found to be more tender (Cardello et al., 1983; Johnson et al., 1990). Therefore, through restructuring, processors can offer a greater variety of meat products.

The University of Alaska Fairbanks Applied Reindeer Research Program purchased six frozen forequarters from Alaskan reindeer from commercial sources in Nome that were shipped to The University of Tennessee, Knoxville for this study. The forequarters included shoulders with fore shanks attached, short rib pieces and necks. Restructured steaks were formed from the forequarter muscles in these cuts; two different flake sizes, 0.5 and 0.75 inches (1.295 cm and 1.905 cm, respectively) were evaluated. These reindeer steaks were also made with and without added salt (0.5%) and phosphate (0.5%). The following formulations were used for each flake size: no additives, salt alone, phosphate alone, and salt and phosphate in combination. Flaking, mixing and forming were done at 36°F (2°C). The flaked meat and additives were mixed for 10 minutes. Formed strip steaks were one inch (2.54 cm) thick and weighed 8 ounces (227 gm).

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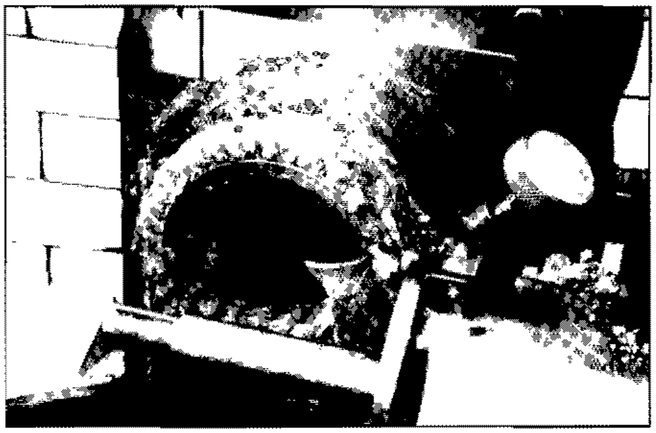
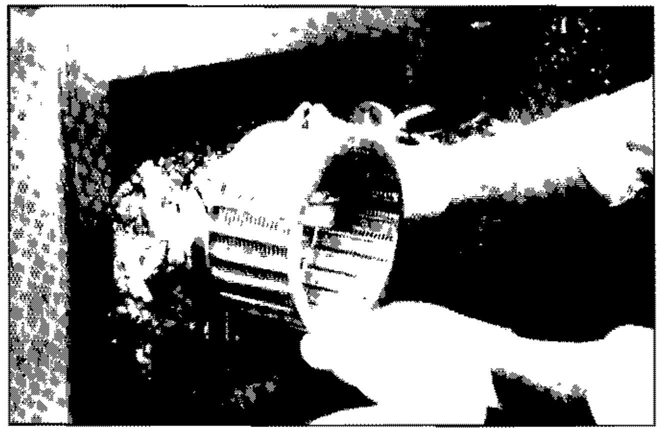
Marjorie P. Penfield, Professor, Department of Food Technology and Science, Agriculture Experiment Station, The University of Tennessee.

Figure 1. The restructuring process.



Thawed, boned muscles are cut into chunks and flaked in a Urschel Comitrol (Model 2100, Valparaiso, IN).



A cutting head contains a ring of blades that slice thin, individual flakes off the meat chunks as they are impelled against the blades. Spacing of the blades on the cutting head determines the flake size and product texture.

After mixing the flaked muscle tissue in a Leland Mixer (Model L-100DA, Detroit, MI) to incorporate additives and extract proteins, the desired product is formed with a Koppens food forming machine as shown here (Model VM 100, Bakel, Holland). The formed product is vacuum-packaged, and typically held frozen after flash freezing in a CO_2 freezer. (Dr. Curtis Melton shown on the left in photo and Dr. Jim Reimann on the right are meat scientists, from the Department of Food Technology and Science, The University of Tennessee.)

The product

Cooking losses

Cooking losses reflect the change in size of the steaks that occurs with cooking; weight changes are due to losses of moisture and fat. Small cooking losses are desirable because less raw product is required to produce a cooked product of the desired weight. The reindeer steaks were broiled in a conventional oven to an endpoint temperature of 158-165°F (70-74°C). The steaks were weighed before and after cooking to determine total cooking losses (Penfield and Campbell, 1990). In these restructured reindeer steaks, flake size influenced cooking losses. Those steaks formed from the larger flakes had smaller cooking losses (20.0% versus 26.9%). Berry et al. (1987) also report greater cooking losses for beef steaks fabricated from smaller flakes. Salt addition reduced cooking losses about the same magnitude, 26.6 versus 21.4%. The addition of phosphate resulted in intermediate cooking losses (22.5% without salt and 23.9% with salt).

Sensory properties

Sensory characteristics of the restructured reindeer steaks were evaluated three times by 10 sensory panelists on a 15-point scale, where 1 represented the lowest intensity of a particular attribute and 15, the highest intensity of that attribute. These panelists had previously consumed hunt-killed deer. They also participated in sessions to orient them to the score card. The sensory parameters, their anchors and the procedures used for their evaluation, are outlined in Table 1. Overall acceptability was also evaluated on a 15-point like-dislike scale, where 1 was not acceptable and 15 was extremely acceptable. Effects of flake size on sensory properties are shown by the data in Table 2. Steaks made from the larger flakes

Characteristics	Scale anchors (1 – 15)	Procedure
Appearance	Rare - very well done	Before tasting, visually judge apparent doneness.
Softness to tooth pressure	Very soft – very hard	Rate amount of force needed to bite through sample.
Moisture release	Slight – great	After 2 or 3 chews, judge the amount of moisture released.
Chewiness	Yields readily – highly resistant	Judge the amount of work required to prepare sample for swallowing.
Greasiness	Not at all difficult very difficult	Judge the difficulty of removal of fatty film that coats the mouth.
Gamy flavor	None – intense	Evaluate the presence of gamy flavor.

Adapted from: Costello, 1984.

***Table 1.** Sensory characteristics, scale anchors and procedures for evaluation.*

released more moisture upon chewing, were softer to tooth pressure, were perceived to be more greasy and appeared to be less well-done. Overall acceptability was also higher when the larger flake size was used. The effect of salt addition is also reported in Table 2. Although all of the steaks were cooked to the same endpoint temperature, those steaks with added salt appeared to be more well-done. Moisture release, an indicator of juiciness, was increased with the addition of salt. Similar salt effects have been found in both beef (Wheeler et al., 1990) and pork (Huffman et al., 1981) restructured steaks. Gaminess was consistently rated on the lower end of the sensory scale (Table 2). This indicates that all of these steaks had a relatively mild gamy flavor. However, salt further reduced perceived gaminess and increased overall acceptability. This may reflect the improved flavor balance that is frequently associated with salt addition. Gillette (1985) has previously reported this salt effect in a variety of food products. Salt, in this study, generally had a positive effect on desirable sensory attributes. Phosphate produced a similar effect on these attributes. However, when phosphate and salt were incorporated together, a trend toward the reduction of these positive effects occurred. This is shown in Figure 2. Reindeer steaks made from the larger flake size that contained at least 0.5% salt were most desirable. Addition of phosphate was not recommended. The lack of tenderness, the quality problem frequently associated with meat from the forequarter of both domestic and game animals, was not a problem with these restructured reindeer steaks. Despite a low fat content of approximately 10% (Swanson et al., 1990), these steaks were also found to be moderately juicy.

Conclusions

Production of restructured reindeer steaks using the technology previously applied to beef and pork appears to be feasible. The result is an additional reindeer product with desirable sensory characteristics. This product may broaden marketing opportunities for the reindeer forequarter. Although the reindeer forequarters used in this study were representative of those commercially available, different results may be found if different animal selection criteria and handling, slaughtering and processing conditions are used. Success of restructuring, like other post-slaughter processing procedures, is dependent on the availability of a good quality raw product. Additional work is needed to verify the results of this study and to select the optimum salt level and flake size. ❑

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Without funding from the University of Alaska Fairbanks Applied Reindeer Program and the efforts of Bill Thompson in obtaining the reindeer forequarters, this study would not have gotten underway. Dr. M.J. Reimann and Douglas S. Mitchell, Department of Food Technology and Science, The University of Tennessee, provided assistance in carcass break-

	Flake size[b] (in)		Salt[c] (%)		Phosphate[d] (%)	
Characteristic[e]	0.5	0.75	0.0	0.5	0.0	0.5
Appearance	9.7x	8.7y	7.9x	10.4y	8.9x	9.4x
Softness	7.3x	6.4y	6.8x	6.9x	7.0x	6.7x
Moisture release	5.8x	7.6y	6.1x	7.4y	6.5x	7.0y
Chewiness	6.9x	6.9x	7.0x	6.8x	7.2x	6.6x
Greasiness	5.2x	6.0y	5.8x	5.4x	5.4x	S.9x
Gaminess	5.6x	5.8x	6.0x	5.4y	6.0x	5.4x
Overall acceptability	8.0x	8.9y	8.0x	8.9y	8.5x	8.4x

[a] Means within a row and source of variation (flake size, salt, or phosphate) followed by like letters do not differ ($p > 0.05$) according to Tukey's Honestly Significant Difference Test. SAS (SAS Institute, Inc.) was used for data analyses.

[b] Main effects means for 10 judges and 3 replications across salt (2) and phosphate (2) levels.

[c] Main effects means for 10 judges and 3 replications across flake size (2) and phosphate (2) levels.

[d] Main effects means for 10 judges and 3 replications across flake size (2) and salt (2) levels.

[e] Samples were evaluated on 15-cm intensity scales; characteristics are defined in Table 1. Overall acceptability was also evaluated on a 15-point hedonic scale where 1 = not acceptable and 15 = extremely acceptable.

Table 2. *Effect of flake size, salt, and phosphate on the sensory properties of restructured reindeer steaks.*[a]

down and the steak fabrication process. Cathy Dorko, also from the Department of Food Technology and Science, assisted by Douglas Mitchell administered the sensory panels. Finally the sensory panelists made the study possible.

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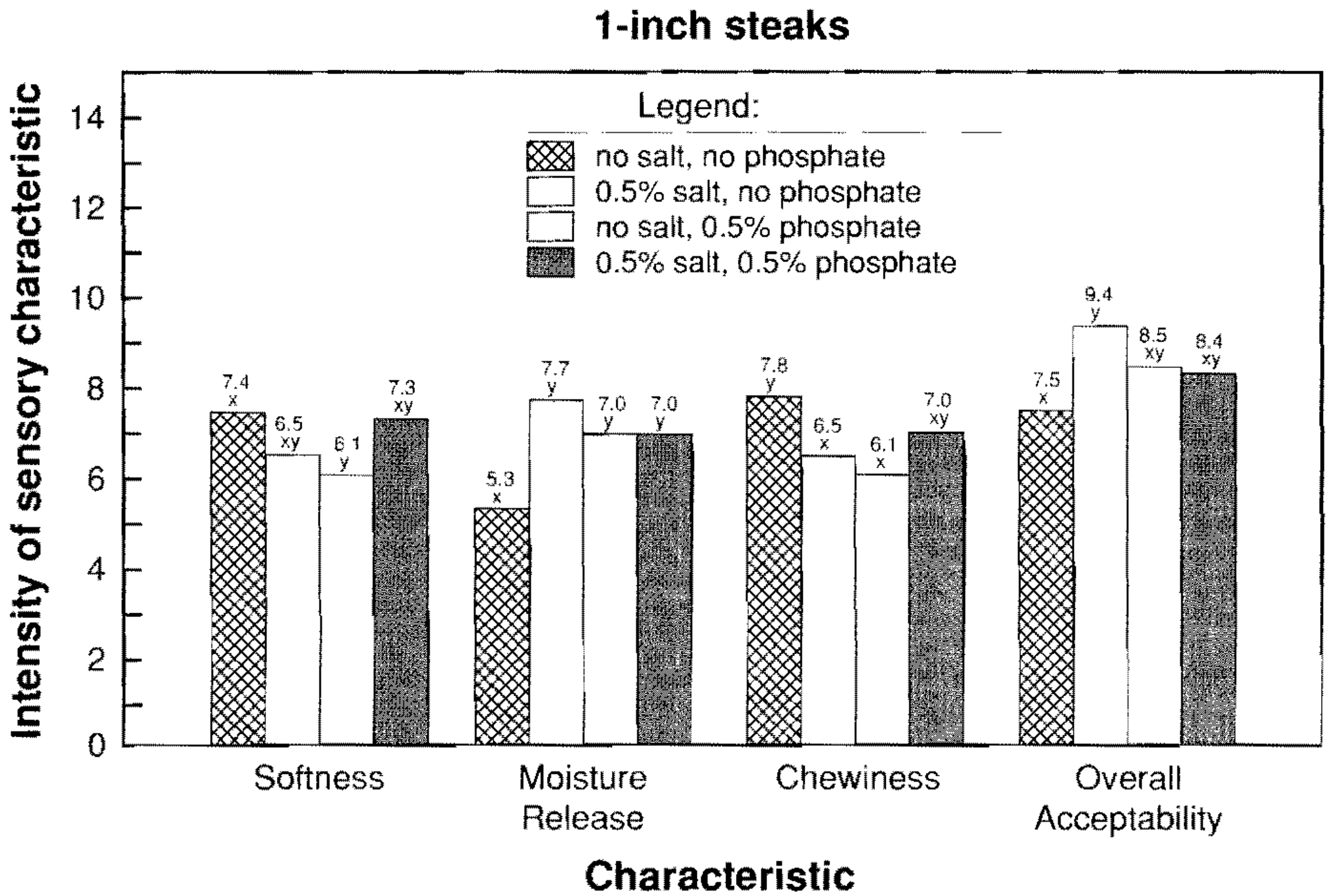

Figure 2. *Sensory characteristics as affected by the interaction of salt and phosphate. Bars within characteristics with like letters do not differ (p>0.05) according to Tukey's Honestly Significant Difference Test (SAS Institute, Inc.). Characteristics are defined in Table 1.*

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The History of National Forest Planning

Robert A. Ott

THE NATIONAL FOREST SYSTEM presently includes 191 million acres of publicly owned forests and grasslands (Shands 1986). Although this land base is essentially static, demands for services and products are increasing. While some uses can be simultaneously derived from the same forest acres, other uses are often conflicting. Land management planning has evolved as the process to decide the mix of uses that will occur on specific areas of each national forest (Wilson 1978).

The United States Department of Agriculture Forest Service (USFS) is mandated by law to plan and manage the national forests for a variety of forest resources: timber, fish and wildlife, outdoor recreation, water, livestock grazing, and wilderness (Applegate 1978). The USFS develops national forest plans under the direction of numerous legal mandates. The three most important laws affecting the planning process are the National Environmental Policy Act of 1969 (NEPA), the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA), and the National Forest Management Act of 1976 (NFMA). Despite these laws, or perhaps because of them, national forest planning is still evolving. Part of this evolution has involved critiques of the planning process from all sectors of society: individuals, environmental groups, academia, professional societies, and the USFS itself.

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History of National Forest Planning

Multiple-use planning has existed in various forms in the USFS since the early 20th century, and the word "planning" has been in the vocabulary of the USFS since that time (Applegate 1978). Early forest plans were not required by law and their content varied from place to place. Since a requirement to develop plans was not broadly and uniformly imposed, and plans had no consistent and well-defined format, they did not provide adequate direction for the entire national forest system (Wilson 1978).

The legal basis for these early forest plans was the Organic Act of 1897 (Wilson 1978), which stated that the major purposes of the national forests (then called forest reserves) was to provide a continuous supply of timber for United States citizens, and to protect watersheds (Parry et al. 1983, Shands 1989). However, The Organic Act did not set specific standards or requirements for land management planning. It also did not anticipate that the USFS would need to define an acceptable mix of forest land uses or resolve conflicts among competing uses (Wilson 1978).

By the 1950s, increased demands for conflicting uses of natural resources from national forests spurred Congress, with the recommendation of the USFS, to pass the Multiple-Use Sustained-Yield Act of 1960 (Lyden et al. 1990). This act supplemented the Organic Act and mandated multiple-use management of the national forests. The act explicitly stated that national forests must be managed for range, timber, fish and wildlife, outdoor recreation, and water. In time, however, it became apparent that the Multiple-Use Act was too discretionary. The act's effect on USFS actions was not uniform because it only established general policy. The result was inconsistent activity and little accountability by the USFS (Applegate 1978).

The Wilderness Act of 1964 was the next congressional act that influenced national forest planning. Pressure from environmental organizations whose members wanted to preserve the naturalness of portions of the national forests led to passage of the act (Lyden 1990).

NEPA became law in 1969. Three major provisions of NEPA that affected USFS land management planning practices are its requirement to prepare Environmental Impact Statements, develop more complete resource inventories (Wilkinson and Anderson 1987), and incorporate public involvement (Sample 1989). Passage of NEPA marked the culmination of the environmental movement that began in the early 1960s (Lyden et al. 1990).

However, Congress decided to increase its control over USFS budgeting decisions. This was one reason for enactment of RPA in 1974 (Le Master 1982). RPA established a permanent, systematic process for appraising the nation's renewable resources. It allowed for choice and management of the programs associated with these resources (Bergoffen 1976). RPA required three planning documents:

1. An assessment every 10 years describing the renewable resources of forests and rangelands;

2. A program every three years proposing long-range objectives with a 45 year minimum planning horizon; and

3. An annual report evaluating USFS activities in comparison with objectives proposed in the program (Wilkinson and Anderson 1987).

Clearcutting was an issue of special public concern. Several environmental organizations, including the Natural Resources Defense Council and the Sierra Club (Barlow and Hall 1976), sued the USFS charging that clearcutting was illegal according to the Organic Act of 1897. Although the Organic Act did not give specific standards or requirements for land management planning, it specifically stated that national forest managers could cut only individually marked "dead, matured or large growth" trees (McQuillan 1990).

In 1973, in the *Izaak Walton League v. Butz*—the Monongahela decision—the U.S. district court found that certain USFS timber sale practices were illegal according to the Organic Act. These practices included writing timber sale contracts that allowed cutting trees that were not dead, mature, large-growth, or individually marked (Le Master and Popovich 1976).

The USFS appealed the decision, but in 1975 the 4th Circuit Court of Appeals determined that clearcutting in the national forests was illegal (Applegate 1978, McQuillan 1990). The Ninth Circuit Court of Appeals ruled likewise (Applegate 1978). These rulings forced Congress to address national forest management laws (Applegate 1978, McQuillan 1990).

The result was that the USFS "ventured deep into the wilderness of comprehensive strategic planning to improve its management of the national forests and its responsiveness to emerging public values for these vast resources" (Sample 1989). This occurred with the amendment of RPA by passage of NFMA in 1976.

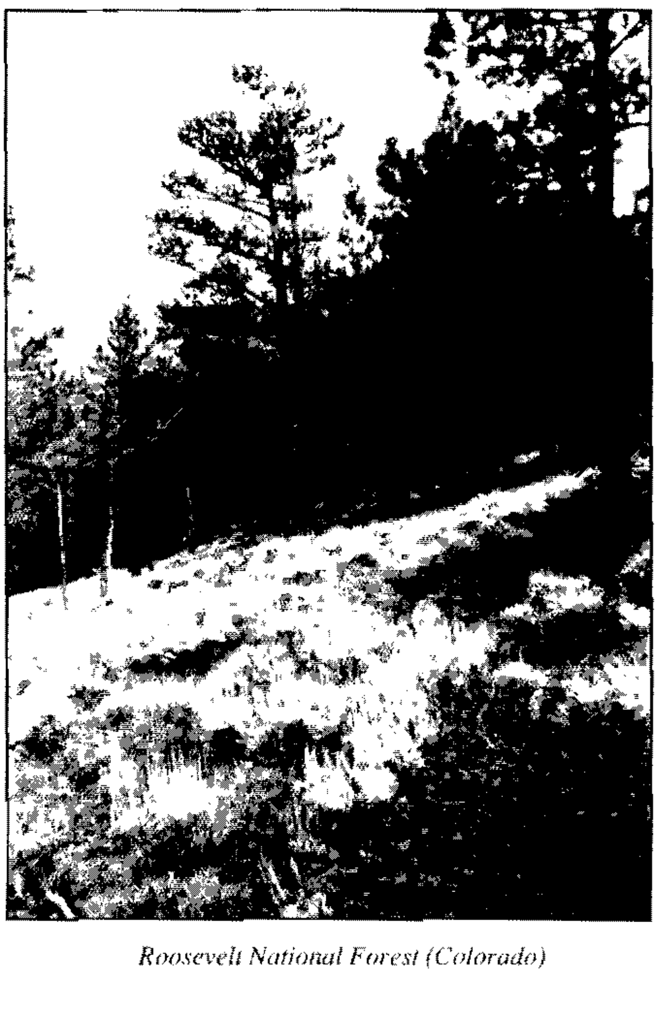
NFMA addressed two primary questions in the forest planning process: "What acres should be managed for timber production?" and "How much timber can be cut from those acres on a sustainable basis?" (McQuillan 1990). It required the USFS to develop forest wide management plans for each national forest (Wilkinson and Anderson 1987). It also outlined specific requirements for the planning process such as:

- Coordinated achievement of multiple-use and sustained-yield;
- Public participation; and
- A systematic, interdisciplinary approach that integrated physical, economic, biological, and other scientific information (Applegate 1978).

NFMA also required the widespread use of formal regulations for multiple use planning. For example, land use planning regulations were implemented with guidelines to:

- Identify the suitability of an area for certain types of management;
- Consider economic and environmental aspects of forest management; and
- Allow increased timber harvest by incorporation of thinning, reforestation, and stand improvement if the increased harvest was not in violation of the Multiple-Use Sustained-Yield Act (Applegate 1978).

