Agroborealis

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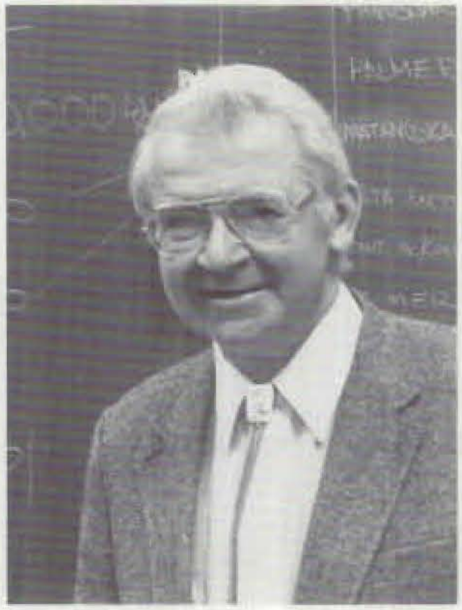
Agricultural and Forestry Experiment Station
University of Alaska-Fairbanks

From the Director's Desk:



In this issue of Agroborealis, *you will notice a change in our name from the Alaska Agricultural Experiment Station to the Agricultural and Forestry Experiment Station. This change reflects an increasing emphasis on research in forestry within the experiment station. Moreover, research on forestry in the experiment station is coordinated with teaching and public service in forestry, resource management, land-use planning, and outdoor recreation within the School of Agriculture and Land Resources Management, University of Alaska-Fairbanks.*

For more than a decade, research in forestry has been an important and integral part of the agenda of the experiment station. Particularly important are research programs in northern forest ecosystems under the aegis of our Forest Soils Laboratory, as well as research designed to solve specific problems in forest management identified by the Alaska Division of Forestry and the Forest Service, U.S.D.A.

This work has resulted in scientific journal articles, technical bulletins, chapters in books, symposium papers, and articles in Agroborealis *to document conclusions from the research. In addition, through a poll of forest managers in northern countries, the School of Agriculture and Land Resources Management identified forest regeneration at high latitudes as a forest management problem of circumpolar interest. Consequently, annual workshops sponsored by the school in cooperation with state and Federal agencies have been held since 1979 in Alaska, Canada, and Sweden. Proceedings of these workshops have been published cooperatively each year by the school of Agriculture and Land Resources Management and the Pacific Northwest Forest and Range Experiment Station, Forest Service, U.S.D.A., in Portland, Oregon.*

Approximately one-quarter of the research budget of the experiment station within the School of Agriculture and Land Resources Management is devoted to forestry research. This includes Federal formula funds made available to the experiment station from the Cooperative State Research Service, U.S.D.A., through the McIntire-Stennis Act as well as state appropriations, grants, and contracts. Scientists involved in forestry research also teach in the bachelor's and master's degree programs in natural-resource management offered by the School of Agriculture and Land Resources Management. A staff member who works with a demonstration project in intensive forest management within the school also holds a joint appointment as an extension forester with the Cooperative Extension Service. In addition, the school and its associated experiment station function in close cooperation with the Institute of Northern Forestry operated by the Forest Service, U.S.D.A., on the campus of the University of Alaska-Fairbanks.

Effective management of forest land in Alaska for a variety of uses and the successful development of forest products industries in the state will require new research results and the application of these results in forest management systems. Research toward this end is underway within the Alaska Agricultural and Forestry Experiment Station.

Sigmund H. Restad

Sigmund H. Restad, Acting Director

(Editor's note: In this issue of *Agroborealis*, "From the Director's Desk" was written by Sigmund H. Restad, acting director of the Agricultural and Forestry Experiment station. Mr. Restad will serve in this capacity until July 1, 1985, when he will return to his usual position of assistant director. At that time, Dr. James V. Drew, serving at the request of University of Alaska-Fairbanks chancellor Dr. Patrick O'Rourke as acting vice-chancellor for academic affairs at UAF, will return to his dual position of director of AFES and dean of the School of Agriculture and Land Resources Management. During this period, Dr. Wayne C. Thomas, professor of agricultural economics at AFES, will serve as acting dean of SALRM.)