As required by NFMA, the USFS has attempted to develop integrated resource management plans that achieve publicly identified long-term goals for each national forest (Sample 1989). The USFS is close to completing the first round of these plans. Now a debate has begun as to how effective the planning process has been.



Roosevelt National Forest (Colorado)

Some Debated Issues of National Forest Planning at the National Level

At the national level, debate about national forest planning involves many overlapping themes including: budgetary problems, data collection and analysis, supply-demand and cost-benefit analyses, cost, politics, and implementation.

Data Collection and Analysis

The USFS is required by NFMA to provide material forest output while maintaining the quality of the environment of the national forests. RPA requires the agency to conduct inventories, surveys, and assessments of all renewable forest-related resources in the country. However, the data base and knowledge necessary for management of material goods and environmental demands is not equal. Information about forest commodities and rangeland can be quantified and rigorously analyzed, and management actions can be predicted to some extent.

By contrast, knowledge about demands, quality, and management of non-market goods such as wildlife, aesthetics, and outdoor recreation are often qualitative and therefore difficult to subject to rigorous analyses (Vaux 1976, Nelson 1977, Krutilla 1987, Krutilla and Bowes 1989). Krutilla (1987) stated that because determining the value of nonmarket multiple-use benefits is too costly for planning, these values are subjectively determined.

The lack of consistent quality and quantity of information about different forest demands and uses is responsible for other problems in forest planning and management. Information used in the linear programming model FORPLAN is an example. FORPLAN is an acronym for **forest planning** model and it is used by USFS planners and managers. The model is used for two major purposes:

1. Analyzing production and economic trade-offs among the multiple uses of a forest; and
2. Determining how effective various plan alternatives are in resolving management issues (Barber and Rodman 1990).

FORPLAN allows for integrated planning, both in space and in time (Alston and Iverson 1987). It also determines the most efficient way to achieve stated objectives and provides insight into planning issues (Barber and Rodman 1990).

However, there are several problems with the use of FORPLAN. Values (coefficients) that represent multiple-use interactions (e.g. between timber harvest and aesthetics) in the model are only guesses. These coefficients, however, control the model's output level of timber-harvest and other programs (Teeguarden 1982). In effect they determine the model's decision. Because the impact of forest management on biological and physical factors (Krutilla and Bowes 1989) is uncertain, the most desirable plan alternative is often not clear.

Incorrect application of FORPLAN also caused criticism of its use as a planning tool. The USFS expected FORPLAN to confirm that its policies and traditional planning methods were the correct ones, and that NFMA planning was only a formalized version of its historical forest management practices (Barber and Rodman 1990). However, FORPLAN frequently found that many traditional USFS activities are neither socially or economically favorable according to the model's criteria. FORPLAN solutions resulted that are difficult and sometimes impossible to implement. For example, under the traditionally vague multiple-use management guidelines of the past, forests did not have acreages specifically designated for timber production. Because of this, new plans often could not meet historical levels of timber production (Barber and Rodman 1990). Forest plans today continue to encounter this problem.

Cost Effectiveness

Determining whether the detailed planning required by RPA and NFMA is a sound investment is another debated issue. Behan (1981) felt that very little had been achieved for the enormous amount of "money, manpower, political energy, and activity (and legal fees)" invested in the planning process. Nine years later, Behan (1990) still felt that national forest planning was "exorbitantly expensive," with the USFS spending at least $200 million annually on the process (President's Private Sector Survey on Cost Control 1983 cited by Behan 1990).

In contrast, Giltmier (1981) felt RPA and NFMA planning regulations, though costly, were beneficial. He felt that improved forest management and data bases justified the cost. Shands (1986) also felt the costliness of RPA planning, both in money and time, was justified because it brought out issues well in advance of plan implementation.

Due to the mix of market and non-market outputs derived from the national forests, determining what constitutes economically efficient forest management is a complex issue (Krutilla and Bowes 1989). Conducting a cost-benefit analysis of the process is complex, if it is possible at all. Schweitzer et al. (1984) identified four problems in conducting such an analysis:

1. How to tell when a benefit is really a benefit;
2. How to measure benefits;
3. How and when to measure benefits that will not appear for a long time; and
4. How to tell what would have happened if planning legislation was not required.

They stated that if no measurement or prediction problems existed, it would be easy to decide the likely consequences or effects of management. However, "categorizing those effects as benefits or costs depends on making judgments, and those judgments cannot be made free of values" (Schweitzer et al. 1984). Because it is necessary to incorporate value judgments in cost-benefit analysis, Schweitzer and others determined that objective cost-benefit analysis of federal planning could not be a complete analysis. They concluded that since no completely objective method exists for comparing the costs against the benefits of RPA/NFMA planning, RPA/NFMA planning benefits required political rather than objective criteria.

However, Hof and Baltic (1990) showed theoretically why output targets and budget allocations across national forests would be inefficient in the absence of forest planning at the national level. A multilevel (such as the USFS: national, regional, forest) optimization model was used, and both commodity items (e.g. cubic feet of timber) and nonmarket items (e.g. number of deer) were included as outputs. Hof and Baltic showed that minimum cost savings of 1-11% would be experienced for output levels in the preferred alternatives of current national forest plans if budgets and outputs were more efficiently distributed across the national forests.

Implementation

The feasibility of implementing RPA/NFMA forest planning has also been debated. Behan (1981, 1990) argued that current forest planning law is impossible to administer, and that RPA/NFMA did not solve, and will not solve the resource management conflicts it was designed to address. In 1981 he wrote "RPA/NFMA mandates with the force of law that forest plans will be rational, comprehensive, and essentially perfect." With the mandate of a perfect plan, he argued, comes the corollary that "an imperfect plan is an illegal plan," resulting in forest management by judicial decisions rather than by professional land managers.

The public participation process greatly influences the implementation of national forest plans at all levels. Twight (1977) stated: "If judiciously carried out the public involvement process can be a way of increasing public support for programs of natural resource agencies. Effectiveness depends on the involved parties perceiving some degree of personal impact on the outcomes."

Nantahala National Forest (Tennessee)

Lyden et al. (1990) found in their study that the majority of the respondent public felt it was realistic to plan national forest use 50 years into the future, and respondents felt they could be useful participants in the planning process. However, Lyden also found that respondents did not believe that they actually had any effect on the forest planning process and they were dissatisfied with the process because of this.

Appeals and court actions regarding forest plans support the observations made by Behan (1981, 1990) and Lyden et al. (1990). Ten years after implementation of the NFMA planning process, parts of 96 plans have been appealed by industry, and/or state and local governments, and/or environmental groups. Although, many of the appeals have been administrative, increasing numbers of them are being taken to court. No plan has been approved without an appeal (O'Loughlin 1990). With public participation, it may be that any decision involving competing interests and demands will end up in court (Knopp and Caldbeck 1990).

Conclusion

National forest planning is probably here to stay. However, the planning process is dynamic, and, if history is any indication, forest planning will change as the demands on forest lands change. Existing regulations will be altered, new ones will be imposed, and old ones may be repealed.

It may be too soon to pass judgement on the success or failure of the current RPA/NFMA planning process. Debates regarding national forest planning will contribute to changes in the planning process itself. Also, as natural resource data bases grow, and as planning tools such as FORPLAN become more sophisticated and accurate, several technical problems in national forest planning may be

Great Smoky Mountains National Park (North Carolina – Tennessee)

resolved. More, but especially better use, of technical information may reduce the number of plans that are appealed. However, the USFS will probably continue to have problems in implementing forest plans because of complicated legal mandates and increasing demands by conflicting user groups. ❑

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Charles Christian Georgeson —

A Man with a Vision

Janice T. Hanscom, Glenn Allen, Meriam G. Karlsson

NINETY-TWO YEARS AGO Charles Christian Georgeson came to Alaska as the special agent in charge of the United States Agricultural Experiment Stations. The Secretary of Agriculture instructed him to "act as if the country is your own and go ahead. Washington, D.C. is a long way from Alaska and all I want are results."

Georgeson surveyed Alaska's agricultural potential by establishing and administering seven experiment stations throughout the territory. In addition he personally conducted plant breeding research. He became a vocal supporter of Alaska in its efforts to attain a stable agricultural economic base and increase its population. He truly is the father of Alaskan agriculture.

Charles Christian Georgeson was born on the island of Langeland off the coast of Denmark on June 26, 1851. In 1873 he came to the United States to go to school, eventually earning his masters degree in 1882. He received his doctorate in 1916 from Michigan State College. He established his reputation as an outstanding plant breeder and agronomist before finishing his degree. Georgeson taught at Kansas State Agricultural College for seven years. In Kansas he met many of the men who would eventually come to Alaska to lead the various experiment stations.

Arriving in Sitka in 1898, the 47 year old Georgeson plunged into his assignment. Since no one knew much about Alaska's agricultural potential, Georgeson's freedom was limited only by his drive, enthusiasm, and budget.

Life in Sitka was very different for the Georgeson family. Georgeson originally viewed his appointment to Alaska as exile. On his way to Alaska, he, his wife, and three children wished every day to be recalled.

Charles Christian Georgeson

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The first winter the family lived in an unfinished house. "Yes, we were cold sometimes," Georgeson said of his dwelling, "but our view was the finest in the world!" His house was built on Castle Hill, the location of the log stronghold used by Baranoff, the first Russian governor of the fur colonies. The family came to feel they were very lucky when compared with others.

The first manager of the Rampart station, Professor Isaac Jones, lived in a woodchopper's old cabin along the Yukon River. The roof leaked so badly that Jones erected his tent inside the cabin to keep dry. Jones spent the entire winter at temperatures as low as -70° F in his tent-cabin combination.

Georgeson opened the Sitka station and his headquarters in 1898. In rapid succession, the Kenai station was established in 1899, Rampart station in 1900, Copper Center station in 1903, Kodiak station in 1907, Fairbanks station in 1907, and finally the Matanuska station in 1917. Both the Tanana Valley and the Matanuska Valley proved to be fertile grounds for crops. These are the only two stations left functioning today. The Fairbanks station is now the university farm of the University of Alaska Fairbanks Agriculture and Forestry Experiment Station. The Matanuska station is today's Palmer Research Center.

Gradually the five other stations were closed down. By 1925 Kenai, Copper Center and Rampart had gone due to transportation problems or low population in the region. The Sitka station continued operating until 1929, one year after Georgeson retired. Crops were never very successful there. The station in Kodiak was plagued with problems. Cattle fell off cliffs, ate too much dead wet grass and got sick, and bears regularly helped themselves to the livestock. In 1912 Katmai volcano exploded, covering the grazing land with up to 18 inches of volcanic ash. The herd was moved to Washington state to prevent it from starving. Two years later, after the grasses recovered, researchers returned the cattle to the island. The herd developed tuberculosis and cattle research then ceased. The Kodiak station continued researching small livestock until it closed.

The 'Toklat' strawberry was developed at the Agricultural and Forestry Experiment Station in Fairbanks, Alaska.

Setbacks were part of the job, but none seemed to dampened Georgeson's enthusiasm for future Alaskan agricultural development. He was to provide results for the Secretary of Agriculture and he did. He studied everything from cows to grain to apples. Adequate land was not immediately available for his use. It had to be cleared of woods, brush, and sometimes drained before planting could begin. The experiment station land in Sitka was in the middle of a tundra swamp making cultivation impossible the first year. Georgeson borrowed land to start his experiments.

In an interview Georgeson later explained, "My plots were scattered all over the village and having insecure fences, or no fences at all, the local boys, cows, pigs and tame rabbits rollicked joyously through them. Hens, which in Sitka fly like seagulls [sic], flocked to the feast I had unwittingly prepared for them, and when, by chance, they overlooked anything, the seeds came up to become the playthings of diabolical ravens, who, with almost human malice, pulled up the little plants merely to inspect their other ends."

He continued conducting experiments for many years in back and front yards throughout Sitka. A few apple trees scattered around the town today can be traced back to Georgeson's days. Dr. Georgeson hybridized the native crab apple with several early maturing apples from the lower 48 states.

His research efforts received popular approval. "You can imagine my joy when many branches set fruit. Everyone in the village was advised of the experiment and warned against disturbing those bushes. Then just about the time the fruit was ripe, the Indian women came along and gathered every one of my apples and made them into jelly!" he explained.

He developed the Sitka hybrid strawberry in response to some very skeptical Alaskan miners. "They all looked on me and my mission with pity and derision," commented Georgeson. That challenged him. He decided to give all Alaskans the opportunity to breakfast on strawberries and cream from their own back yard. In seven years he developed a hybrid strawberry "eight of which have been known to fill a quart container."

To complete the menu he searched for a cattle breed that could survive the winter, live off the land and produce good milk for cream. Georgeson imported Galloway cattle to Kodiak and later Yaks to Fairbanks with this goal in mind. Galloway cattle were eventually replaced with Holsteins and the Yak experiments were halted due to lack of funds. But not all his efforts ended in failure. The development of grain varieties that matured at the Rampart station guaranteed an economical local feed source for dairy herds in the Interior. Georgeson's dream of strawberries and cream came true before he retired.

Georgeson battled constantly for funding to carry out his work and provide for his employees. The 1898 budget for the Alaska district totalled $5,000. By 1900, Georgeson had a budget of $12,000 but he was supporting three experiment stations. Members of rhe Committee on Agriculture felt $12,000 was enough or perhaps even too much. Many people both in Alaska and in the contiguous states doubted the possibility of agriculture in Alaska. Georgeson went to Washington to address the committee only to be told "It's no use, your coming before this committee for a hearing. Your appropriation is twelve thousand dollars a year, and we're not going to allow you another cent."

Lack of money continued to be a problem even after he received increased funding. Once an Indian cut off Rampart station Superintendent George Gasser's finger. He went to the nearest doctor, an army physician, in Tanana for treatment. The bill was $90. When Gasser presented Georgeson with the bill, Georgeson refused to pay. He claimed that experiment station personnel were federal employees. They received no other benefits so the army could pay this bill. Georgeson was a master at getting his money's worth. Gasser felt Georgeson hired all Kansas State men because they knew "how to work hard long hours from dawn to dusk."

Georgeson became an advocate for Alaska. He wrote 47 books, pamphlets, and circulars about the state and its agricultural potential. He published in popular magazines like the *National Geographic* in addition to Alaska Agricultural Experiment Station publications. "Alaska has been maligned, abused, and totally misunderstood," wrote Georgeson.

Georgeson was a vocal supporter of both homesteading and the immigration of Finlanders. He believed that since the Finns were used to the similar climates of Finland, they would adapt to Alaska and benefit the United States. Georgeson believed the biggest hindrance to settlement of the territory was the difficulty in obtaining land. It was very expensive to survey land and 80 acres was not enough to make a living in the Alaskan climate. In a 1902 testimony before the Committee on Public Lands at the House of Representatives, Georgeson argued eloquently for an increase from 80-acre to 320-acre homesteads. "Alaska can furnish homesteads of 320 acres each to 200,000 families," said Georgeson. Eventually he won his point and Alaskan homesteads were enlarged.

It is evident from his writings that Georgeson never doubted Alaska's potential for a great future in agriculture. Georgeson was convinced that Alaska could become a world leader in agriculture because of the land Alaska had to offer.

That potential still exists today. Great strides have been made in the development of new varieties that produce well in Alaska and the land is still there. It just waits for the correct economic climate. Then we will see Georgeson's vision for his adopted land come true. ❑

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Georgeson Botanical Garden

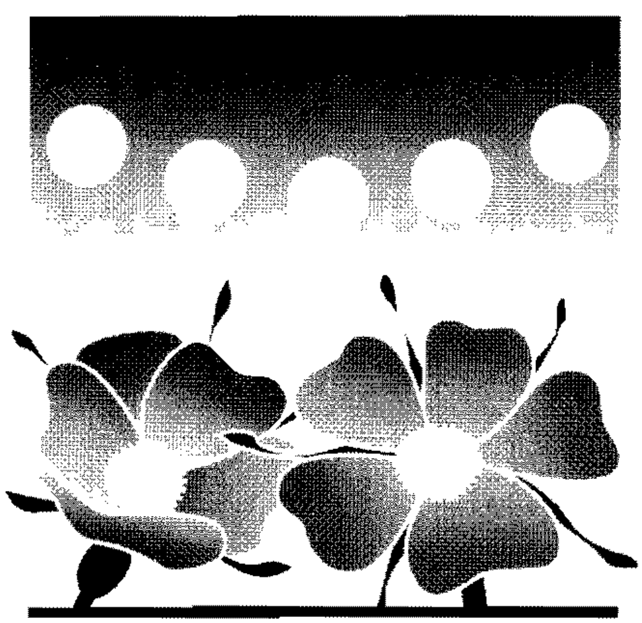
Patricia S. Holloway
Associate Professor of Horticulture

LAST SUMMER, THE AFES demonstration flower garden became the Charles Georgeson Botanical Garden. For many years, the Garden has contributed valuable information on suitable varieties of annual flowers and vegetables for commercial growers and home gardeners as well as being a major visitor attraction. We're now expanding the Garden to fully reflect our mission as a center for subarctic education and research in the plant sciences.

The Georgeson Botanical Garden is a germplasm repository for plants and seeds of circumpolar species. Far north inhabitants and researchers benefit from studies at the Garden. Plants from the Garden supports faculty and student research in clonal plant propagation, plant cultivation techniques, plant hardiness evaluation, Alaska native plant cultivation and plant breeding. Alaska's only endangered plant species, the Aleutian shield-fern, now grows in the Garden in addition to scattered Aleutian Islands sites. Studies on this fern—spore germination and tissue culture techniques, vegetative propagation methods, and plant growth under controlled conditions—will help determine why this plant is so rare.

The Garden also offers visitors opportunities to learn about the variety of annuals, herbaceous perennials, woody landscape plants, fruit crops, grasses and grains that grow in interior Alaska. Garden plots demonstrate cultivation techniques for maximum fruit and vegetable productivity. Many of the techniques resulted from AFES's horticulture research programs over the past 25 years. During 1991, more than 15,000 people from every state and many foreign countries visited the Garden. Children from 29 local schools studied subarctic plant science through field trips to the Garden.

Many changes have occurred in the Garden during the past year. Through the Special Projects Fund, University of Alaska President Jerome Komisar funded renovation of the Garden entrance. Gravel walkways replaced some of the dirt paths. A kiosk provides a focal point for visitor information and interpretive displays. Near the entrance, a landscaped, dry stream bed replaced a seasonal drainage ditch. Public donations placed park benches throughout the Garden. An observation deck for early-season bird watching and other activities will be completed this spring.

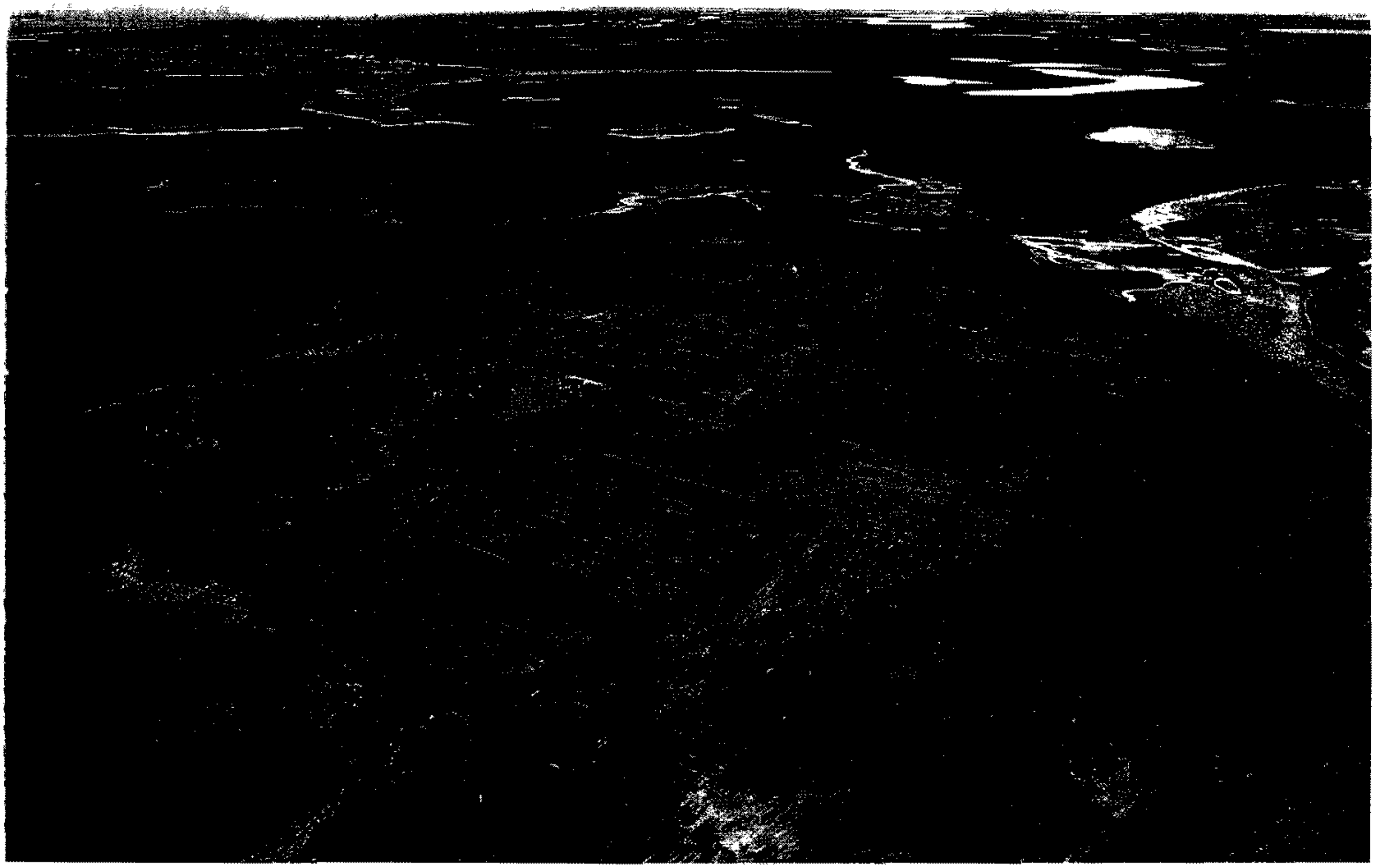


Last March, a volunteer program was begun to assist in expanding the Garden. Alaskans worked in every phase of development including bedding plant production and maintenance, landscape construction, design and maintenance, data collection, graphic arts, plant evaluation and education. In return for their valuable time and effort, they received hands-on education in subarctic horticulture. The program continued during the winter. Volunteers worked on seed germination research, tissue culture, a historical bibliography of Alaska horticulture and greenhouse plant culture.

In 1992, renovations will continue with the relocation of the annual flower and All America Selections display section to a new permanent site. Other construction projects include a Boreal forest nature trail; design and planting of perennial flower beds; and installation of more research test plots. Next summer's research projects will test woody and herbaceous perennial ornamentals, identify frost tolerance of annual flowers, and evaluate greenhouse-applied growth regulators on begonias growth and flowering.

Educational displays will highlight celebrations of the 75th Anniversary of the University of Alaska Fairbanks. Crops and techniques common in turn-of-the-century Alaska will be compared to modern crops and cultivation practices.

A sculpture designed by UAF art students will be placed on permanent display at the Garden this summer. Under the direction of Dr. Wendy Ernst, sculpture students will compete in a juried art competition to create a bronze commemorating this anniversary and the university's commitment to Alaska's future in higher education. ❑



Aerial oblique photo of BP Put River No. 1 gravel pad. Gravel thickness was altered during restructuring of this pad to create experimental plots. Snow fencing was installed on two of the blocks to increase snow accumulation to shelter plants while they become established. The entire area was fenced to exclude caribou grazing and vehicle traffic.

Gravel Vegetation Experiments —

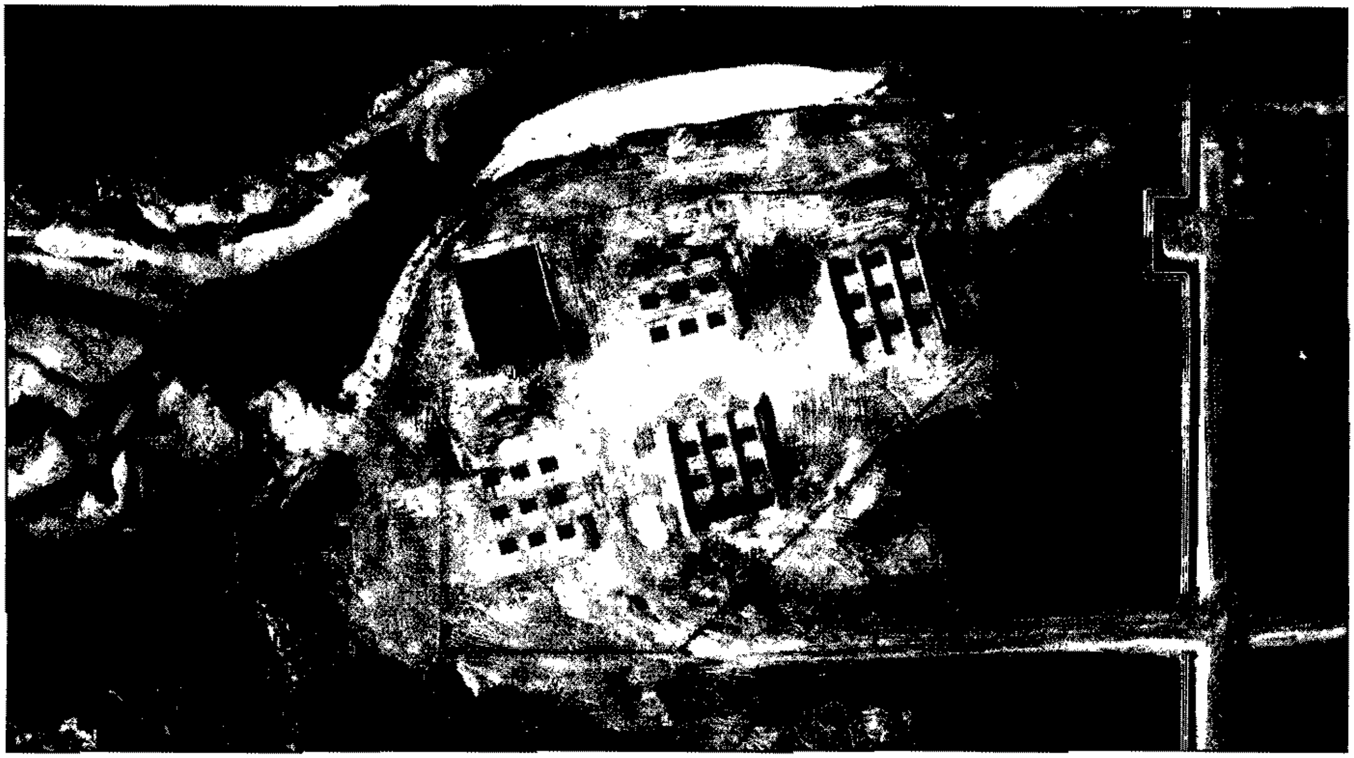
Alaska North Slope

Jay D. McKendrick, Peter C. Scorup, Warren E. Fiscus, and Gwendo-Lyn Turner

REHABILITATION OF GRAVEL pads and roads in Arctic Alaska after those structures are no longer needed for oil and gas exploration and production is an important issue for regulatory agencies as well as industry. Compliance standards have not yet been established; permits simply require each site to be rehabilitated to the satisfaction of the permitting agency. This latitude is desirable, because it will be decades before all structures are abandoned. It is impossible to predict technological changes and public wishes that far into the future. However, this also leaves agencies and industry in an uncomfortable position, open to criticisms and possibly even litigation from third parties who were not involved with the original project planning and development.

Jay D. McKendrick, Professor of Agronomy, School of Agriculture and Land Resources Management, University of Alaska Fairbanks.

Total gravel removal offers one obvious option, but that would leave dead tundra under the fill needing revegetation. An even greater problem with gravel removal is "where to put it?" Some suggest returning it to where it was originally mined, but that has serious implications. Most of the gravel for the first Prudhoe Bay structures came from river channels. Returning gravel to those sites could violate federal wetland regulations and statutes as well as damage stream



Aerial photograph of BP Put River No. 1 gravel pad (24 July 1991). In this color infrared image the green vegetation appears red. The plants established from the strips planted across the plots in 1990 appear as red streaks.

channels. Today, gravel mined from deep pits provides most new construction material. Many of these pits are flooded and converted to overwintering habitat for fish, a rare habitat in that region. Dumping used gravel into those sites violates state fish habitat protection regulations and law.

The most plausible approach to gravel removal is to reuse it in another project requiring roads and pads which means leaving it in place until needed. This is convenient, cost effective and has minimum environmental impact. Also, some of the negative perceptions about gravel fill and wildlife habitat may be overstated. Recent studies (LGL, Inc., 1990, 1991 and TERA, 1991) indicate some wildlife species use gravel structures and disturbed sites more than they use the adjacent undisturbed tundra. Developing vegetation on gravel structures that would provide habitat for wildlife is an appealing alternative.

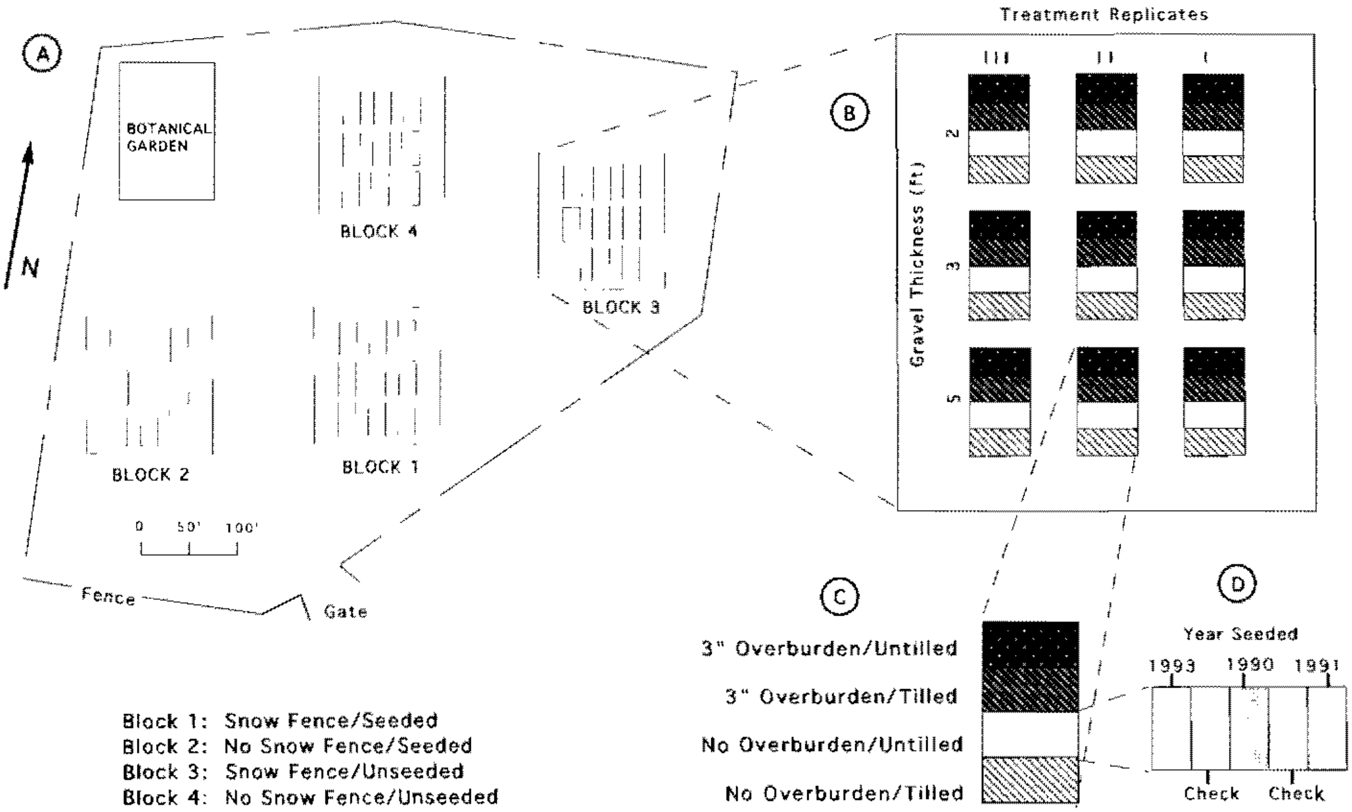
Dr. Maynard A. Fosberg, University of Idaho, and Warren E. Fiscus, University of Alaska Fairbanks, examine vigorous growth of grasses resulting from a mixture of native plants seeded a year earlier at the BP Put River No. 1 gravel pad (15 July 1991).

Restoring tundra aesthetics is seldom mentioned as a reason for rehabilitating disturbed sites on the North Slope, but we believe it is a strong, although often overlooked, motivation. Any rehabilitation effort that visibly blends the disturbance into the natural landscape seems to appeal to first-time observers. Unsightliness cannot be ignored.

Our gravel vegetation research project is looking for answers to help agencies and industry select acceptable and attainable vegetation objectives for gravel structures on the tundra.

This project consists of three main areas of study:

- identifying native plants that will survive on gravel sites;
- experimenting with seeding indigenous plants on gravel fill; and



• manipulating gravel fill to improve conditions for plant establishment and survival.

From our two decades of experience in the region, we have learned that some of the most significant plant responses occur seven, ten, or more years after initial plant establishment. To acquire as much information on long-term vegetation changes as possible from our tests, we designed this experiment as a 10-year study. The study officially began in 1989, but we started gathering information in 1984, while evaluating gravel fill used for the second exploration of the National Petroleum Reserve in Alaska (NPRA) (McKendrick, 1986).

Identifying Native Tundra Plants Colonizing Gravel

The environment of gravel fill is very different from wet or moist tundra adjacent to the fill. Consequently, most plants surrounding gravel fills are unadapted to living on the gravel. However, tundra plant species adapted to gravel sites occur naturally on gravel along rivers, on dry banks and ridges, and on stony slopes. Also, throughout the region there are many older fills, which have been invaded, to varying degrees, by plants adapted to such environments. We are examining and cataloging plant species on such sites, to identify those adapted to gravel. By noting the ones preferred by wildlife, it should be possible to develop plant communities useful to those animals on gravel fill. We have observed gravel fills in the Prudhoe and

Robert Rodriques, LGL Research Associates, Inc., collecting seed (24 August 1989) with a mechanical harvester designed and constructed by Warren E. Fiscus. A portable generator supplies power for running a shop vacuum which is attached to an electric hedge trimmer.

Kuparuk oil fields, gravel bars and dry and rocky ridges along the Sagavanirktok River from the seacoast into the foothills, exploratory sites in NPRA, and sandy soils in the Tyumen Region of Russia. We have found more than 150 vascular plants on such sites on Alaska's North Slope. From among those, we've selected about 100 as having potential for vegetating gravel fill, based on seed production, life form, wildlife use, and aesthetics.

Collecting and Planting Native Plants on Gravel Fill

Because gravel fills are not surrounded by plants suited to growing on them, adapted species must be brought to the sites. Given sufficient time, many plant species will eventually be introduced naturally by animals, wind, or other sources. To accelerate the process, we are gathering seed from the most promising native plants. We take our collections to the laboratory, hand thresh, clean, and test them for germination. Collections are stored until we need seed to prepare planting mixtures for field experiments.

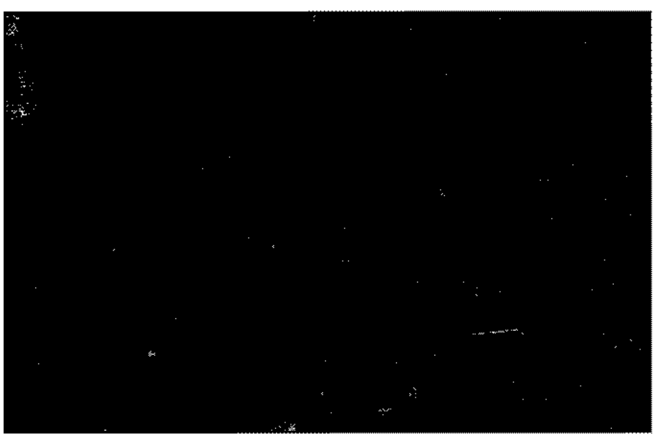
It is believed that stands of the most desirable tundra plants could be established to provide seed for vegetating specific gravel fill sites. Most of these indigenous plants will not survive outside the Arctic. Therefore, seed production sites will have to be located in the Arctic.

We have discovered that natural seed production in the Arctic varies markedly among years, probably in response to temperature. Even when growing season temperature conditions are favorable for seed production, weather effects can still prevent acquiring a plentiful seed crop. Wind, ice storms, and other factors at harvest time can ruin the harvest. Disease and insect predation on seeds also contribute to reduced harvests. Similar natural oscillations in vegetation reaction to weather variations over years have been recorded in the salt-desert shrub, another extreme environment (Sharp et al., 1990).

The 1989 growing season was unusually warm around Prudhoe Bay. Our temperature records indicated air and soil heating for July, August, and September was cumulatively double that for 1988 and 1990 and four times that of 1991. Plants flowered profusely, and *Arctophila fulva* seeds matured at locations where we had previously found none (McKendrick, 1990). We had relatively little time in the autumn of 1989 to gather seed; however, we did harvest 43 species.

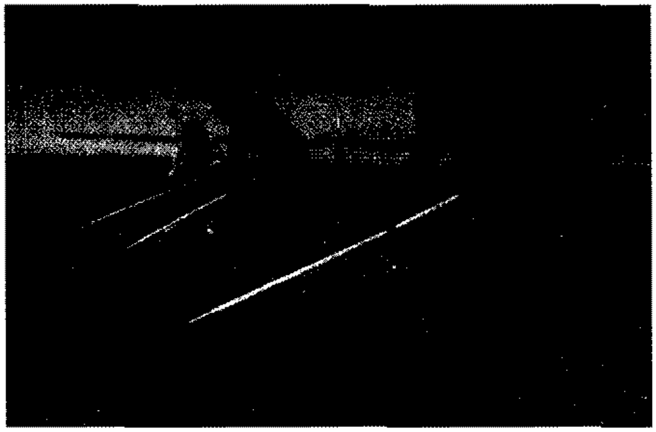
During 1990, there seemed to be carry-over effects from 1989, which were exhibited as abundant flowering and seed formation by indigenous plants. Unfortunately, strong winds shattered much of the seed crop before we could harvest it. There was one nine-day period with constant winds, often greater than 45 mph velocities. Despite the inclement weather, we obtained seeds from 62 species. Our 1990 seed harvest was directed toward forbs and shrubs, as grasses dominated our previous planting, and diversity of plant growth form is aesthetically desirable. Pure stands of single plant species valuable as wildlife feed may be preferred, if short-term growth of an animal population is the management goal. But monoculture—the growing of one plant species—runs the risk of total failure, which would leave the land unprotected.

Growing conditions in 1991 were most unfavorable, due to cool temperatures. This year, many plant species failed to flower. Seeds never had a chance to form and mature. The ef-

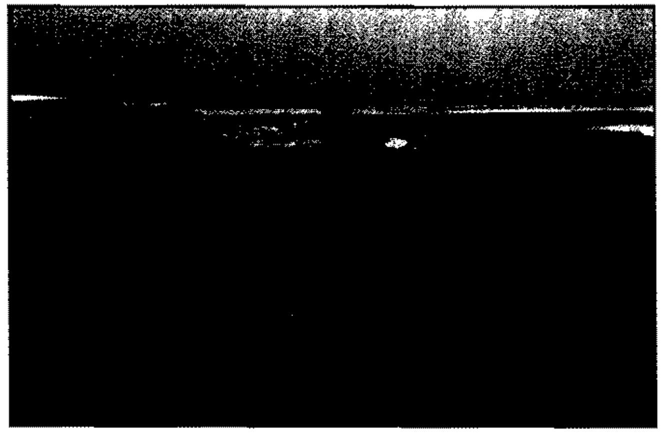


Seeds and plant fragments, along with soil particles, accumulate in the snowbeds created by snow fencing. The accumulation shown (21 June 1991) in this photo of gravel in the BP Put River No. 1 experiments is from one winter. It appears as if temporarily using snow fences might improve soil conditions on gravel pads.

Snow beds created inside the snow-fenced botanical garden remained until the third week of June in 1991 and may shorten the available growing season for plants. Note the soil and debris caught in the snow drift and its effect in melting the snow. Photo taken 30 May 1991.



Amber Mayo, Eric W. Fiscus, and Warren E. Fiscus raking plots for planting, 27 June 1991. Note snow fencing remains in place even during the summer in this experiment.



Judy Scorup collecting seed of ice-coated Arctagrostis latifolia, a native grass commonly found in the Alaska Arctic (15 September 1991).

fects were more pronounced on the coastal plain than in the foothills. To compensate, we extended a greater seed collecting effort in the autumn of 1991, including using a helicopter to reach previously unharvested sites. Fifty-six vascular plant species were included in the 1991 seed collection. However, many seeds were immature, and it is likely that few will be viable. We may have to postpone our 1992 planting until we have adequate seed supplies.

Our field tests include a botanical garden of gravel colonizing plant species and planting mixtures of indigenous seeds in experimental plots on a restructured gravel pad. Six inches of silt loam overburden was added to the gravel fill surface to create a 125 X 100 ft botanical garden on BP's Put River No. 1 drilling pad. Each species was planted in a single row—approximately 30 ft in length. Rows are parallel with the prevailing wind direction, and four foot snow fencing was erected to create a snow accumulation to protect plants. However, based on first-year observations, we believe this created too much snow cover for some species, and plan to reduce the snow fence height in 1992. Thirty-three species were planted in 1990, using seed gathered in 1989. Thirty additional species were planted in 1991, from the 1990 seed harvest, bringing the total number planted in the botanical garden to 63. These include 38 forbs/half-shrubs, 18 grasses, four shrubs, and three sedges/rushes. Considering that current tundra revegetation practices in Alaska usually include only three grass species, we believe this experiment might significantly increase the number of species available for revegetating disturbed Alaskan Arctic sites.

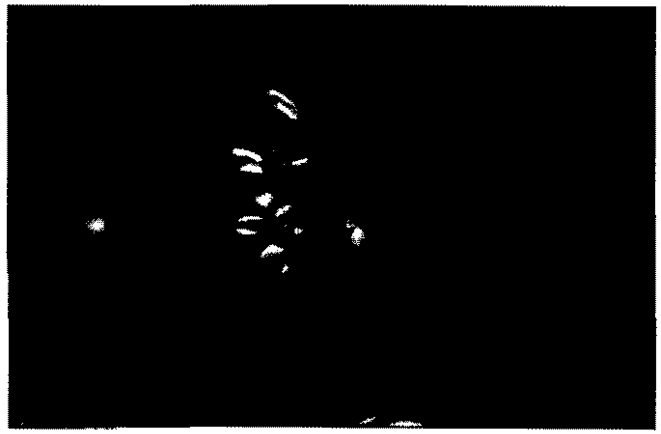
Generally, success in gathering indigenous tundra plant species seed and establishing stands on gravel plots and the botanical garden has been encouraging. But from a practical view, we must conclude that successful seed production sites in the Arctic should be away from the seacoast. Also, the harvest window is very restricted. For instance, Blackish oxytrope (*Oxytropis nigrescens*) seed pods on plants in the Sagavanirktok River Delta were abundant in 1989. One of us gathered several large bags of pods. Three days later the entire crop had shattered, making further collecting impossible.