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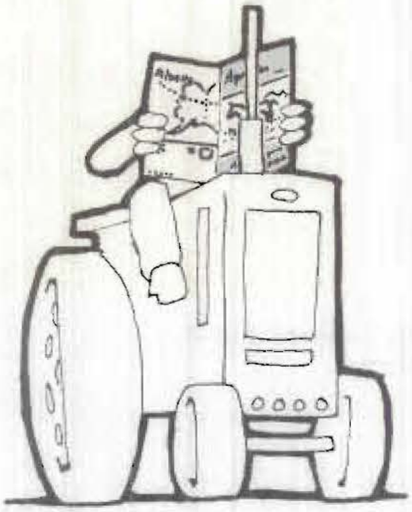
ABOUT THE COVER . . . *An overmature, 250-year-old, white spruce forest stand with a moss-lichen floor. Such forests demonstrate important, but often unrecognized, ecosystem relationships. Throughout stands like this one, one can frequently find the diggings of rodents in search of truffles, the fruiting bodies of underground cup fungi. These truffles form a mycorrhizal relationship with the roots of white spruce. Research into such important relationships within a forest community will enable scientists to recommend forest management practices that will lead in turn to long-term successful production of forest products.*



AFES Notes

Ground-breaking ceremonies for the new AFES laboratory building at Palmer included, left to right, Alaska State Senator Jalmar Kerttula of Palmer, University of Alaska-Fairbanks Chancellor Dr. Patrick J. O'Rourke, and Dr. James V. Drew, director of the Alaska Agricultural and Forestry Experiment Station and dean of the School of Agriculture and Land Resources Management, UAF.

The Agricultural and Forestry Experiment Station's Matanuska Research Farm near Palmer is getting a new laboratory building. Completion date for the 12,800-square-foot research facility is the end of May 1985. The construction is being financed by a $2,560,000 legislative appropriation obtained through the efforts of Alaska state Senator Jalmar Kerttula of Palmer.

Designed by the architectural firm Selberg Associates Inc., the new structure will upgrade the existing agricultural research capabilities for the staff presently working at the Matanuska Farm and the Palmer Research Center. The facility will also provide for expanded coordination with the agricultural education programs of the Mat-Su Community College. The existing obsolete central plant now located in the maintenance shop will be replaced with a boiler system located in this new building.

Dr. Jenifer Huang McBeath, plant pathologist at the Agricultural Experiment Station, Fairbanks, has been awarded a grant by the United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine Program, for the continued development of a computer-based plant pest data storage and retrieval system in Alaska. Dr. McBeath is the chairperson of the Alaska Plant Pest Survey and Detection Committee, which is a charter member of the Cooperative National Plant Pest Survey and Detection Program.

Dr. McBeath was an invited speaker at a "No-till Winter Crop Production" workshop at Pocatello, Idaho, last November. The topic of her talk was "Snow mold—yield loss, cause, control." Over two-hundred farmers and

. . . Continued on page 50

Forest Landscapes of Interior Alaska

By

Keith Van Cleve*

The pattern of forest-type distribution seen across the landscape of interior Alaska owes its mosaic character to two key environmental factors: topography and the incidence of forest fires. Topography, through its slope and aspect components, determines the amount of radiation received on the landscape and, consequently, soil temperature, the degree of soil drainage and moisture content, and patterns of precipitation. The occurrence of forest types in generally predictable locations across the landscape is an indication of their ability to establish and survive in habitats in which soil temperature, moisture, and fertility favor their growth and reproductive requirements. Fire controls the character of the forest by modifying plant-species compositions and age-class distributions of the tree cover. Moreover, fire acts as a rapid decomposer of organic materials through the combustion process. The result is a renewal of supplies of chemical elements formerly locked up in dead plant parts which had accumulated on the soil surface since the last fire. The improved nutrient supply helps support the growth of the next generation of trees which occupies the landscape.

An example of the landscape pattern of forest types in the Fairbanks area is seen in the photograph. Black spruce forests are encountered on north aspects and on poorly drained lowland sites indicated by points "A" and "B." A lush ground cover of mosses characterizes these sites. This plant cover overlies relatively thick accumulations of slowly decaying organic matter (largely moss remains). The surface organic mat helps to maintain cold soil temperatures, and a shallow, poorly drained, thawed layer of mineral soil over permafrost. Tree production on these sites is the lowest encountered among interior Alaska forest types. The black spruce currently has no commercial timber value. However, this forest type provides valuable watershed cover and game habitat. Several species of edible, wild berries occur in these forests. The common woody shrubs include willow, alder, blueberry, lingonberry, and Labrador tea. Grasses and horsetails also are found there.