Manipulating Gravel Fill to Improve Habitat for Plants

Most gravel structures in Alaska's Arctic are about five feet thick to protect the underlying frozen soil (permafrost) and to provide a stable surface for equipment and buildings. A recent study indicates an inverse relationship between gravel thickness and plant establishment (Jorgenson, 1988). Thicknesses greater than two feet were considered inferior to those of two feet and less. Various factors—reduced soil moisture availabilities, wind exposure, lack of snow cover to shelter seedlings during winter, etc.—might explain this.

The Arctic Coastal Plain tundra landscape is flat and subjected to strong winds that remove snow from elevated areas, depositing it in depressions. Typically, standing dead plant remains trap snow. Once a stable plant community forms, a natural process for accumulating snow and protecting overwintering plant parts from desiccation and injury is established. This is opposite of elevated gravel pads where winter storms scour snow from the surface. Wind break effectiveness on gravel fill was noted where small portable buildings created a temporary shelter between 1973 and 1984. In that sheltered area, a natural grass stand formed and persists even though the buildings have been removed for eight years. Providing shelter during the critical establishment period may effectively accelerate plant community formation on gravel fill.

Aster sibiricus colonizing on an abandoned gravel pad in the foothills.



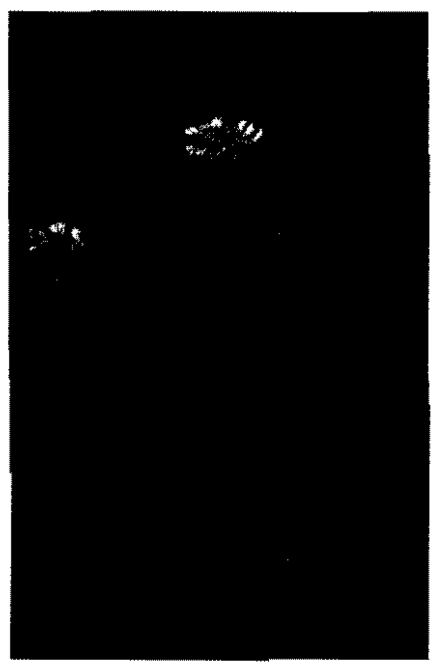
Astragalus alpinus, an indigenous legume, grows naturally along stream channels in the Alaska Arctic.

To be useful during oil exploration and production, gravel fill must be compacted to support traffic and weight of structures. Aeration and moisture penetration are limited in a compacted fill, due to reduced pore space, rendering it less hospitable to plant growth.

Typical gravel contains relatively little silt- and clay-sized particles. Hence, it has relatively low capacity for retaining moisture and nutrients needed to support plant growth. Previous work on mine spoils near Fairbanks indicated as little as 10% silt and clay in the spoils was associated with relatively dense stands of trees and other colonizing plants. We have measured the combined sand, silt, and clay contents of gravel from various Prudhoe Bay region sites and found it varied between 19 and 33 percent (McKendrick and Holmes, 1989). We suspect more detailed analyses will reveal that this fraction consists mainly of sand and relatively little silt and clay for most locations in this region. Thus, the fine fractions of these gravel fills may contain low proportions of the kinds of particles best suited to retaining available moisture and nutrients for plant roots. There is also considerable variation in fine fractions quality among the region's different gravel sources. At some locations in the Kuparuk field, there appears to be more silt and organic matter than found in the Prudhoe Bay gravels.

A five-factor experimental design (3 X 2 X 2 X 2 X 2) was used to test methods for correcting gravel pads' most obvious adverse conditions. These factors are: three gravel thickness, two amounts of overburden, two tillage, two snow fencing levels, and two grass seeding levels. Each experimental unit was replicated three times and will receive three separate mixtures of native plant seeds. The experiment began with the first planting in June 1990. The second planting was in June 1991 and the final planting will be June 1992.

The BP Put River No. 1 drilling pad was selected for the field experiments. It was constructed during 1969 using gravel removed from the nearby Putuligayuk River. British Petroleum discovered their portion of the giant Prudhoe Bay oil reservoir at this site. After exploratory drilling ended, the location remained unused until our project started. In the late winter of 1989, cores were systematically drilled through the frozen gravel to measure the existing fill thickness. Based on those data, the pad was restructured to create four blocks, each containing gravel thicknesses of two, three, and five feet above the underlying tundra. Each lift was compacted to imitate normal pad conditions and divided into three replicates of four plots each. Three inches of silt loam overburden was added to half of each plot. The overburden had been stripped and stockpiled at a gravel mine site. Half of all the plots were tilled to reduce compaction and to mix loam into the upper three to four inches of gravel in half the overburden treatments. All plots were given a single application of fertilizer, 50, 30, and 30 lb/acre (elemental



Tanacetum bipinnatum (a.k.a. Chrysanthemum bipinnatum) colonizing sand in the Kuparuk River drainage.

Senecio congestus, colonizing on gravel washed onto wet tundra from a drilling site (25 July 1991).

equivalent) of nitrogen, phosphorus, and potassium. Two blocks of the experiment were hydro-seeded to glaucous bluegrass (*Poa glauca*) to provide four seeds per square foot. This grass was seeded to initiate the colonization process to test sparse grass stands effectiveness in trapping snow and thereby improving other plant establishment. All blocks were oriented perpendicular with the prevailing wind, and two foot gravel berms were constructed at the edges of two blocks to trap snow. These berms proved ineffective, and four-foot snow fences were added in October 1990.

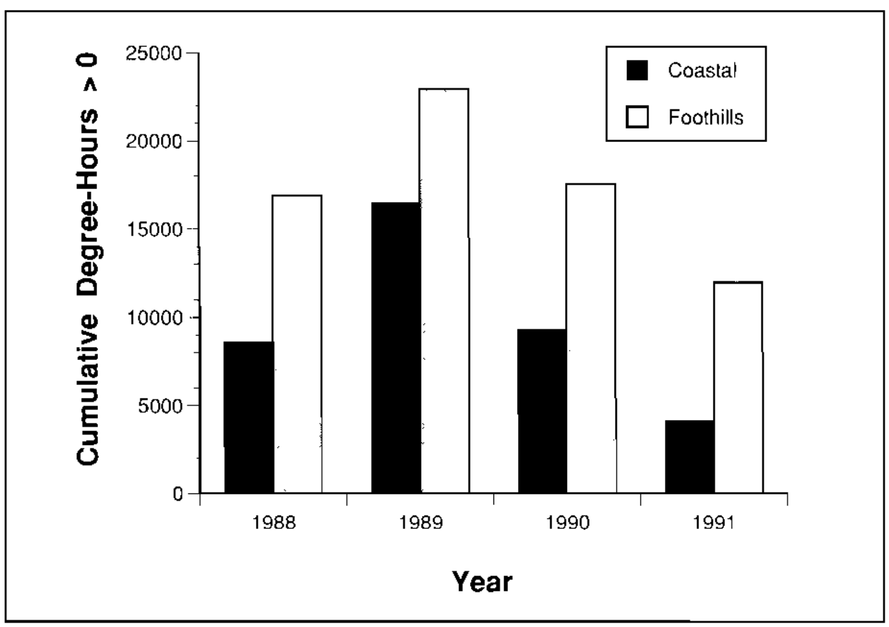
Mixtures of seed from our collections were planted on portions of each of the 144 plots in this experiment. Seed mixtures were blended with dry sand and hand applied to plot surfaces. Before seeding, plots were raked. After planting, plots were again lightly raked and tamped to ensure at least a portion of the seeds were incorporated into the gravel surface.

Before planting, each treatment plot was subdivided into five equal rectangles. The center fifth was planted with a mixture of 31 plant species in June 1990. Grasses initially dominated the stand from this seeding. To shift the emphasis away from grasses, the right-hand fifth was planted with a mixture of 28 tundra species, primarily forbs and shrubs, the following year. A third, and final, planting is scheduled for the spring of 1992, if we obtained sufficient viable seed from the 1991 collection. Two-fifths of the plot will remain as unplanted controls to monitor the natural invasion of plants. Gravel thickness, tillage, native seed mixtures, overburden applications, and replications were applied as split plots rather than allocated randomly, to accommodate the heavy equipment used in restructuring the pad.

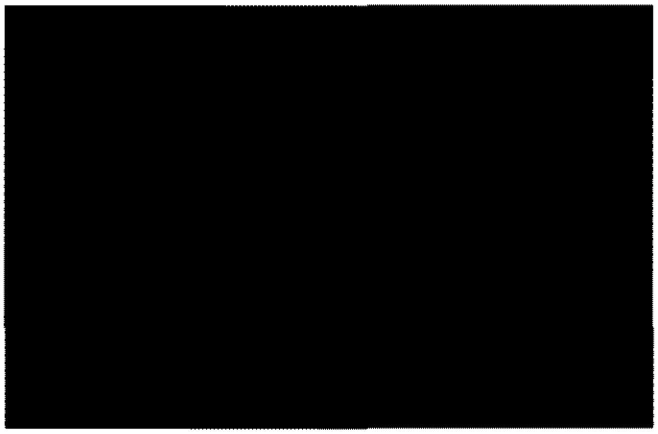
From initial observations, it is clear that the snow fencing provides a significant snow trap. After even light snow, accumulations accompanied or followed by wind produced a snow cover in the fenced plots, while the surrounding natural tundra and non-fenced plots remained snow free. On May 7 and 8, 1991, we measured snow cover on these plots and found 41 inches accumulated in the fenced area. This accumulation contained 16.5 inches of water. Portions of the overburden plots without snow fencing were snow free. Average snow cover on these plots ranged between none and 10 inches, with the least accumulation on portions of the five foot lifts. Maximum moisture accumulated on these unprotected plots was 1.5 inches, and averaged less than .5 inch.

Snow fencing also trapped a large amount of wind-carried soil and plant particles. After observing this, we placed pans in both the fenced and unfenced plots to measure the outfall of soil and plant materials, which accumulated on the gravel surface over winter. We noted the importance of very small elevation changes on the pad's surface. Where no snow fences were constructed, the three inch lift of overburden on selected plots was often cleared of snow while the adjacent gravel retained a slight snow covering.

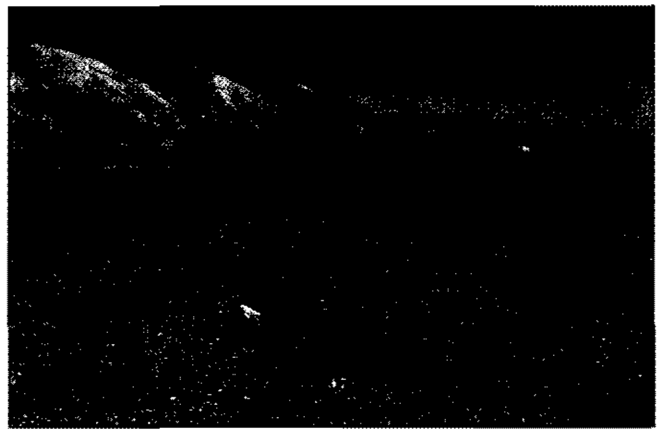
Germination and subsequent plant growth in these first two plantings on the plots, as well as the botanical garden, were encouraging. We noted un-



July through September Air Temperature Degree-Hours at Coastal and Foothill Sites: 1988–1991



Snow accumulations inside snow-fenced plots at the BP Put River No. 1 experiment (6 May 1991).



Jill Knapp,a botanist, temporarily employed by BP Exploration (Alaska), Inc., searches an area near Franklin Bluffs, south of Prudhoe Bay, Alaska, for native plants that can provide seed for experimental planting on gravel pads (12 July 1991).

usual reddish leaf colors in some of our grasses in 1991. This may have been a reaction to the low temperatures experienced during that year or to declining soil nutrient supplies. Samples of soil and gravel, as well as vegetative tissue from establishing plants, were taken for laboratory analyses to investigate possible causes for that response in these plants. ❑

Acknowledgments

Support for this research has been provided by contracts with BP Exploration (Alaska), Inc., and the U.S. Geological Survey (USDI). The Cooperative State Research Service, U.S. Department of Agriculture, and the University of Alaska Agricultural and Forestry Experiment Station (State of Alaska) also provide financial support. The USDA Soil Conservation Service provided snow survey equipment for measuring depth and water content of the snow pack.

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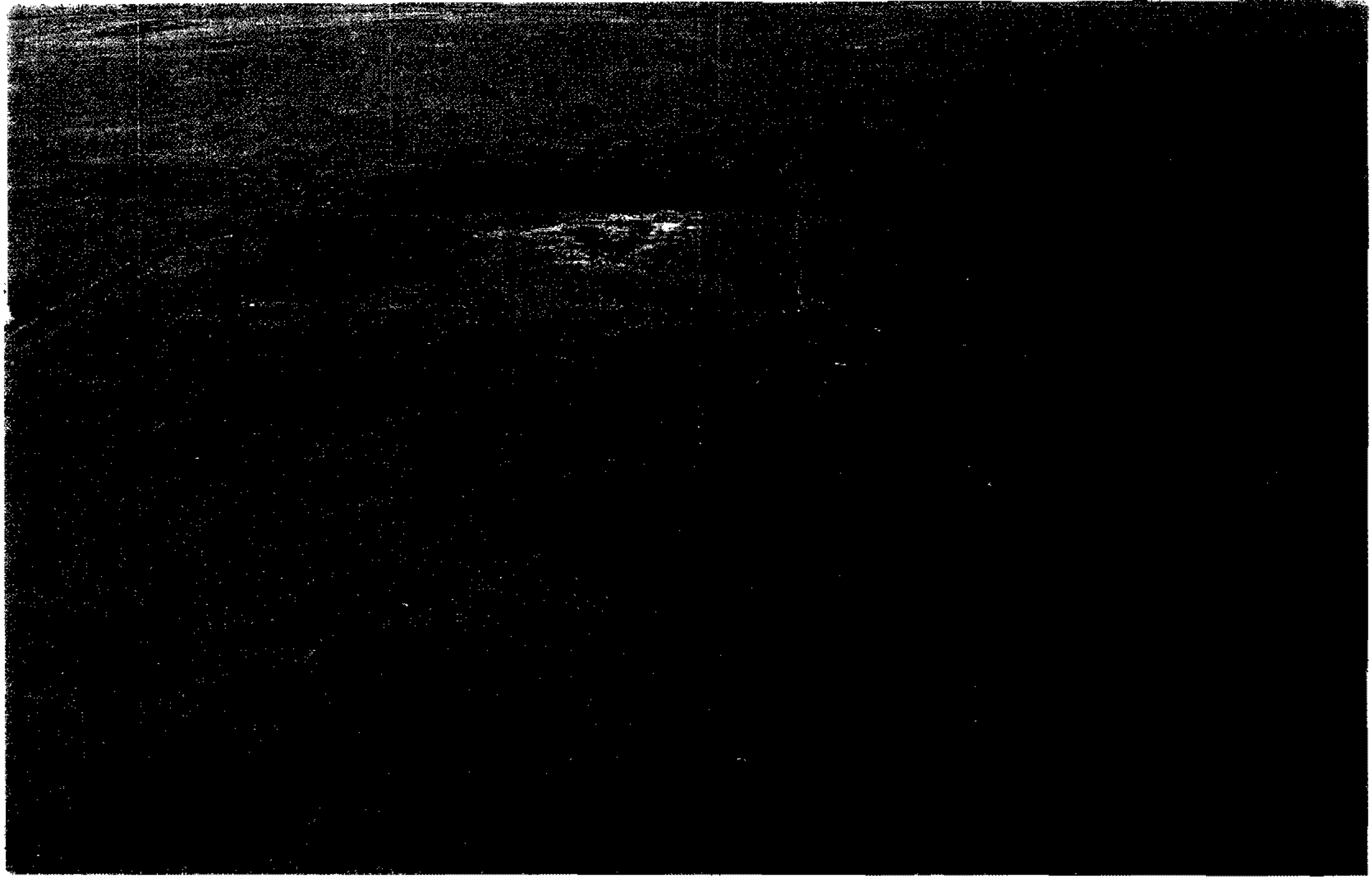
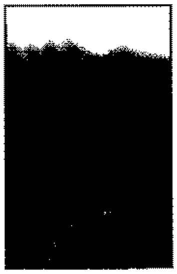


General aerial oblique view of the Tunalik Testwell No. 1 drilling site.

Lessons from the Tunalik Test Wellsite No. 1 —
National Petroleum Reserve in Alaska

Jay D. McKendrick, Peter C. Scorup, Warren E. Fiscus, and Gwendo-Lyn Turner

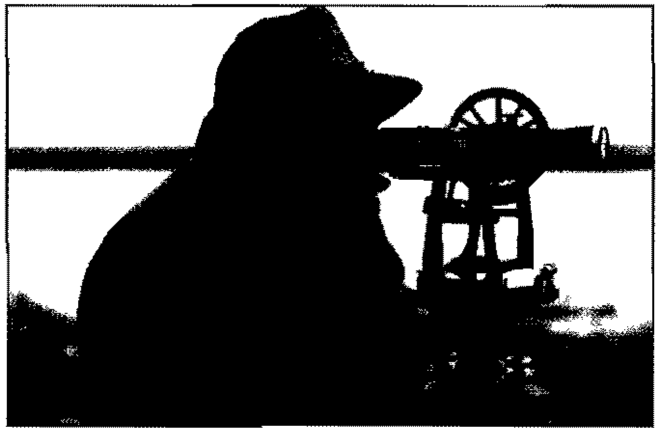
TUNALIK TEST WELL NO. 1 WAS drilled between November 10, 1978 and January 7, 1980 by Husky Oil NPR Operations under contract from the U.S. Geological Survey, Department of Interior, during the second exploration of the National Petroleum Reserve in Alaska. The 20,335 ft well was the deepest drilled in Alaska. It is approximately seven miles from the seacoast on Alaska's Arctic Slope, and about 120 miles southwest of Barrow. Construction cost for the site, not counting drilling and mobilization expenses, was $15 million. Approximately $1.1 million covered purchase and delivery of Styrofoam® insulation used between the gravel fill and the underlying tundra.



Jay D. McKendrick, Professor of Agronomy, School of Agriculture and Land Resources Management, University of Alaska Fairbanks.

These facts, though interesting, were not the main reason for selecting this wellsite for our long-term study of tundra vegetation on gravel pads. This location's value rests with its documented history and our previous experiences there and at similar locations in the region. Plants occupying these gravel structures represent vegetating progress since the structures were abandoned. At Tunalik and other NPRA drilling sites, we have a record of when the site was constructed, how it was used, when it was abandoned, which species of plants were seeded, the amount of fertilizer applied, and how seeding and fertilizing occurred. As a result, we can examine and evaluate plant com-

Dr. Maynard A. Fosberg and Jill Knapp collecting water samples and related data from the reserve pit at Tunalik Test Well No. 1 drilling location (25 July 1991).



Warren E. Fiscus surveying the Tunalik Drilling pad to map locations of photopoints and key sampling areas (26 July 1991).

munities knowing the various construction and repair practices used. We can determine the long-term implications of land rehabilitation practices used at the site. This helps industry and government agencies working in Alaska's Arctic regions develop realistic expectations for gauging progress for tundra land management.

Tunalik facilities consist of a drilling pad with reserve, fuel, and flare pits, a runway, taxiway, an aircraft parking apron, and a road connecting all these structures. The runway, parking apron, taxiway, road, and half the drilling pad were insulated prior to adding the sandy, gravel fill. A portion of the drilling pad fill was excavated from the reserve pit. The light-colored subsoil from the bottom of the pit is evident on the drilling pad surface. When the location was abandoned, a trench was cut through the taxiway at the edge of the runway to drain a large impoundment between the airstrip and taxiway. This also prevented vehicular travel from the airstrip to the drilling pad.

The Tunalik drilling pad, road, taxiway, and parking apron were seeded in 1980 and again in 1982 using a mixture of glaucous bluegrass (*Poa glauca*), red fescue (*Festuca rubra*), arctic polargrass (*Arctagrostis latifolia*), and Kentucky bluegrass (*Poa pratensis*). Those same areas were fertilized in 1980 and 1982 with nitrogen, phosphorus, and potassium. The airstrip was neither seeded nor fertilized.

We obtained our first vegetation information on the gravel pad at Tunalik during an on-site-evaluation, July 15, 1984, three years after the area was first seeded and fertilized. At that time six families, 14 genera, and 15 species were observed on the abandoned drilling pad. On July 24-27, 1991, seven growing seasons later, we reexamined the site. Eleven years after site abandonment, the drilling pad vascular plant community consisted of nine families, 19 genera, and 23 species.

In 1991, we found the upper surfaces of the taxiway, road, parking apron, and insulated section of the drilling pad occupied mostly by glaucous bluegrass. Polargrass and red fescue dominated the structures' side slopes. The only evidence of Kentucky bluegrass was a few shoots in subsidences on the drilling pad's non-insulated area and one clump on the gravel fill slope of the airstrip.

The airstrip's landing surface was covered with a dense stand of Phippsia (*Phippsia algida*) and snow pearlwort (*Sagina intermedia*). These are, respectively, a grass typically found on sandy, saline soils along the seacoast in this region and a small member of the pink family, also common on sands and gravels in the area. At the east end of the airstrip there were several distinct patches of dark green, robust stands of Tanacetum (*Tanacetum bipinnatum*) and northern tansy mustard (*Descurainia sophioides*.). These two plant species occupied the gravel surface in those locations to the exclusion of *Phippsia* and *Sagina*. *Tanacetum bipinnatum* is a member of the sunflower family and resembles wild chrysanthemum and camomile. *Descurainia sophioides* is a biennial member of the crucifer or cabbage family. Both of these herbaceous, broad-leaved plants occur naturally in this region.

The trench cut through the taxiway was almost completely occupied by a stand of Arctic pendant grass (*Arctophila fulva*), a native grass that occurs in shallow margins of ponds and along streams in the Arctic. Certain migratory waterfowl seem to prefer habitats with *Arctophila*. Along the airstrip margin, *Arctophila fulva*, and several other indigenous grasses, sedges, shrubs (mainly willow), and forbs were colonizing.

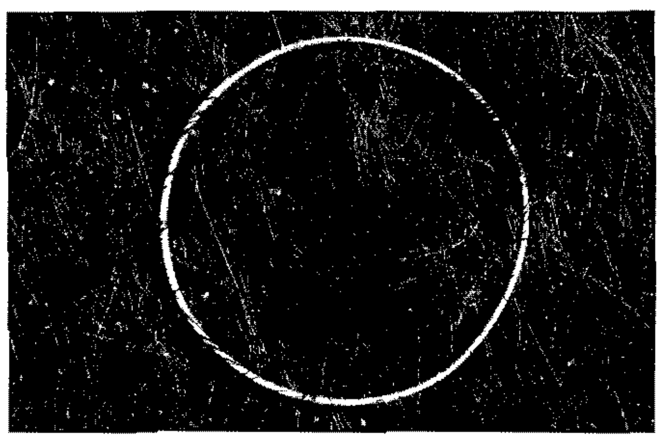
In 1991, thermokarst—an altering of the terrain caused by melting permafrost which results in pools, ponds and subsidence—was occurring over much of the non-insulated portion of the drilling pad, forming troughs and closed depressions, some of which contained standing water. At one thermokarst pool, we observed and photographed a female pintail duck with her young, while they fed and swam seemly oblivious of our presence. *Arctophila fulva* was a common colonizer in these drilling pad wet areas, as were sedges, moss, and some grasses. It was evident that lemmings had grazed heavily on these plants during the winter, when lemming populations naturally increase under the cover of snow. Certainly geese and perhaps caribou had added to the grazing pressure on these plants during the early growing season. They left only the short stubble of green leaves we observed in July, 1991.

In 1984, we found the reserve and fuel pit berms had been breached by water from melting snow, which typically drifts into such structures. At this location, melt water enters on the west side and exits on the east during spring runoff, adding water to the pits. At that time, we discovered fluids leaking from the reserve pit had killed much of the vegetation in a drainage on the down slope side from the site. The drainage was natural habitat for wet sedge meadow tundra plants. In 1991, the flare pit berm had also breached, and one continuous body of water connected the three formerly separate pits. Fluids still leak from the combined pits into the drainage during spring runoff, but the water quality in the pits was much improved over what we found in 1984. By 1991, the dissolved solids were within the range of those found in some natural ponds and lakes. We were pleased to discover that most of the wet sedge meadow, formerly killed by the reserve pit fluids, had recovered naturally. These new sedge and cottongrass stands obscured reference points, making rephotographing our 1984 scenes of the leak-affected area difficult.

Measurements on the insulated portion of the pad indicate glaucous bluegrass and moss dominated the vegetation. The same was true for upper surfaces of the taxiway, road, and parking apron, all of which had been seeded and fertilized. Vascular plants that had naturally invaded the insulated portions of the gravel drilling pad were not as abundant as glaucous bluegrass, which had been seeded. There was a caribou trail down the middle of the road. It resembled a typical cow path on livestock ranges. We observed many caribou using the path during our four-day stay at the site. They were possibly attracted to the road because it was elevated and permitted them some insect relief and offered a better view of approaching predators. It was also much easier to walk on the road than on the hummocky tundra.

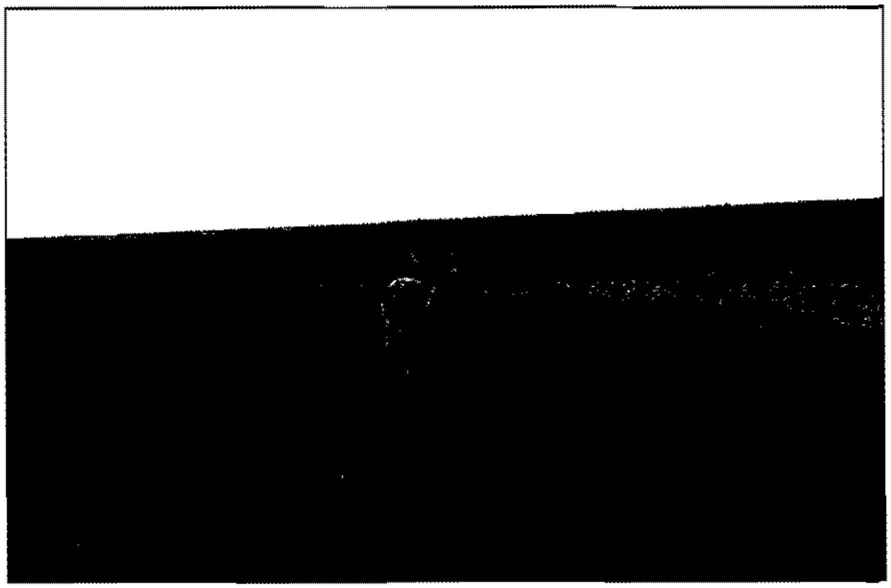
Warren E. Fiscus, Peter C. Scorup, and Dr. Lee A. Sharp collecting bulk density samples from the surface of an insulated gravel drilling pad in NPRA (17 July 1991).

Circular frame defines 0.1m² of a portion of the non-insulated pad surface at the Tunalik Testwell No. 1 drilling pad. Notice the area was heavily grazed by lemming during the previous winter.

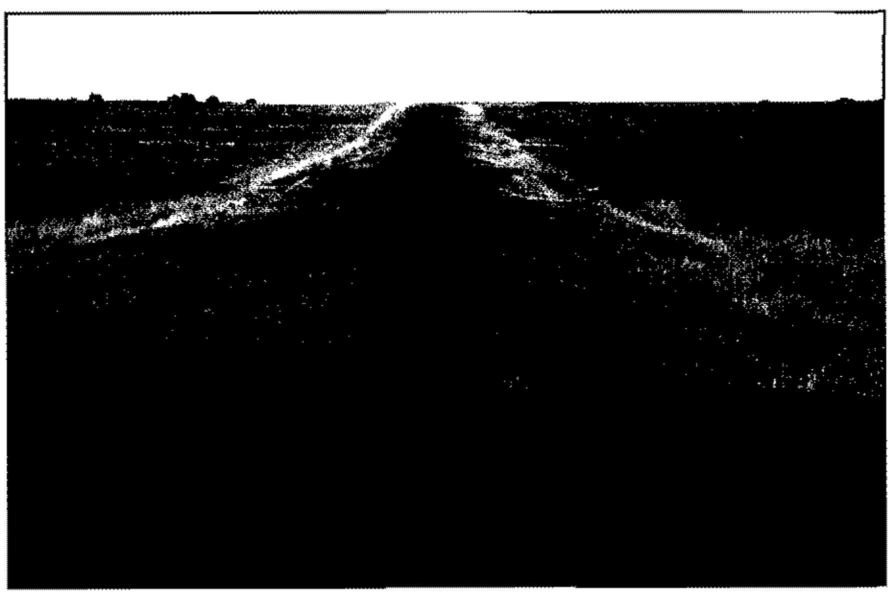


Close view of drilling pad surface, insulated portion.

It was instructive to compare the relative abundances of various plant species among moist, dry, seeded, and unseeded portions of the Tunalik gravel structures. The most abundant species on the driest portions, which had been seeded, were glaucous bluegrass and moss. The bluegrass was part of the seed mixture, and the moss had invaded naturally in response to the fertilizer. Indigenous vascular plants and moss were successfully colonizing non-insulated drilling pad areas and were responding to fertilization by growing more vigorously than in undisturbed sites. On the airstrip surface, driest portion of the unseeded gravel, *Phippsia algida* and *Sagina intermedia* were the two most abundant species. In terms of species diversity on dry microsites, there was little quantitative difference between seeded and unseeded locations. However, we noted several species inhabiting the runway that did not occur on the gravel pad. These were: downy oatgrass (*Trisetum spicatum*), alpine holygrass (*Hierochloe alpina*), dwarf fireweed (*Epilobium latifolium*), and arctic poppy (*Papaver lapponicum*). In addition to *Sagina intermedia, Phippsia algida, Tanacetum bipinnatum,* and *Descurainia sophoides*, airstrip vegetation included considerably more northern woodrush (*Luzula confusa*) and scurvy-grass (*Cochlearia officinalis*) than the drilling pad. In moist microsites, plant species diversity was greater than in dry microsites. Lack of unseeded moist habitat on gravel surfaces precluded comparing plant communities between moist and dry habitats on unseeded gravel.



Caribou trotting along gravel road at Tunalik Test Well No. 1 drilling site (25 July 1991).



Caribou trail on the gravel road between Tunalik Test Well No. 1 drilling pad and parking apron (25 July 1991).

Fertilizer spilled while loading aircraft caused the dense stands of *Tanacetum* and *Descurainia* at the end of the airstrip. Remnants of the fertilizer pellets almost one-inch thick were evident in some of these green patches of vegetation. Thus, shifting the balance of soil nutrients can have a marked influence on the kind of vegetation that forms on such sites. We have observed a similar response from *Descurainia* where fertilizer was spilled on a trans-Alaska pipeline site in the Sagavanirktok Valley south of Prudhoe Bay.

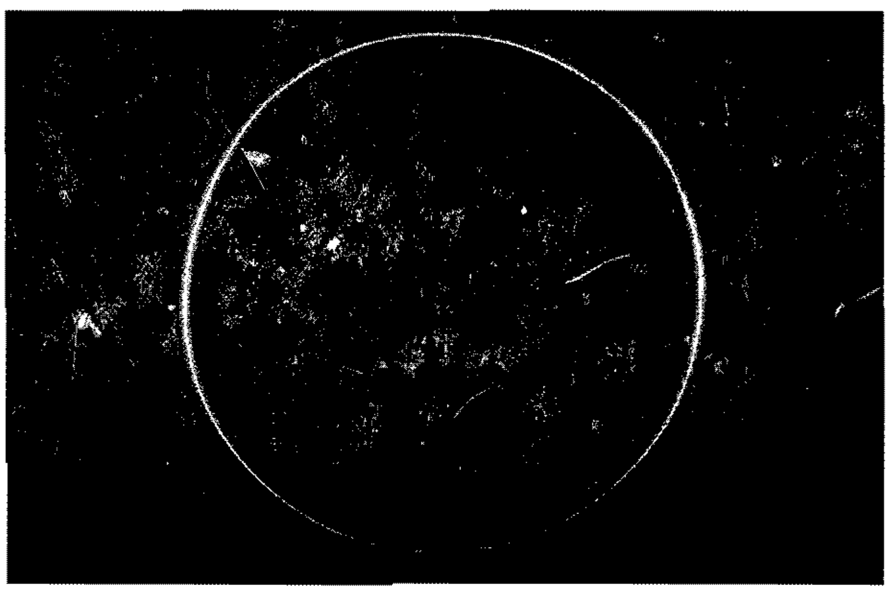
We have observed in the Alaska Arctic, as well as in Russia, that following disturbances to the soil, there is a tendency for certain plants to change their growth pattern from primarily vegetative to a more robust form generating many flowers and seed heads. Cottongrass (*Eriophorum*), grasses: hairgrass (*Deschampsia*), *Festuca, Arctophila,* and *Arctagrostis* and forbs groundsel (*Senecio*), bistort (*Polygonum*), and *Descurainia* are examples. Applying fertilizers to tundra plant communities induces the same response. This response to form seed is how tundra plant communities restore themselves following disturbances. However, on gravel pads, there are no plants, soil, nor a latent supply of mineral nutrients to begin the healing process. Thus, people must supply those elements to accelerate plant community formation.

The preponderance of new *Arctophila fulva* stands in impoundments, as well as in the open ground of drained sites throughout the area, indicated the species' ability to colonize a variety of disturbed soils. There were no natural *Arctophila fulva* stands in the immediate vicinity prior to the Tunalik drilling site development. We suspect that grazers, attracted to these structures and new stands of seeded grasses, may have been partially responsible for introducing *Arctophila fulva*. Water flowing across the landscape during spring breakup may have also brought *Arctophila* to the location.

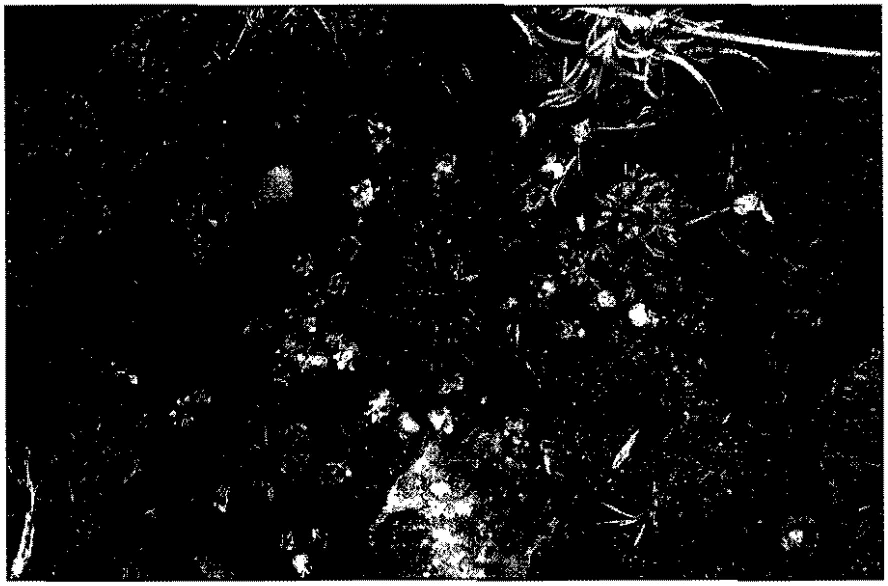
The recovery of plants in the area affected by the reserve pit leak was encouraging evidence that such damages are only temporary. Flushing of salts from drilling sites by runoff water and decomposition of the hydrocarbons over time will naturally return productivity to damaged soils.

What do these observations indicate for tundra rehabilitation? They show that seeding with a mixture of native grasses adapted to the tundra and available from commercial seed growers in Alaska can produce vegetation stands on gravel pads. Glaucous bluegrass, here as well as at other locations surveyed, usually dominates the horizontal, compacted (driest) areas of gravel pads. Polargrass and red fescue are confined to the side slopes and margins (more moist) sectors of these structures. The 'Nugget' variety of Kentucky bluegrass is not adapted to the region and persists, if at all, for only a short period. Thus, if a long term seeded-

Close view of the accidentally-fertilized surface to the airstrip at Tunalik Test Well No. 1 drilling site (27 July 1991). Fertilizer was spilled in 1982, when a fixed-wing aircraft was used to apply the treatment to seedings on the pad, apron, and road. The plot area is 0.1 m². The coarse leaves are Descurainia sophioides, a biennial member of the mustard family. The fine-leaved plant is Tanacetum bipinnatum, a member of the sunflower family. These two plant species have occupied fertilizer spill areas, at the exclusion of other plant species.



Close view of airstrip surface at Tunalik Test Well No. 1 drilling site (27 July 1991). The area of the circular frame is 0.1 m², and the small grass is Phippsia algida. The forb is Sagina intermedia.



A close view of Sagina intermedia with ripe seed pods. Notice the small brown seed among the sand grains on the gravel surface to the left of the plant. This species is a member of the pink family and has established extensively on the gravel surface at the Tunalik location, except where grasses were planted and fertilizer was spilled.

grass stand is needed, planting a mixture of glaucous bluegrass, red fescue and polargrass is a dependable option. If a short-term cover, initially attractive to grazers, is desired, then seeding with either annual grasses and/or Nugget bluegrass is suggested. One should realize that establishing a persistent grass cover will slow the rate of native plants colonizing the area, due to competition from the seeded grasses. On the other hand, a temporary grass cover may not meet current requirements of land management agencies. Also, the natural invading plants that occupy gravel pads in this region will be neither those species typical of the wet ground next to the gravel structure nor will the plant densities on the gravel pads be as great as in the communities surrounding the pad. Regardless of whether vegetation formed on gravel structures is by natural processes or from seeding and fertilizing, the resulting communities will more closely resemble those of gravel and sand bars along streams, dune ridges near the seacoast, or the stony ridges of the foothills than either the wet or moist tundra nearby.

Which of these disturbed and rehabilitated habitats is the better for wildlife? Obviously, for waterfowl, the non-insulated, seeded and fertilized, *Arctophila fulva*-dominated impoundments were preferred over the dry locations for feeding. Waterfowl rested on dry areas adjacent to the wet areas between feeding bouts. During winter, lemmings thrive in the fertilized and vegetated non-insulated portions of gravel pad where thermokarst basins formed but remained free of standing water throughout much of the growing season. During the summer, lemmings survive elsewhere. Caribou preferred the high, dry habitats during insect harassment season, but along with geese, may forage on the wet sedge meadow vegetation in thermokarst microsites. Small birds that feed primarily on plant seeds would find the airstrip inviting with its abundant supply of *Sagina intermedia* seeds. It is important to recognize natural communities on gravel bars of streams are periodically sought by caribou because they provide palatable forbs.

Which of these habitats is preferred by people? A botanist would find the thermokarst areas of naturally occurring plants most interesting, along with the airstrip's cover of *Phippsia* and *Sagina* in the middle, flanked by numerous other pioneers along the margins. The dense stands of glaucous bluegrass may be preferred by those who would choose any plant cover in contrast to bare gravel. The recovery of the site following abandonment was in itself interesting to us, because it indicated the resiliency of tundra plants to naturally recover, even where soils have been altered drastically with drilling wastes. It also showed the capacity that indigenous plants, as well as some commercially available grasses, have for vegetating gravel and how even excessive applications of fertilizer do not always result in barren soil.