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Point "C" represents the wettest, most poorly drained condition commonly encountered adjacent to small drainage ways. Sphagnum moss and scattered black spruce are the most common plants on these wettest sites.

Warmer, south-aspect sites and more-productive forests are seen in the middle distance of the photo. Point "D" shows a south-aspect white spruce forest. While a lush ground cover of feather mosses still exists in this forest, only about one-half to two-thirds the amount of organic matter encountered in the black spruce forests accumulates on top of the mineral soil in these locations. Soil temperatures are nearly twice as warm on south aspects, and tree production may be five times that of the black spruce forests. Because of the warmer soil temperatures and better drainage, these locations generally are free of permafrost. In interior Alaska, greatest commercial utilization is currently taking place in this forest type. Wood products from this forest include house logs, rough and finished construction-grade lumber, and firewood. Shrub vegetation in these locations includes alder, prickly rose, high-bush cranberry, twin-flower, northern comandra, and horsetails.

The types encountered in zone "E" are characteristic of south-aspect paper birch and quaking aspen forests. Little or no moss ground cover occurs in these forests, and only about one-third to one-half the organic matter encountered in the black spruce forest occurs on top of the mineral soil. Consequently, the substantially warmer (up to three times warmer than black spruce forest soils), well-drained soils of these locations are free of permafrost. Along with white spruce forests, these sites are preferred for home construction because of the higher temperatures and absence of permafrost. Paper birch is used primarily for firewood. To a lesser extent, aspen is also used for home heating. Shrub vegetation commonly includes alder, high-bush cranberry, prickly rose, buffaloberry, twin-flower, and kinnikinnick on drier locations.

Annual tree production generally reflects the influence of topography on soil temperature. Black spruce forests growing on cold soils show the lowest production. White spruce, birch, and aspen display increasing productivity in that order. Aspen forests may be up to seven times more productive than black spruce forests. This array of forest

Relative positions of major forest-cover types in interior Alaska.

types across the landscape of interior Alaska provides graphic evidence of growth response to the environment.

This interaction among topography, forest type, and fire was clearly demonstrated by the recent Rosie Creek fire which occurred west of Fairbanks in June of 1983. The fire burned examples of most of the forest types encountered in interior Alaska. To a large extent, the intensity of the fire depended on topography. Trees in most of the burned area were killed regardless of topographic location. However, upland, well-drained, drier sites experienced more severe combustion of the organic layer which covers the mineral soil surface. In many cases, this material was completely burned. In poorly drained, wetter, lowland sites, this ground-surface organic matter was only slightly burned because of its high water content. Plant cover on many of the severely burned upland sites is recovering. The new growth includes dense stands of aspen sprouts and other herbaceous plants which produce excellent moose habitat. The composition of the forest in the short postfire period has largely been determined by the plant species which were able to survive the fire and those which regenerate by stump or root sprouting or from buried seeds or rhizomes. Aspen and birch have the capability to root and stump sprout, respectively. The extensive forests comprised of these species which are encountered in interior Alaska depend on periodic fires for establishment and maintenance. Long-term elimination of fire from the environment could result in a forest largely dominated by two species: white spruce and black spruce.

Foresters take advantage of the natural distribution of forest types by managing sites for the appropriately adapted tree species. Research is contributing to a clearer understanding of the factors which control forest distribution, growth, and development in interior Alaska. This information provides a firm basis for management of our renewable forest resources. □

Moose-Browsing Damage in a Recently Thinned Stand of Sapling Paper Birch in Interior Alaska

By

Allen P. Richmond*

Introduction

The University of Alaska's School of Agriculture and Land Resources Management has, since 1980, been conducting intensive research in the field of forest management with the goal of identifying economically and biologically feasible forestry practices for use in managing interior forests. One of the practices being examined is thinning, i.e., a portion of a stand is removed to promote growth on the remaining trees. Although thinnings normally decrease the total volume of timber which can be harvested from a stand, the value of the stand increases due to the large size of the trees at harvest. Thinnings can be done on both a commercial and precommercial basis depending on the tree species, the management objectives for the stand, and the anticipated value of the stand at harvest.

The trees removed in a commercial thinning can be sold as fuelwood, poles, pilings or sawlogs, thereby helping to pay the cost of thinning. Precommercial thinnings are performed in sapling stands where the material to be removed does not have any commercial value. In this case, the increase in value of the thinned stand has to be great enough to offset or justify the treatment cost. The response of the stands to the thinning treatments is being assessed with regard to diameter-height growth and post-treatment damage. Types of damage most common to thinned stands are windthrow, snow breakage, and insect attack. A recent precommercial thinning in a sapling paper birch stand suffered some browsing damage from moose which may have a bearing on future intensive management of this tree species.

The potential for moose browse damage of the residual trees had been recognized prior to the thinning treatment. The stand was known to receive heavy use in winter by moose, as evidenced by the large number of broken and browsed trees observed over the two previous winters. As many as four moose had been observed in the area at one time. During the thinning-treatment period, a moose which had apparently broken the tops of four residual birch trees was observed in a portion of the stand already thinned. Studies of moose feeding habits have found that paper birch is a major food source and comprises between 12 and 35 per cent of total diet (Peterson 1955). This is supported by other research that indicates birch is heavily used when available (McMillan 1953, Dodds 1960, Bergerud and Manuel 1968, Crêté and Bedard 1975, Telfer and Cairns 1978). Palatability (preference) for birch has been rated as equal to willows (Hosely 1949).

Methods

The sapling birch stand in which the thinning was performed is located in the Standard Creek portion of Goldstream Valley west of Fairbanks and was naturally reestablished after a fire in the mid-1960s. Stand age at the time of treatment was 16 years. As can be seen in Figure 1, the stand regenerated heavily to birch, black

Figure 1. The composition of the Standard Creek sapling-birch stand as shown on the unthinned control plot.

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Figure 2. Typical main-stem breakage. The average height of the break was approximately 6 feet, but ranged from 4 to 7 feet.

Figure 3. A typical response of birch to stem breakage is the development of a new leader at or below the break.

spruce, and white spruce. Stocking levels of trees greater than 0.5 inch diameter at breast height (DBH) in the treated portions of the stand ranged from 4,610 to 13,130 stems per acre for all species. (DBH is measured at a height of 4.5 feet.) Birch was the dominant tree species in both diameter and height with only a few spruce reaching heights taller than 6 feet. The thinning treatment was performed in September and October 1983 using gas-powered brush-cutting saws. Trees to be retained were selected on the basis of height, form, and spacing, with the tallest, straightest trees left at an approximate spacing of 10' x 10'. All damaged trees were removed. The post-thinning stocking level for the stand averaged 510 stems per acre, or 17 per cent higher than the 436-stem target.

An assessment of the moose damage in the thinning was made in May 1984 using the five .1-acre permanent plots established to monitor diameter growth. The damage to the stand was found to be of two types: main-stem breakage (fig. 2) and twig or branch browsing. At this time of year, it was easy to distinguish between twig browsing which occurred during the winter of 1983-84 and that which occurred in previous winters, as the broken ends of twigs had not yet discolored with age.

An analysis of the diameter and height distributions of the broken and unbroken stems was made to determine if the moose selected saplings of a particular size. DBH measurements were made on all trees at a height of 4.5 feet using .01 inch-increment diameter tapes. Total height measurements for the unbroken trees as well as the browsed trees were obtained using a Philadelphia Rod. Measurements of total height and height to point of breakage for the broken trees were obtained using a 100-foot cloth tape. Due to the fact that the moose browsed the small branches of the tops once they were down, the missing portion of the stems had to be estimated. Depending on the diameter at the point of browsing, these estimates added from 1 to 2 feet to the measured height of the stem.

Table 1. Summary of damage on each of the thinned measurement plots.

Plot number	DBH (Ave.)	Trees/ plot	Breakage No. Trees	Breakage %	Browse No. Trees	Browse %	Total No. Trees	Total %
1	1.52	51	2	3.9	3	5.9	5	9.8
2	1.61	46	4	8.7	1	2.2	5	10.9
3	1.43	53	10	18.9	1	1.9	11	20.8
4	1.24	54	16	29.6	4	7.4	20	37.0
Average	1.45	51	8	15.7	2.25	4.4	10.25	20.1

Results

The average amount of damage to the residual trees for all plots was 20.1 per cent, ranging from 9.8 per cent to 37.0 per cent (table 1). By far the largest amount of damage was breakage. This is also the category of damage which is of most concern in managing sapling birch. Whereas browse damage is normally confined to the lateral twigs, breakage of the main stem causes a major deformation in the bole of the tree. Breakage does not always result in mortality, as large numbers of trees were removed during the thinning operation that had new leader development at or below the break caused by moose browsing in the previous years (fig. 3). A wound of this type and size takes a number of years to heal and serves as a point of infection for various fungal rots that can attack birch (fig. 4). As the average height of the stem break was found to be 5.9 feet, the bottom 6 feet of the stem is not useable for the production of lumber. This makes it good only for fuelwood, a much less valuable product.