Improved rehabilitation technology for the Alaska Arctic evolves with each new experience. It began in the 1970s, using mid-latitude rangeland revegetation practices and equipment adapted to meet North Slope needs. Revegetation for the trans-Alaska pipeline was the first major tundra land rehabilitation project in Arctic Alaska. Seeding and fertilizing technology of that route was largely based on experience and information from outside the Arctic. During construction, new information about Alaska's plant materials and fertilizer effects in tundra soils was acquired and incorporated into reclamation work. With completion of the pipeline project, the second exploration of NPRA began. Tundra site rehabilitation information and technology gained from the trans-Alaska pipeline—continually modified by ongoing research findings—was used in NPRA. Phillip D.J. Smith, a consultant during construction of the trans-

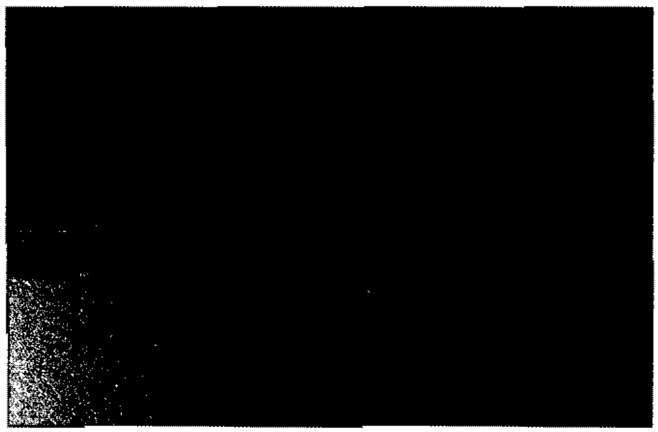
Plant Species	1984	1991*	1991**
Graminoids			
Alopecurus alpinus	P		
Arctagrostis latifolia	P	P	P
Arctophila fulva	P	P	P
Carex aquatilis	P	P	P
Dupontia fisheri	P		P
Eriophorum angustifolium			P
Eriophorum scheuchzeri		P	P
Eriophorum vaginatum	P		
Festuca rubra	P	P	P
Luzula confusa			P
Luzula wahlenbergii	P		
Phippsia algida	P	P	P
Poa arctica	P	P	P
Poa glauca	P	P	P
Poa pratensis			T
Shrubs			
Salix brachyophylla ssp. niphoclada			T
Salix ovalifolia		T	P
Forbs			
Artemisia Tilesii	P		
Cerastium beeringianum		T	
Cochlearia officinalis	P	P	P
Descurainia sophioides		P	
Draba corymbosa		P	
Epilobium angustifolium	P		
Hippuris vulgaris			P
Ranunculus gmelini ssp. gmelini			P
Sagina intermedia		P	P
Senecio congestus	P	P	P
Stellaria humifusa			P
Other			
Lichen		P	P
Moss		P	P
Mushroom			P

P = present; T = trace; blank = absent

* insulated; ** Non-insulated

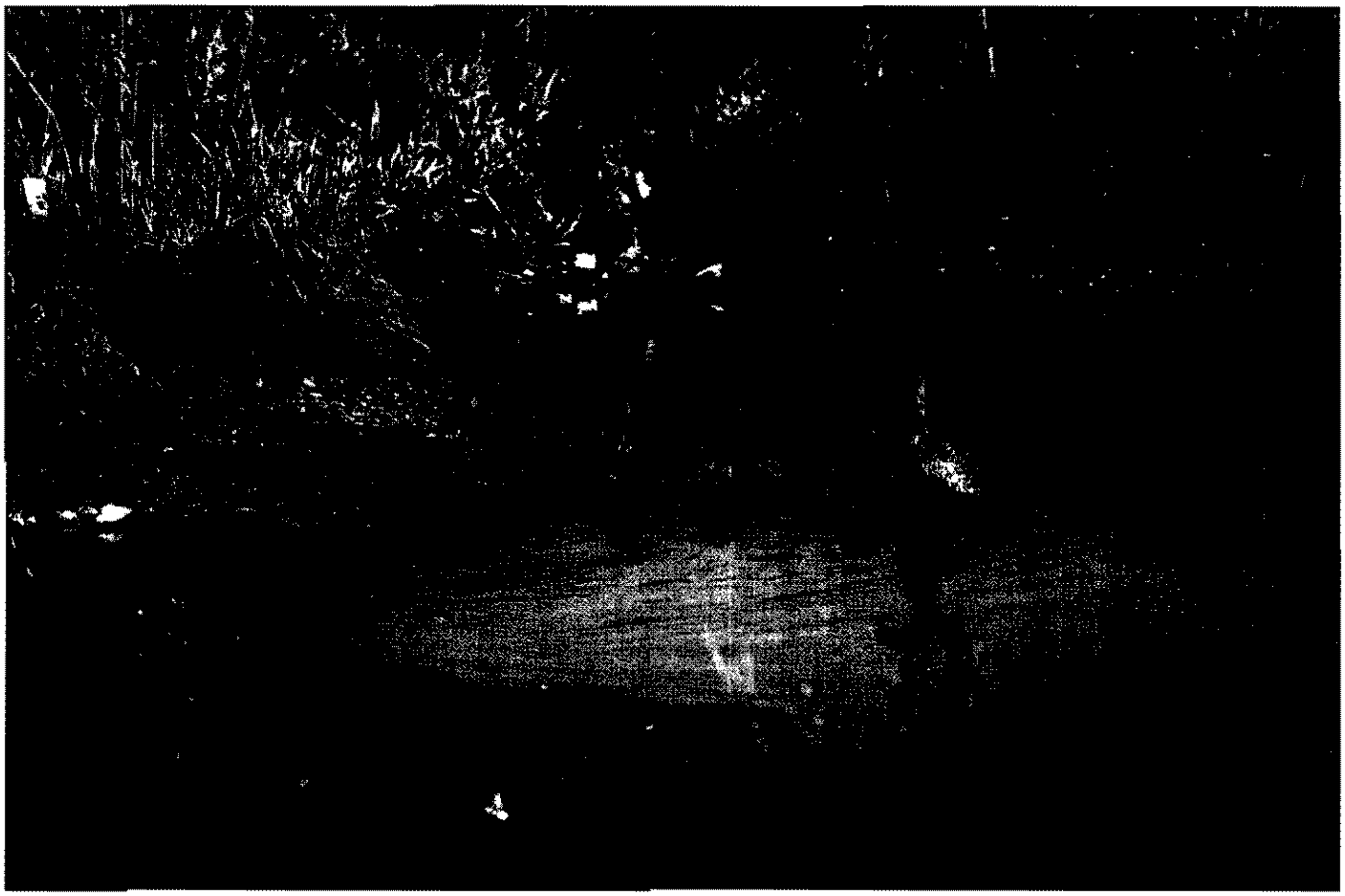
Listing on vascular plant species and lower plant forms found on drilling pad at Tunalik Test Wellsite No. 1, in 1984 and 1991.

Jill Knapp measuring vegetation cover on the east margin of the drilling pad at Tunalik Test Well No. 1 (27 July 1991). This portion of the drilling pad is insulated and has not subsided, as did the non-insulated western portion.



Southward aerial oblique of the non-insulated (western) portion of the drilling pad at Tunalik Test Well No. 1 (24 July 1991).

Southward aerial oblique of the insulated (eastern) portion of the drilling pad at Tunalik Test Well No. 1 (24 July 1991).



Pintail hen and ducklings in thermokarst pool formed on the surface of the non-insulated portion of the Tunalik Test Well No. 1 drilling pad (25 July 1991).

Alaska pipeline, directed NPRA rehabilitation and used methods developed during the pipeline project. As exploration and production are contemplated for other Arctic regions (Russia as well as U.S.), tundra rehabilitation technology will further advance. This constant learning and implementing of new knowledge and skills improves land rehabilitation procedures.

As we continue to monitor changes on locations such as this one at Tunalik, we will gain greater insight into the long-term implications of various tundra rehabilitation practices. The more we know about what occurred at a location, the more insight can be gained. For instance, if we had not witnessed fertilizer being loaded into aircraft at the Lonely Airstrip to fertilize other NPRA sites several years prior to the Tunalik site survey, we may have overlooked the unusual responses of *Tanacetum* and *Descurainia* to excessive fertilizers on the Tunalik airstrip. The kinds of information that become valuable for interpreting vegetation responses in the future are not always readily apparent and documented when site rehabilitation is underway. Having continuity among observers is very valuable for gathering and retaining such information. ❑

Acknowledgments

Drs. Maynard A. Fosberg and Lee A. Sharp of the University of Idaho and Jill Knapp, a temporary employee of BP Exploration (Alaska), Inc., assisted with the survey of sites in the NPRA during the summer of 1991. BP Exploration (Alaska), Inc. provided funding for the research and logistics to the various sites across the North Slope. The University of Alaska Fairbanks Agricultural and Forestry Experiment Station and the USDA Cooperative Research Service also provided funding. The USDI Bureau of Land Management granted permits to allow field work on these sites, and the US Geological Survey provided site specific data for the locations examined.

Of Moose and Mines

D.J. Helm
Research Assistant Professor of Vegetation Ecology

A PROPOSED COAL MINE NEAR Palmer could give moose a big bonus in the Matanuska Valley Moose Range's (MVMR) Wishbone Hill portion. One of the proposed Wishbone Hill Coal Project reclamation goals is to produce moose browse. Many plant species used in land reclamation are also good browse plants. However, during planning for the Wishbone Hill Coal Project, agency personnel wondered about woody species survival and growth rates. They wanted to be sure that healthy plants providing moose browse would be present at the end of the 10-year bond release period.

For three years, 1989-1991, AFES researchers studied experimental plots:

1) to determine woody plant species survival and growth rates on certain soil types in the Wishbone Hill Coal Project and
2) to investigate seed mixes for different goals.

The land management plan governing the MVMR required producing adequate moose browse after reclamation. State and federal coal-mining regulations require establishing self-reproducing plant communities to provide adequate ground cover and diversity (Surface Mining Control and Reclamation Act 1977). Vegetation in the proposed permit area was inventoried according to strict requirements. The findings along with growth rate assumptions were used to determine existing cover and plant species diversity as well as density and current woody plant species production. These findings establish technical standards for reclamation success. The mine operator must post a bond sufficient to cover reclamation costs based on the technical standards. The bond is returned to the operator if the revegetation meets permit standards at the end of the 10-year bond-release period. (See Helm 1991 for an overview of vegetation sampling and revegetation requirements for coal mines.)

Scientific Background

Producing moose browse in the MVMR has its own challenges beyond those normally associated with reclaiming mined lands. The tall grass bluejoint (*Calamagrostis canadensis*) competes with browse and timber regeneration after logging and similar disturbances. The extent of bluejoint competition with moose browse on MVMR was unknown. Bluejoint is both a problem and a solution. It may suppress more desirable plant species, but its vigorous regeneration from rhizomes can be a major help in stabilizing soil.

Soils characteristics important for mined land reclamation include chemical, physical, and biological properties. Most of the soils in the proposed mine area have pH values below 5.5. Balsam poplar (*Populus balsamifera*) and feltleaf willow (*Salix alaxensis*) generally colonize floodplain soils with pH values greater than 7. It was unknown if these species could survive on low pH soils. This was particularly important since these species were expected to produce the most browse.

Additional soil characteristics include biological components such as propagule (seed and rhizome) banks and microorganisms, including mycorrhizal fungi. Plants established from propagule banks may improve the diversity of the plant communities. However, regeneration of bluejoint from rhizomes may also compete with desired species.

Mycorrhizae (Greek for "fungus roots") are positive relationships be-

Figure 1. *Many shrubs and some birch trees are overbrowsed in the Wishbone Hill area. These shrubs are heavily hedged and have some dead stems.*

tween certain fungi and plant roots. The fungus helps the plant take up soil nutrients and moisture. In exchange the fungus receives carbon substrate (energy) from the plant. Mycorrhizae are usually needed for normal growth of most plant species in the field, but species vary in their dependence. The dependence of browse species on mycorrhizae and the presence of mycorrhizal propagules in the soil or in the air was unknown.

The study site is about eight miles north of Palmer in the Matanuska Valley. Old growth paper birch (*Betula papyrifera*)-white spruce (*Picea glauca*) forests dominate the area. Relatively little browse is currently available. Existing shrubs are heavily hedged and some contain dead stems (Figure 1). Birch trees are so overbrowsed that they have a shrub growth form up to 18 years old. When the uppermost leader grows out of the moose's reach, the tree can develop a normal growth form. Development of early successional vegetation types with moose browse is needed to diversify the area's vegetation and the available browse.

Experimental Design

The browse regeneration study was designed to determine:

1) survival and growth of different woody plant species;
2) appropriate soils for different woody plant species; and
3) local plant species that would colonize and maintain themselves over time.

A 4 x 7 randomized block design was established with four soils and seven woody species. Thirty individuals of each species were planted on each soil. On upland meadow soils no alder (*Alnus tenuifolia*) or Bebb willow (*Salix bebbiana*) were planted.

The four soils were selected based on existing vegetation and pH and included soils from:

1) paper birch-white spruce forests;
2) upland meadows (bluejoint);
3) lowland meadows; and
4) overburden.

Vegetation type was important since existing plant species control and are affected by many of the biological properties of soils. Soils under birch-spruce vegetation were expected to contain mycorrhizal fungi for both birch and spruce. The lowland meadow is a diverse community with scattered white spruce, Bebb willow, numerous forbs, and several grass species, including bluejoint. Bluejoint and fireweed (*Epilobium angustifolium*) dominate the upland meadow type. These compete with woody regeneration and seeded grasses. Soils from this community were not expected to contain ectomycorrhizal propagules for the woody plants, unless propagules were dispersed by the wind. The control plot was overburden, presumably with little or no biological activity. Overburden is the material beneath the developed soil horizons, but above or between layers of the coal.

Birch-spruce and upland meadow plots are located on Talkeetna silt loam. Lowland meadow plots are located on a complex of Lucile and Chulitna Variant soil series. These three topsoils had low available nitrogen (8 ppm), phosphorus (3 to 9 ppm), and potassium (41 to 56 ppm), and low pH values (5.3 to 5.5). The overburden plot is adjacent to the lowland meadow plots. Topsoil was removed from it. The overburden pH was about 5.6, slightly greater than the soils, but much lower than pre-mining inventories indicated. Overburden plots were more typical of the contact zone between overburden and top soil rather than true overburden.

The seven plant species used in these trials were selected based on ease of propagation, suitability for moose habitat, and presence in the pre-mining vegetation. Species used were balsam poplar, feltleaf willow, Barclay willow (*Salix barclayi*), Bebb willow, alder (*Alnus tenuifolia*), paper birch, and white spruce. Balsam poplar readily colonizes recently disturbed areas, is browsed by moose, and can have two forms of mycorrhizae.

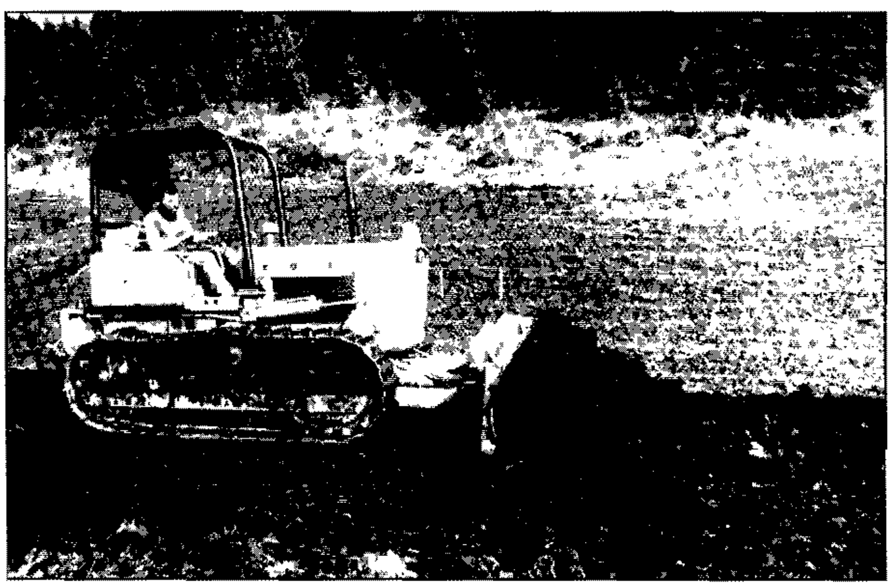


Figure 2. *Topsoil had been completely removed from the plots, then spread back on the plots within one day. This simulated disturbance similar to mining, but does not take effects of stockpiling into account.*

Feltleaf willow is similar to poplar in its ability to produce adventitious roots and moose browse. Moose love feltleaf willow. Barclay willow propagates almost as easily as poplar and feltleaf willow and is found on lower pH soils. Bebb willow grows naturally on low pH soils in the area but is more difficult to propagate. Bebb and Barclay willows are usually found in upland sites while feltleaf willow usually grows on floodplains. Paper birch was selected because its sheer abundance makes it a major browse species in the Wishbone Hill area. Alder can have two forms of mycorrhizae as well as nitrogen-fixing bacteria. Alder litter decomposition could release nitrogen into the soil, which is needed to achieve a self-sustaining plant community. White spruce provides thermal cover for wildlife and is dependent on ectomycorrhizae, an external form of mycorrhizae, for growth.

Methods and Materials

Dormant poplar and willow species cuttings were collected from local plants in April 1989 and rooted in a sand bed at the Palmer Research Center during May and June. Alder (two months old), paper birch (one and two years old but similar size), and white spruce (one year old) seedlings were obtained from Alaska Division of Forestry's Eagle River Nursery.

In early June, study locations were chosen in the selected vegetation communities. Trees were cleared. All topsoil was stripped and temporarily stockpiled (less than one day) beside the clearing to simulate a mining disturbance. Top soil was spread evenly over each site except the overburden control plot, which was adjacent to the lowland meadow site (Figure 2). Most plots were disked to loosen the soil. In last June, eight-foot high fencing was erected around all but the upland meadow (bluejoint) plots to protect the plots from moose. Seedlings and cuttings were planted and measured between June 26 and July 7, 1989 (Figure 3). Plants received about 250 ml (1 cup) of water to ensure good root-soil contact when they were planted.

Plant growth monitoring included measurements at planting time and at the beginning and end of each growing season (1989-1991). Measurements included plant height, crown length and width, basal diameter, twig length, and twig diameter. The number of twigs on each plant was counted, and the vigor of each plant was estimated. Cover by plant species in each plot was also recorded at 30 points within each plot. All species in the plot, whether sampled or not, were recorded.

Snow cover was observed at least twice during the winter to identify depth variations from wind that might affect plant growth. These observations were made after snowfall or windstorms to observe drifting patterns and snow depth. Observations of plant development, made in the spring, indicated when plants broke bud and actually initiated growth. Roots of one plant per plot—three plants per species per soil treatment—were harvested for examination of mycorrhizal development at the end of the second year.

Results

Woody Plant Growth

Feltleaf willow, barclay willow, and balsam poplar were the tallest plants when averaged across all sites at the end of year two (1990) (Figure 4).

Barclay willow had a bushy growth form which provides a windbreak for deposition of seeds, organic material, and snow. Alder and birch had similar heights. Bebb willow was the shortest of the willow family. White spruce was the slowest growing plant species evaluated. Similar patterns continued through year three.

Figure 3. *Balsam poplar cutting shortly after planting on upland meadow soil during June 1989.*

The upland meadow plots contained the plants with the greatest heights and twig lengths when averaged across plant species for all species planted there (Figures 4, 5). Poplar, Barclay willow, and white spruce grew in the upland meadow soils (Figures 4, 5). Lowland meadow soils were associated with the best growth of feltleaf willow, birch, and alder. Bebb willow grew best on the birch-spruce soils.

The plant species-soil combination that resulted in the tallest plants was the feltleaf willow on the lowland meadow soil. One plot contained exceptionally large plants ranging from 3 1/2 ft (109 cm) to five ft (153 cm) high when measured in late August 1990 (Figure 6). Some of these were more than 6 1/2 ft (2 m) tall in 1991. This plot was under a deep winter snow drift which insulated the plants and increased spring soil moisture. Plants growing on the overburden were smaller and less vigorous than plants growing on any of the other soils.

Snow was sufficiently deep during the 1989-1990 and 1990-1991 winters to cover plants most of the time, although during early and late parts of the second winter plants were available for browsing. Snow cover protected plants in the upland meadow from moose browsing in these heavy snowfall years (Figure 7). However, during the second winter, plants were large enough to provide browse during the critical late spring period. Plants were sufficiently large at the end of year three that they were available for browsing through early winter. Moose appeared to favor Barclay willow.

Variation in growth initiation in the spring is important for plant competition. Birch family species (paper birch and alder) began growing earlier than the willow family (balsam poplar and willows). All transplanted woody species initiated growth before local herbaceous colonizers attained much height. Woody plants get full sunlight for several weeks before bluejoint reaches near the woody plants canopy height (Figure 8). This early development contributed to good plant growth on the upland meadow plots. Many woody plants were about even with the top of the bluejoint canopy at the end of year three. Browsing during the 1991-1992 winter will reduce some of the height gain, but the woody plants will still have a head start over the bluejoint in the spring.

Native Plant Regeneration

Colonization by local species is important for species diversity and reestablishment of communities. During year two, 27 identified native plant species were recorded during sampling. Total vascular vegetation cover averaged 63% after two years with bluejoint (28%), tall fireweed (*Epilobium angustifolium*) (15%), and horsetails (***Equisetum** spp.*) (10%) the most common species. Vascular plants include those with roots and shoots, but do not include mosses and lichen.

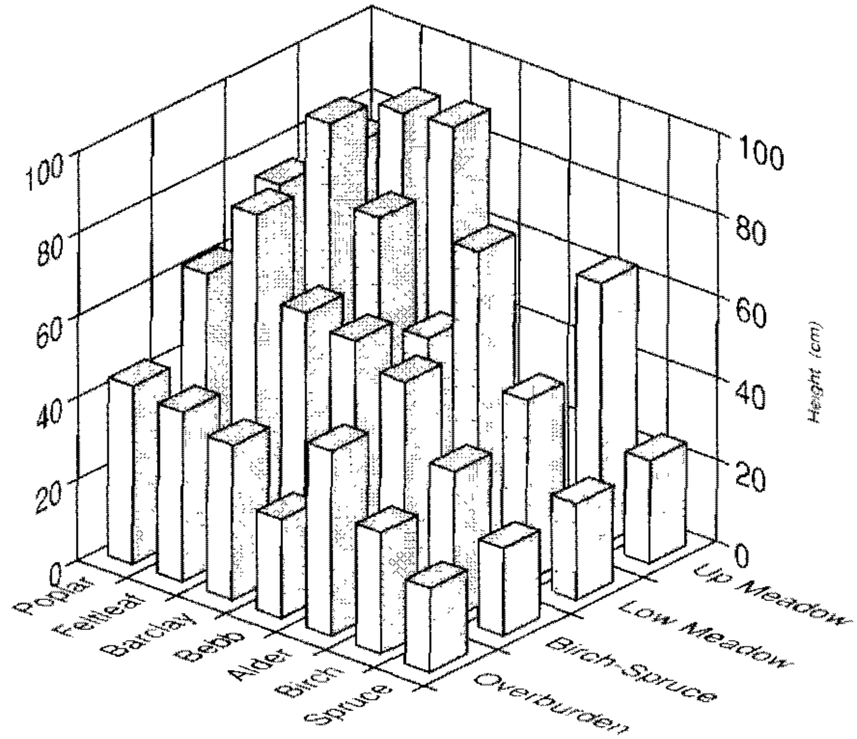


Figure 4. *Heights of woody plant species at end of year 2 (August 1990) by species and soil.*

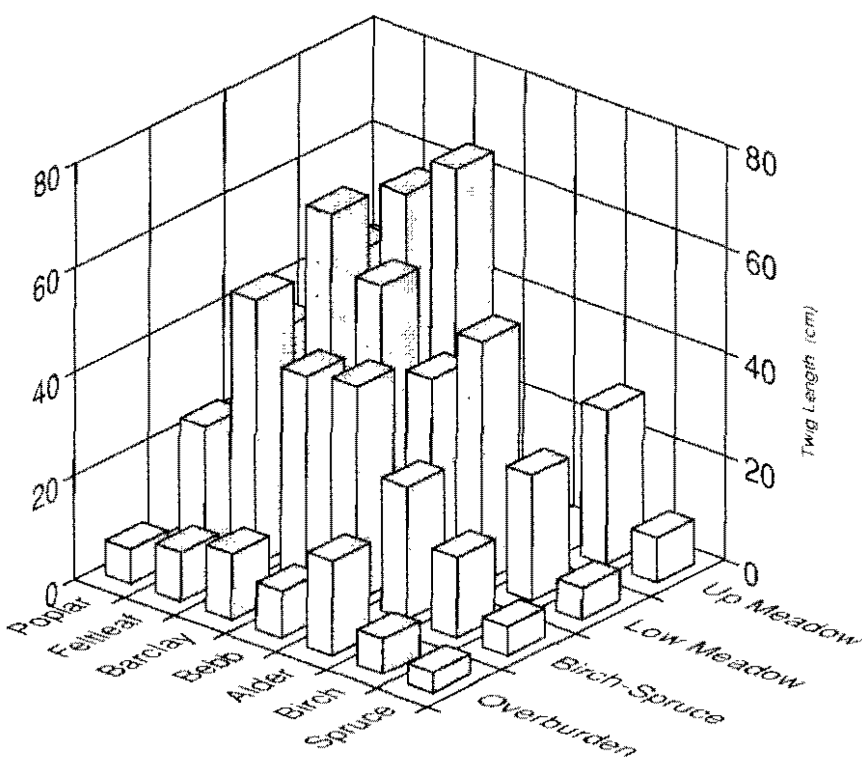


Figure 5. *Twig lengths of woody plant species at end of year 2 (August, 1990) by species and soil.*

Reclaiming Lands —

A Balancing Act

RECLAIMING COAL-MINED LANDS in the Matanuska Valley Moose Range (MVMR) is a balancing act among several conflicting goals. Moose habitat regeneration is required by the MVMR land management plan. All Alaska coal mines are subject to federal and state requirements to produce diverse, self-reproducing plant communities within 10 years after mining is completed to have their bond released. Where there's more precipitation requirements must be met in five years. This means that a certain amount of cover must be produced to stabilize the soil. A number of plant species must be present for diversity, and the vegetation must be capable of reproducing without amendments such as fertilizer. To achieve the cover needed, seeded grass species may be used. However, grasses provide cover for voles that girdle tree stems. Vigorous grass growth may also interfere with woody plant growth and with native colonization. On the other hand, some native species present in "live" topsoil may grow vigorously from rhizomes. This regeneration helps stabilize the soils but also competes with woody plants and colonization by other native species. In addition to these trade-offs among different species, separate portions of the reclaimed areas may require different strategies for diverse goals.