Analysis of the breakage found on each plot showed a correlation between decreasing average plot tree diameter and increasing amounts of breakage. Even though only four plots made up the diameter-damage sample, this relation-

Figure 4. Typical internal defect caused by stem breakage. Note the darkened heartwood of a prerot condition. The damage to this stem occurred 6 years before sampling.

ship is supported by the fact that breakage was restricted to the smaller-diameter trees. No main-stem breakage occurred to trees larger than 1.75 inches or smaller than 0.8 inches DBH (fig. 5). A majority of the breakage (78 per cent) occurred in the 0.9- to 1.35-inch diameter classes. The average diameter of the broken stems was 1.17 inches. A study of moose damage in Elk Island National Park, Alberta, found that the average diameter of broken paper birch stems was 1.38 inches, with the diameter range of most frequently broken stems being 0.51 to 1.54 inches DBH (Telfer and Cairns 1978).

Over the range of diameter classes which sustained stem breakage, there was a statistically significant difference between the heights of the broken and the unbroken trees. Compared to an average height of 14.4 feet, the broken stems were 2.3 feet shorter. Some or all of this difference may be attributable to measurement error caused by estimating the length of missing leaders and the reconstruction of severely broken stems. Due to the uncertainty of the height measurements, it is not possible to determine whether or not the broken trees were actually shorter for a given diameter than the unbroken trees.

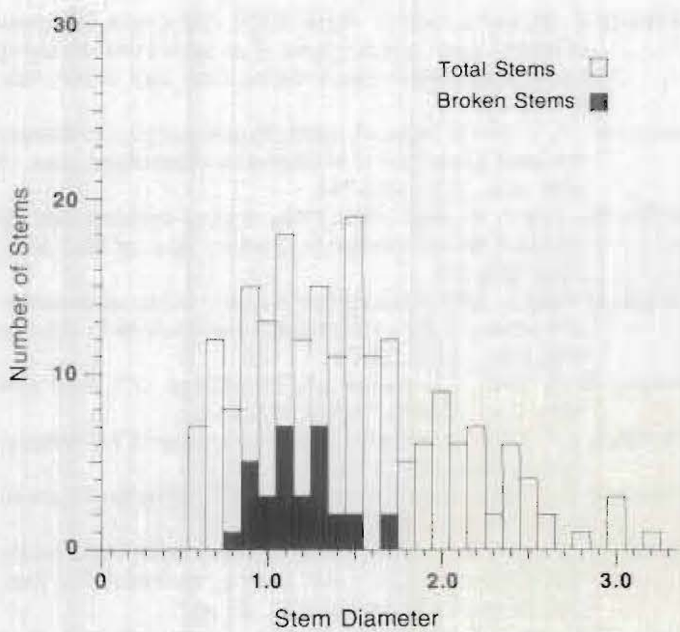

Figure 5. Frequency distribution of total residual stems and broken stems for all thinned plots by 0.1-inch-diameter classes.

Twig browsing was found to be spread over a wider range of stem diameters than breakage. Saplings up to 2.7 inches DBH were found to have been browsed, though in the larger diameters it was restricted to low lateral branches only. This corresponds to findings that 96 per cent of the moose browsing which occurs on trees takes place at heights under 12 feet (Dodds 1960). In the smaller diameters, particularly those under 1.0 inch, browsing had taken place on the tops as well as the laterals. The tops of some trees removed in the thinning operation had been browsed back repeatedly so that they had multiple leader development and a bushy appearance (fig. 6). Although not as severe a form of damage as main-stem breakage, top browsing can cause a stem deformation which may or may not be outgrown. At heavy levels, over a period of time, browsing can reduce the size of the trees from what they would be if left unbrowsed (Bedard et al. 1978).