To address these issues, a grass seed mix study was conducted simultaneously with the browse study. This study's goals were to identify grass species, mixes, and seeding rates useful for soil stabilization or low competition. Low competition strategies are needed where native regeneration, diversity, or moose habitat improvement is desired.

Soil stabilization should be the primary emphasis on portions of the project with steep slopes. Recommended treatments here might include live topsoil from an upland meadow community with many viable rhizomes of bluejoint. If this soil is not available, the site could be seeded with a mix developed for erosion control. This may consist of 'Norcoast' Bering hairgrass (*Deschampsia beringensis*), 'Nortran' tufted hairgrass (*D. caespitosa*), and 'Arctared' red fescue (*Festuca rubra*) in the Wishbone area. Other parts of the state might use other grasses.

Where greater diversity is desired, additional grass species could be used with lower seeding rates than of the three main species. Lighter seeding rates of the entire mix reduce seeded species competition with native colonization, but should only be used in areas where erosion potential is low. Grass species that can be used for diversity in the Wishbone area include 'Gruening' alpine bluegrass (*Poa alpinum*) and 'Nugget' bluegrass (*P. pratensis*), although the latter is considered an introduced species rather than a native species.

Gruening alpine bluegrass is useful for special reclamation goals. Its low growth form will almost eliminate any competition between it and woody plants. However, it must either be seeded at higher relative rates to survive with other grass species, or it should be seeded as a monoculture near woody plants.

Fertilizer application increased growth of both seeded species and natural regeneration. However, bluejoint regrowth improved more than other natural regeneration. Hence, fertilization to help seeded grasses become established may increase the competition from less desirable native species.

Revegetation research is a challenging area of interdisciplinary research that requires vegetation ecology, forestry, agronomy, and soils as well as other disciplines. Characteristics of numerous plant species and environmental conditions must be considered when developing plant communities. Revegetation plans combine characteristics of plant communities with substrate and environmental characteristics to form a landscape capable of meeting the desired goals. ❑

***Figure 6.** Large feltleaf willows grew in one of the lowland meadow plots possibly because of a large snow drift and good soil moisture.*

Plots on the birch-spruce soils averaged 72% cover by vascular plants with the same three dominant species. Eleven plant species were sampled on these plots. About 24% of the birch-spruce plots area was bare.

Plots on the upland meadow soils had 87% vascular vegetation cover with bluejoint providing 63% cover. Just 11% was bare ground. Eleven plant species were also sampled here.

The lowland meadow plots contained 78% vascular vegetation cover with 18% bare ground. These plots were the most diverse. Twenty plant species were recorded during sampling in year two. Eight species covered more than 3% of the ground with tall fireweed (26%) and bluejoint (12%) being the most abundant.

In contrast, the overburden plots contained only 15% cover by vascular plant species and 82% bare ground. Cover was substantially less on the overburden plots than on any of the local soils.

During the third year minor species cover was reduced. However, other broadleaved forbs, such as cow parsnip (*Heracleum lanatum*), shaded some smaller woody plants. Bluejoint competition was particularly intense in some areas and reduced cover of some native colonizers. Figure 9 illustrates changes in cover over time on the upland meadow plots that were dominated by bluejoint. Individual grass stems had almost no space between them in the densest stands of bluejoint.

Mycorrhizae were well-developed on roots of many plants. Some birch volunteer seedlings on the birch-spruce soil had root systems completely covered with ectomycorrhizae.

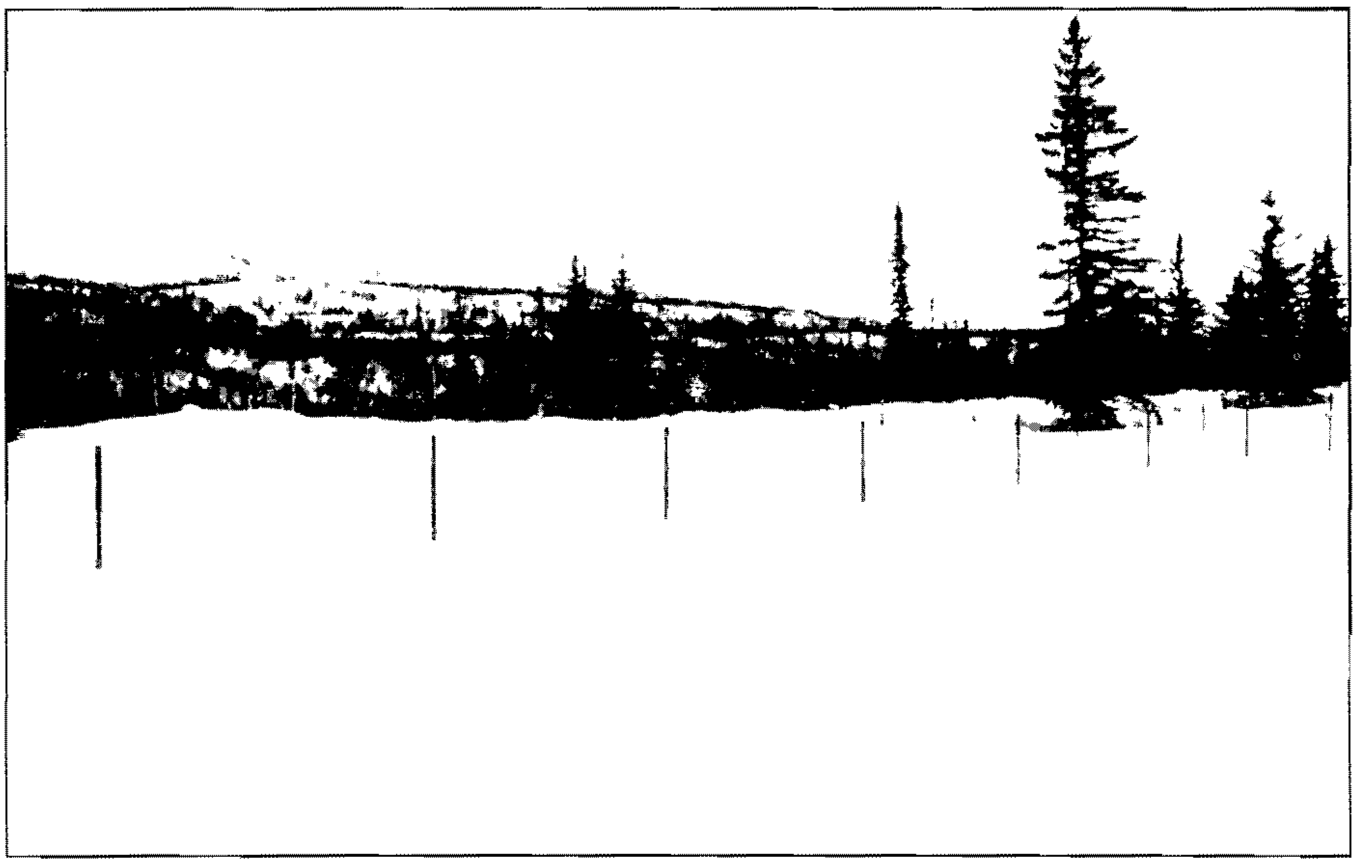


***Figure 7.** Snow cover during the winter protects plants from cold and desiccation. It protected the unfenced plants from browsing during the first two winters.*

Discussion

It has been established that browse can be produced in three years under existing environmental conditions. Plants have reached sufficient size that results of species interactions can now be documented. Canopies of adjacent plants are starting to touch and will become more closed over time. This may affect their growth, but more importantly, it may shade bluejoint underneath it.

Perhaps shade tolerant native species can colonize if the bluejoint expansion is slowed. Woody plants start growing before bluejoint in the spring.

These are preliminary findings. Continued monitoring will be needed to learn the long-term results on achieving moose browse and diverse, self-reproducing plant communities.

All soils, other than the overburden, produced good plant growth. However, significantly better growth was achieved on some soils. Upland meadow soils had the best growth when averaged across species.

Taller woody plants were usually associated with more ground cover. Based on feel of the soils and visual observations, soil moisture under this ground cover appeared greater than soils in open areas. Plants were taller in places where a moisture gradient was known to exist because of standing water during breakup. Mycorrhizal colonization does not appear to be related to results to date, possibly because ectomycorrhizal propagules are easily dispersed onto plots surrounded by native vegetation. Also the moisture relations seem to have overwhelmed any mycorrhizal effects.

The plant seed and rhizome banks in the soil provide a source for extensive natural colonization. This increases cover and diversity. However, under actual mining conditions, soils may be stockpiled for six years or more rather than the one day of the study. This will reduce the biological components viability.

Poplar, willow, and birch plants were large enough and healthy enough to be above the bluejoint at the end of year one and nearly the same height at the end of years two and three. These plants initiated growth earlier than bluejoint in the spring. Since bluejoint dies back to ground level each year, woody plants have several weeks without significant bluejoint competition each spring (Figure 8). Longer-term monitoring will evaluate whether shade-tolerant native plants could colonize if the bluejoint growth can be suppressed by canopy closure of planted woody species. Crowding from bluejoint forced the plants to grow taller with more narrow crowns.

Figure 8. *Woody plants had begun expanding leaves while bluejoint was initiating growth. For the first several weeks or longer of each growing period, the woody plants are much taller than the bluejoint, thus reducing the amount of competition from bluejoint.*

Colonization by many species increases diversity. Dominance by a few species, such as bluejoint and fireweed, can suppress not only woody regeneration but colonization by other desirable native species. Hence, the use of seeded grasses to control bluejoint may not significantly reduce diversity since bluejoint may out compete other native colonizers.

However, bluejoint may be used to improve soil stability so it is desirable to help establish some plant communities. In particular, in some cases, *live* topsoil may be used in the mine's later years when some areas are being stripped while others are being reclaimed. Where steep slopes are involved, soils from areas with bluejoint cover could be used to promote early ground cover to prevent erosion.

These studies have produced useful information for the Wishbone Hill Coal Project. The scientific background and results are being shared with other coal mines in the area, the Alaska Miners Association, and state agencies. The study has produced valuable information for short-term reclamation planning. The plots are now beginning to provide longer-term information on species succession on disturbed sites. Private industry, state organizations, and the university worked together to find practical answers to a real Alaskan resource management problem. ❑

Figure 9. *Regrowth of bluejoint on upland meadow plots from shortly after planting woody species until end of 3rd growing season (August 1991).*

Acknowledgements

The Alaska Science and Technology Foundation and Idemitsu Alaska, Inc. jointly funded the study. The Alaska Division of Agriculture's Plant Material Center helped select plant materials and provided grass seed and some willow cuttings. Alaska Division of Forestry's Eagle River Nursery provided surplus alder, paper birch, and white spruce seedlings.

Special thanks go to Norma Saunders for help with planting the cuttings and seedlings and first year measurements. I would also like to thank C. Brainard, K. Brainard, and P. Reed for helping evaluate the plots in years two and three.

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Geographic Information Systems (GIS)

John A. Yarie
Associate Professor of Silviculture

A GEOGRAPHIC INFORMATION SYSTEM (GIS) is a computer-based information system designed to work with data referenced by spatial or geographic coordinates. A GIS may also include nonspatially referenced data. GIS programs are commonly used in decision making for managing the use of land, natural resources, transportation, retailing, etc. The primary connection among all the elements of the system is their geography—their location, proximity to each other, or spatial distribution across the landscape. Within this context a GIS can be viewed as a system of computer hardware, software and procedures designed to bring all the elements together. This facilitates input, management, manipulation, analysis, modeling and display of spatially-referenced data. Using the computer lets managers and others solve complex planning and management problems involving land resources.

This spring, the School of Agriculture and Land Resources Management and the Agriculture and Forestry Experiment Station inaugurated a teaching and research program based on GIS technology. A two-course sequence introduces undergraduates to GIS technology. Both courses include a laboratory section to give students a thorough understanding of the capabilities and potential pitfalls of GIS technology. The National Science Foundation awarded three supplemental equipment grants through the Long Term Ecological Research program, to help SALRM acquire the necessary computer hardware and software for landscape level analysis of important ecological factors in the Alaskan boreal forest.

One of the most time-consuming and expensive tasks in implementing a GIS is the data-acquisition phase. Within Alaska a number of data sets already exist. Other agencies and governmental entities developed these sets for specific management problems. For example, the Department of Natural Resources, Division of Forestry complied a vegetation inventory for the Tanana Valley State Forest. Soils, stream networks, and other information has been added to this database. The USFS, Tongass National Forest complied a comprehensive data set on the Tongass Forest to help in developing the current forest management plan. The Department of Natural Resources has an extensive database dealing with the *Exxon Valdez* oil spill, and the North Slope Borough has data that it uses to manage its lands related to oil industry development.

SALRM and AFES place a high priority on development of both teaching and research programs that use the GIS technology. Undergraduates in resource management are at a distinct disadvantage in today's job market without some knowledge of the capabilities and utility of GIS. Resource management is a landscape activity and as such is enhanced greatly by the analysis of resource problems with that landscape as an integral part of the problem-solving process. ❑

Gordon Worum and Don Jarvinen examine data with GIS computer system.

Models for Management :

Megabytes for Insights

John D. Fox
Assistant Professor of Land Resources

Models represent something else. Almost every day, we use models to help us. A map is a model of the landscape. A watch is a model of earth-sun relations. A checkbook serves as a model of our financial transactions. We use these and other models to explain, understand, describe, manage or predict.

Yes, just like the Shakespearean character surprised to discover he had been speaking "prose" all his life, we have been using models all of our lives.

In science, we use specialized models to find answers to questions of all sorts. In natural resources—as in almost all scientific fields—we rely heavily on the mathematical model in our research. Programmed and implemented on a computer, the mathematical model improves our understanding and management of natural resource systems.

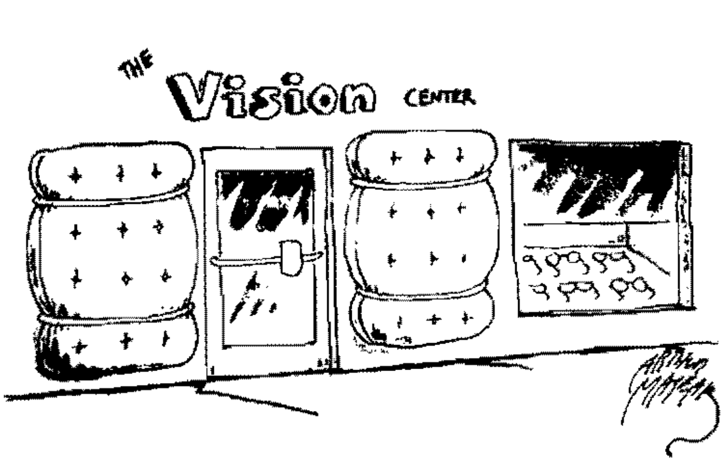
Natural resource managers and scientists use the models to organize and communicate information as well as to identify areas of research most relevant to solving specific problems. I prefer to start with a general model of the situation, and then, through progressive refinement, identify an area of high sensitivity and high uncertainty that needs further work. An artist takes much the same approach. The artist sketches the whole scene first, then progressively refines the specifics, sub-area by sub-area across the canvas.

Models also help researchers give more meaningful advice to managers. For example, I may start with a manager's general question of "what will be the effect of timber harvest on stream flow?" Typically, the university scientist's response is, "it all depends!" At this point the manager may shuffle away mumbling something about "ivory towers!" The scientist may shuffle off in the opposite direction mumbling "it's not that simple" or "no one has measured that in Alaska." With the appropriate model, however, the multitude of specific conditions related to geomorphology, soils, climate (and weather), and vegetation can be considered in a rational way. At least insight into the problem can be obtained and communicated.

In order to build such a model (or paint a picture) considerable effort must be spent looking at a variety of sub-questions or sub-models (just as an artist works on small intricate details of a painting). Sometimes the detail required may seem unrelated to the original management question. However, just as attention to detail contributes to the overall quality of a painting, the overall reliability of a model is increased by subtle refinements of sub-models. By working through a hierarchical modeling framework, the relevance of the detailed work to the original question is increased. Figure 1 shows a hierarchy of questions. Work on this particular branch of the model quantified a seasonal variation in the ability of cloudless skies to transmit solar energy. Such information directly feeds back into a sub-model of solar input to the landscape. It can also be used in other models to answer questions on seedling survival, photosynthesis, snow melt, soil thawing, solar heating design, etc.

After establishing an appropriate level of detail in the overall model, "what if" type questions can be asked. For example, I recently combined models of soil water flow and storage with models of soil freezing and thawing to simulate the effects of frozen soils on vegetation—stream flow relations. Through the use of this model I've gained insight into the effects forest harvest or climate change

Modeling: Pathway to Insight



would have on spring runoff and freeze-thaw depths. The model is speculative without field verification, but we cannot have a separate field experiment for every possible combination of latitude, slope, aspect, elevation, soil, and vegetation. Even if we could perform such a wide variety of field tests, results would be strongly influenced by that particular year's weather. Field experiments in natural resource systems are expensive, potentially dangerous, and not always subject to the degree of "control" needed for clear, unambiguous results.

However, with a mathematical representation of the system, we gain insight by artificially holding certain conditions constant. This way we can design and implement the "what if?" experiment. Using models to perform sensitivity tests, in hypothetical yet entirely possible circumstances, allows the range of possible responses to be investigated. In this way, not only do researchers give more relevant responses to managers, but managers formulate more relevant questions; questions not about what will happen, but rather about the probabilities of what might happen. Both researcher and manager benefit from insights gained through mathematical modeling when it is used in conjunction with common sense and data collection. ❑

When managing resources under environmental rules,

We must not become financial fools.

Use high, as well as, low tech tools,

GIS and Models in addition to mules !

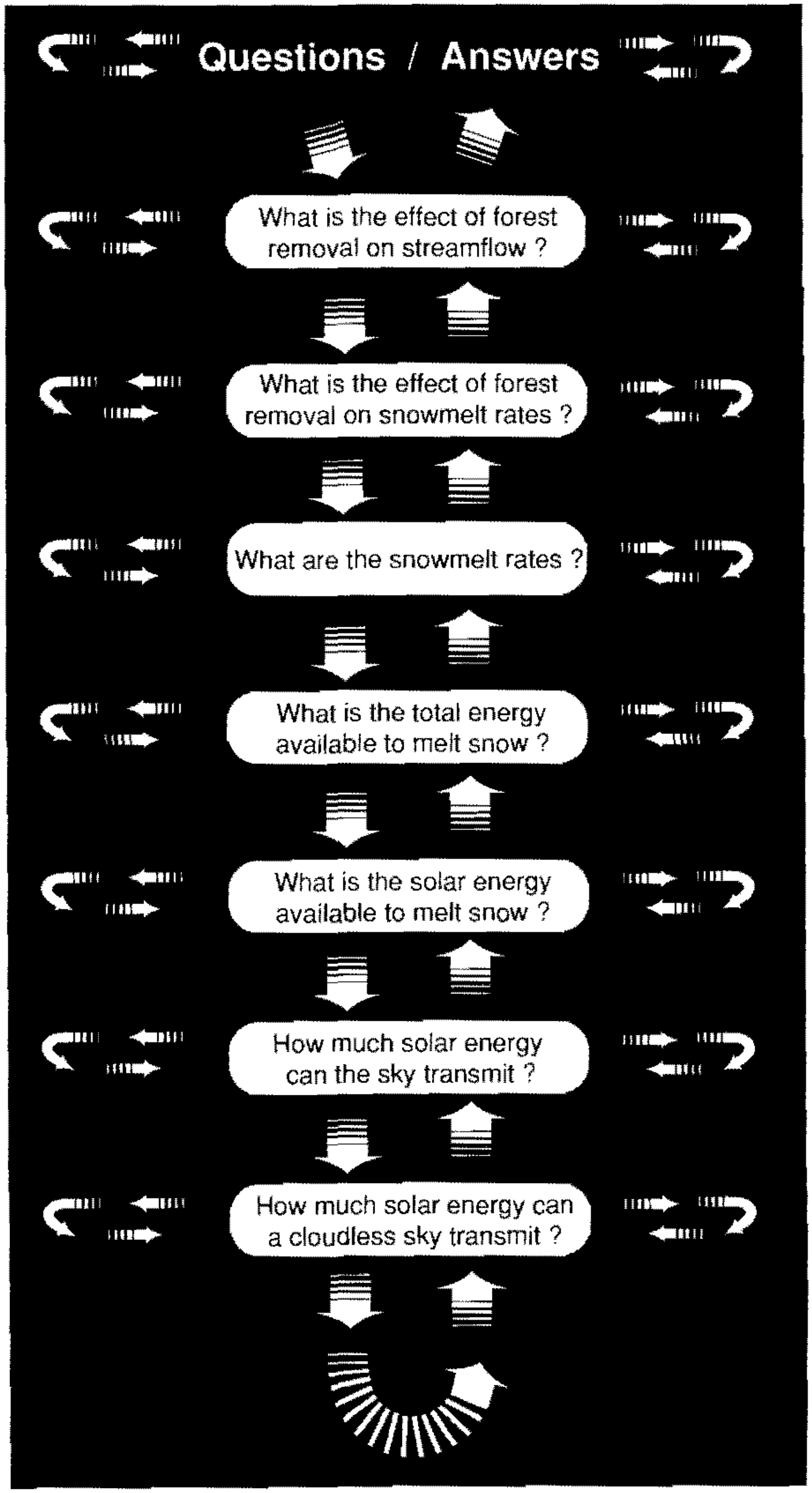


Figure 1. *Hierarchy of questions leading to a specific research project with answers flowing back to original question.*

On the Meridian of Friendship —
Soviet and American Scientists

O. Garmaev


Американцы в Иволге
Что увидели у нас ученые с Аляски?

"In the middle of June and in the beginning of July [1989], representatives of the University of Alaska Fairbanks, USA, visited the Buryat Scientific Research Institute (BurSRI) of Agriculture, SB VASKhNIL. We asked the scientific secretary of the BurSRI, O. Zh. Garmaev—who is in charge of the Institute's involvement with foreign institutions—to report on the visits and the prospects of cooperation between Buryatian and American scientists.

Editor's Note: This above article appeared in the weekly news sheet distributed in Ulan Ude, Buriat Republic, Siberia. University of Alaska Fairbanks graduate student John Stinson translated the original into English while leaving the original meanings intact. Although some of the "facts" about Alaska are incorrect, they were left as Garmaev wrote them.

Americans in Ivolga

What did the scientists from Alaska see here?

"Since growing conditions in Alaska are similar in a lot of ways with those of Siberia, an agreement on scientific and technical cooperation was concluded between the University of Alaska Fairbanks and the Siberian Branch of VASKhNIL. By the way, the university is known just as that—the University of Alaska Fairbanks—since it's in that 49th and largest of the USA's states. There are two more universities.

"The first delegation was made up of specialists in cropping systems, agrochemistry and soil science. In the first part of July we had the administrators of the University visit us: Chancellor Patrick J. O'Rourke, Director of the Agricultural and Forestry Experiment Station James Drew, and economics professor Wayne Thomas. John Stinson accompanied them as their translator.

"The routes we took both delegations on were practically the same: a meeting with the employees of the Buryat SRI, a viewing of our field experiments, getting acquainted with crop and livestock production on the experimental production farms, a trip to the Severobaikalsk Region. While in the BAM Zone [along the Baikal-Amur-Mainline of the Trans-Siberian Railroad], the agronomists visited Kumora and saw the experiments of the Siberian SRI of chemical use and cropping systems; the second group visited Kazachinsk-Lensk, where a station of the Irkutsk SRI of agriculture is located.

"In our institute's test fields, as well as in the BAM Zone, the Americans showed great interest toward applied crop rotation, tillage and fertilizer systems, and research methodology. Increasing soil fertility and protecting soil from erosion especially interested them.

"Extraordinary interest was expressed in our land clearing methods and technology and subsequent conversion into cropland. UAF is engaged in scientific studies to service the Delta region which, by its location (i.e. absence of reliable transportation) and environmental conditions, is a lot like our northern Transbaikal.

"Answering questions that interested our guests were our leading specialists - B.V. Bokhiev, B.I. Krivogornitsyn, F. Ya. Dudnikova, A.P. Batudaev, Yu. M. Nagaev, Ts. D. Tsyrendorzhiev, and others. The trip for the American university's administrators in the Severobaikalsk Region was led by our Institute's director, B.I. Nikolaev.

"Of course, we had our own turn to probe a little about the achievements in the agrarian science of the American north. In short, our guests related the following:

"The main grain crops in Alaska are oats and barley. Wheat is cultivated in limited quantity because conditions are too severe. This, in my opinion, is smart. In Buryatia, a zone of high-risk agriculture, with all its livestock specialization it also would be prudent to not produce commodity grain to sell in regions outside Buryatia; what should be done is to sharply increase the volume of oats and barley and orient wheat only for feed use.

"Barley yields in Alaska range around 30-35 c/ha [55-65 bu/acre]. Barley is considered valuable feed not just for cattle but also for . . . dogs! It seems the highly nutritious and light feed made from barley is in big demand in Alaska and is actively sought after in other countries where dogs are used for transportation or sport racing. Every year in Alaska there are Olympic games for the state's Natives—Eskimos, Indians and Aleuts—and an obligatory element of these games is sled dog racing.

"The most widely distributed of the herbaceous crops are rape and bromegrass. Potatoes are cultivated. Scientists have developed some rather cold-resistant potato varieties.

"Corn cultivation under mulch is being studied. Strawberries are grown under plastic. It's also profitable there to grow flowers, and hi-tech flower cultivation is operating throughout the state.

"The university is also digging into how to develop livestock farming. There's only one meat plant in Alaska, and it's located 120 km [75 miles] from the state's largest city, Anchorage. It's curious that in Alaska they raise beef cattle only up to 430 kg [948 pounds] live weight because fatty meet is not in demand.

"I accompanied the first group around the Severbaikalsk region. On the state farm, Tyiskii, the supervisor of the dairy herd commented with an element of pride that with milk yields of 3100 kg [6834 pounds] per cow [when averaged over both milking and dry cows] his farm was holding first place in the region. He was a bit chagrined when he learned that the average yields in Alaska reach 7000 kg [15,432 pounds] per milking cow. They use black and white Holsteins which receive silage and hay year-round. Up to 25 percent of the cows' ration is made up of concentrates. Hay is virtually not used. The cows are not even taken out to pasture.

"The meat supply in Alaska is regularly supplemented with buffalo meat. In the western region, reindeer farming has been developed.

"Soya flour [soybean meal] is used in significant quantities for feed; Fish meal is sometimes partially substituted [for the soybean meal]. One fact is interesting: Americans prefer to consume milk with low fat content. This, as with lean meat, has its own reasoning; there are far fewer 'full-figured' people in the USA than in the USSR.

"That's basically how we got acquainted with them and came to understand their viewpoints. The Americans were intrigued by our spring barley varieties, in particular with a variety that has just this year been put out into production, 'Vitim'. And we, in turn, have things we can learn from the Alaskans' scientists. For example, they showed us slides of an original way to make silage; it was really interesting for us.

"Along with the likely, mutually-beneficial scientific and technical cooperation between the University of Alaska Fairbanks and the Buryat SRI of Agriculture, however, our meetings were not less important if you look at them as a way to get to know one another. I, for example, was with the Americans only five days, three of which we spent together in a nice hotel, the Severnyi Baikal near the city of Severobaikalsk. The feeling was such that I had known these people for a very long time. In essence they are the same people as our national comrades. They're also genuinely interested in peace for our planet, in keeping our Earth clean, and in preserving her gem, Lake Baikal. They love practically the same foods that we do, except that they prefer coffee to tea, without sugar to boot.

"They are humble, sociable, they laugh infectiously. True, I wasn't lucky: in the first group there were no chess players. At least the second group accepted the challenge from our director, B.I. Nikolaev, and one of the staff from the department of feed production working in the BAM Zone, A.B. Butukhanov. And history's first-ever chess match between Americans and Buryats went in the latter's favor.

"The American guests were deeply impressed by the Ethnographic and Natural Museums. They came to know Ulan-Ude and Severobaikalsk. There they visited the BAM Historical Museum. And they had the opportunity to take a dip in the Khakusy hot springs.

"The American scientists also visited the Ivolginsk Datsan—the USSR's Buddhist center. There they had the chance to get acquainted with the decor of the main monastery and the exhibitions in the museum, where unique objects of the past are collected. E. Tsybikzhapov, of the center, described to them in detail about the Buddhist religion and what Buddhism has contributed to strengthening friendship and cooperation between nations. He also handed the guests some traditional *khadag* [white silk scarves] and some brochures about the Datsan in English. It would seem that this is one more gesture of goodwill from the Soviet people, one more brick in the foundation of a building bearing the sign 'NEW THINKING.' ”

Alaska Grown —

Implementation of a Positive Agricultural Policy

Ruthann B. Swanson, Carol E. Lewis and Frank G. Mielke

ALASKAN AGRICULTURAL development has followed the increased demand for food during boom periods (Pearson and Lewis, 1989). Throughout the territorial era and into statehood, agricultural lands have been considered an important resource (Lewis, Pearson and Thomas, 1987). However no policy encouraging agricultural development was adopted until 1976 (Resolution 77). Generally, like the federal policies that date from 1959 to 1989, the state division of agriculture has been production oriented. Specific directives implementing policy have ranged from totally absent to very specific.

Within the Alaska State Division of Agriculture, the current six policy directives, emphasize a cooperative relationship with producers. Five address capitalization in the industry. The sixth addresses marketing and consumer concerns:

> *Look to the marketplace — don't produce what you can't sell. Grow crops that suit Alaska's climate and Alaskans want to buy.*

This directive aims to increase the market share held by Alaskan products. It seeks to substitute locally produced for imported products and establishes the criteria to identify quality characteristics of Alaskan products. The strategy implementing the directive is the *Alaska Grown* Program. The *Alaska Grown* Program works. A recently completed survey of 400 urban Alaskan consumers documents its success. Methodology outlined by Dillman (1978) was used. Response rate was 93 percent.

Demographic characteristics of the survey population are summarized in Table 1. Among the respondents, 73 percent were the primary food preparer as well as the primary food purchaser. Sixty-five percent of the primary food preparers were employed outside the home for 20 or more hours per week. (Swanson and Lewis, 1991). When compared to residents of the contiguous 48 states, Alaskans tend to be younger and better educated, have higher incomes and have slightly larger households (Hunter & West, n.d.).

The *Alaska Grown* Program

In affluent western countries, many similar products, both local and imported, compete for market share. To secure and maintain market share, products must fill a need or desire. Urban Alaskan consumers are dissatisfied with the quality of produce available (Swanson and Lewis, 1991). They want high quality produce. Specific quality characteristics of fresh and processed products produced in-state must be met to qualify for the *Alaska Grown* logo (Figure 1). Quality attributes of fresh produce include appearance, condition and other factors that influence eating quality. As a result, 71 percent of the urban Alaskan primary food purchasers surveyed, look for the *Alaska Grown* logo. These consumers were not distinguishable by income, education level, household size or sex, according to Chi-square analysis. Respondents who shopped primarily at an Alaskan supermarket chain were no more likely than those who shopped at a national chain to look for *Alaska Grown* products. This indicates that shoppers from all segments of the population look for and buy *Alaska Grown* identified produce.

The colorful, unique and easy to identify *Alaska Grown* logo was first used in 1986. It has become a frequent sight in advertisements, retail markets and food shows around the state. Point-of-purchase posters and stickers on many commodities help consumers identify these Alaskan produced products and add visibility and success to the program.

Producer participation in the *Alaska Grown* program has steadily increased (Figure 2). The individual

Figure 1. *The Alaska Grown logo.*

Characteristic	% (N = 400)
Gender	
Male	34
Female	66
Age range	
18 — 24	8.3
25 — 34	31.0
35 — 44	31.5
45 — 54	13.8
55 — 65	9.8
65 and above	5.8
Education level (highest level completed)	
Less than high school	1.5
High school graduate	20.5
Some college or formal training beyond high school	38.0
College graduate	25.0
Graduate school	15.0
Number of people in household	
One	10.8
Two	28.5
Three	22.3
Four	21.3
Five or six	14.3
Seven or more	3.3
Income	
Under $8,900	2.9
$8,901 — $29,999	15.5
$30,000 — $49,999	33.2
Over $50,000	48.4

Note. Figures are expressed as percentages of the total number of respondents.

Table 1. *Survey sample demographic characteristics.*

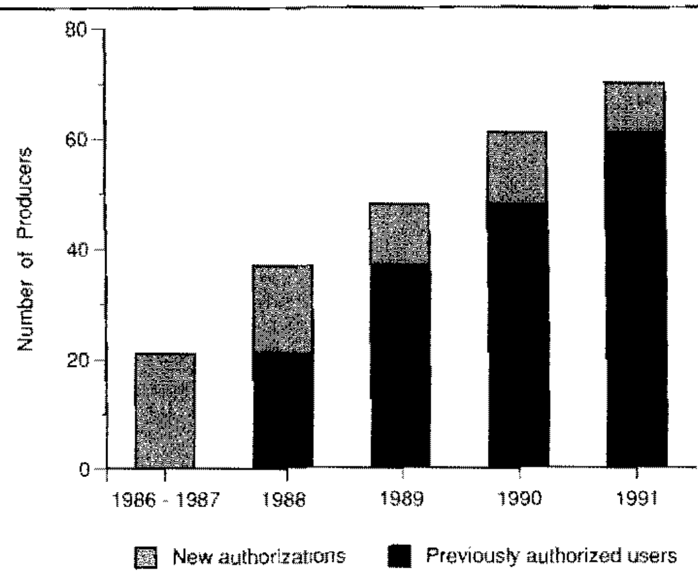


Figure 2. *Number of producers using the Alaskan Grown logo.*

farmer—who may be a small producer—gains the market visibility associated with this shared logo. In effect, Alaskan consumers perceive this logo as a brand name. Brand name, a typical indicator of the importance of quality, is becoming increasingly important on fresh products.

Positive consumer and producer response to the *Alaska Grown* program indicates the potential for an ongoing, cooperative strategy, especially one that addresses consumer concerns and provides farmers with an opportunity for market entry. ❑

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Ping and Sharratt Monitor Wetlands

Dr. Chien-Lu Ping, associate professor of agronomy, received a $25,000-a-year award for 1991–1993 to study the criteria of wet soil classification in Alaska.

The USDA Soil Conservation Service and U.S. Army Waterways Experiment Station are funding Ping's work. The study will establish baseline data for redox potential, water potential and temperature of seasonally frozen permafrost soils and the depth and period of soil saturation. These data are expected to provide information on:

1. growing season and hydric soil criteria in the National Wetland Manual for the Alaska region;
2. redoximorphic features and aquic conditions for soil classification and interpretation; and
3. effect of land use management on soil temperature and soil moisture regimes.

Dr. Brenton Sharratt of the USDA Subarctic Agriculture Research Unit in Alaska will cooperate with Ping. Sharratt has studied the effects of land use management on the surface energy balance. Micrometerological parameters of a forest and cropland site are compared at two locations in interior Alaska.

The study will monitor soil properties at 11 sites. Five sites are in the Matanuska Valley—three in Palmer and two at Point MacKenzie—where soils have seasonal frost. Three sites are near Delta Junction. One site has artesian hydrology. The other two Delta sites are similar; they represent a thawed (cleared of forest) and a permanently frozen (forest) phase of the same soil type. In Fairbanks, a paired site consists of permafrost soil and its thawed counterpart on the university experiment farm. The third Fairbanks site is permafrost soil near Smith Lake.

Monitoring equipment installed on the permafrost soils include time-domain reflectometry (TDR) probes and neutron probe access tubes for soil water content, pt' electrodes for redox potentials, air temperature thermocouple sensors for air and soil temperatures, relative humidity probe, wind speed sensors, net and global radiometer, and soil heat flux transducers.

On soils with seasonal frost or thawed permafrost soils, monitoring equipment installed includes thermocouple sensors for air and soil temperatures, pt' electrodes for redox potentials, tensiometer for soil water potential (measured by tensiometer), and piezometer for soil water table measurements.

The information gathered will contribute to the classification, mapping and better interpretation of permafrost and seasonal frost soils, and to establish baseline data of hydric soils in Alaska. Hydric soil is one of the three technical criteria of wetlands. ❑

First Circumpolar Agricultural Conference

September 28 — October 2, 1992

Researchers, producers and others interested in northern agriculture will meet to share information and ideas at the *Sustainable Agriculture in a Circumpolar Environment* in Whitehorse, Yukon Territory, September 28–October 2. This first circumpolar agricultural conference will concentrate on four basic areas:

- Research,
- Production,
- Policy Development, and
- Market Development.

Among the specific topics on the program will be discussions of cultivation of permafrost affected soils, equipment engineering and design, conservation policy needs in circumpolar regions and marketing barriers.

An international committee from throughout the circumpolar world—Alaska, Canada, Finland, Greenland, Iceland, Norway and Sweden—is coordinating the program. The conference is designed to foster technology-sharing and information transfer of successful applications and research from throughout the North.

To register or for additional information contact the Circumpolar Agricultural Conference Headquarters, 103-302 Steele St., Whitehorse, Yukon, Canada Y1A 2C5. ❑

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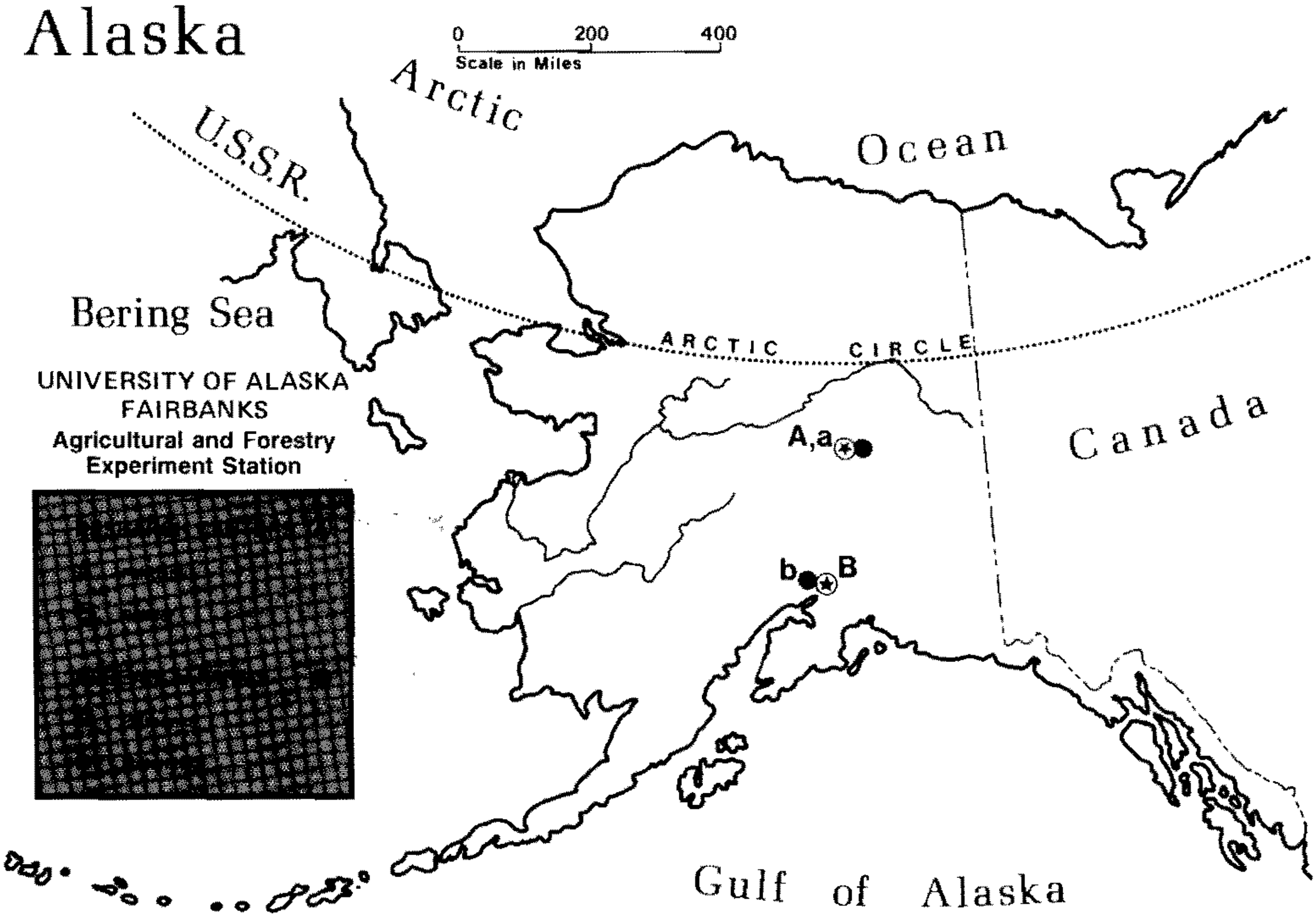

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