Moose damage of both types did not appear to be concentrated on, or restricted to, the thinned portions of the stand, as damage was observed throughout the stand. On a per-acre basis, the control plot received slightly more damage (210 stems per acre) than did the most heavily damaged thinned plot (200 stems per acre). The effect of the damage on the control was not as severe as in the thinned portion of the stand due to the large number of stems present. On the basis of average prethinning stem count of 7,048 per acre for the stand, only 3.0 per cent of the stems were damaged.

Figure 6. The bushy appearance of this birch sapling has been caused by main-stem breakage and subsequent browsing by moose.

Management Options

Several options available for thinning sapling birch will reduce the effect of moose damage, particularly main-stem breakage. These will increase the number of residuals to allow for loss while maintaining adequate stocking or making the stand less susceptible to damage.

The first is to increase the number of residual stems to a level at which the stand will still have adequate stocking even if severe damage does occur. As no stocking guides for paper birch have been developed for Alaska, "adequate" stocking has to be based on management experience from other regions. The post-thinning stocking guidelines used for birch management in the northeast states (Safford 1983) indicate that 300-400 stems per acre are adequate. Using this level and an allowance equal to the highest amount of breakage suffered by the stand (29.6 per cent), a residual stocking level of between 390 and 520 stems per acre would allow for losses. This range corresponds closely to the stocking on the remeasurement plots in the Standard Creek thinning. The problem with this option is that the moose damage was not uniform over the thinned portion of the stand, but occurred in patches. This left some portions of the stand too heavily and others too lightly stocked. Differences in stocking could have a detrimental effect on stand value by reducing the growth rates of trees in the overstocked portions and, thus, their size at harvest.

The second option is simply to delay the thinning operation until there are a sufficient number of stems over 1.8 inches DBH to provide adequate post-treatment stocking. This minimum residual diameter was selected because all breakage observed occurred to smaller stems, and diameters above it received only minor browse damage. In Safford's birch-management guide, the recommended timing of the thinning is between 20 and 25 years. A problem with this approach is that delaying the thinning of sapling birch stands until they reach this age may reduce the value of the timber crop over a given rotation age, particularly if the stand is heavily overstocked. The time that saplings spend in a suppressed condition reduces the size of the crop trees over a given rotation period due to increased competition for moisture, light, and nutrients. A delay in thinning may also increase the cost of treatment, as the larger the stems become, the harder they will be to cut. The larger stems may also create more of a slash problem. Heavy slash may cool the soil enough to reduce the potential for growth over the first few years after thinning.

With regard to the sapling birch stand in Standard Creek, indications are that the thinning could have been delayed. Remeasurement of the permanent plots in October of 1984 revealed that the diameter growth of the selected crop trees on the unthinned plot equals that of trees on the thinned plots, or 0.22 inches per year. Although this probably reflects a delayed response to treatment on the thinned plots, it clearly indicates that the selected stems on the control are not suppressed. If the growth of the unthinned birch continues at or near present rates, a delay in thinning this stand until age 20 could have increased the average plot diameter of the selected residuals to 2.33 inches. This would have pushed the diameter distribution up to the point where as many as 420 stems per acre would have exceeded 1.8 inches, providing a better selection of trees from which to choose residuals. As far as final crop value is concerned, thinning the stand at 16 years does not appear to have gained any advantage over letting the stand continue in its natural condition for another growing season.

Management Recommendations

Two recommendations may reduce the amount of moose damage to thinned sapling birch stands, particularly main-stem breakage:

1. The first thinning in sapling birch stands should not be performed prior to age 20.

2. No stems smaller than 1.8 inches DBH should be retained as residual trees.

These recommendations are based on growth rates observed in the Standard Creek stand which may or may not be representative of other birch stands in interior Alaska. Before applying these recommendations, it would be prudent to examine the stand to be thinned to determine present growth rates and whether or not there is moose damage. If moose damage is not present, then it may be possible to perform thinnings at earlier ages, though opening up a closed stand of sapling paper birch could attract moose to an area they normally would not use. If moose are present in an area, which is the case for most of Alaska, then these recommendations should help to improve the value of birch stands under intensive management.□

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The Rosie Creek Fire

By

Glenn P. Juday*

Introduction

The winter of 1982-83 was mild in interior Alaska. Aside from an early, heavy snowfall in October and November which insulated the ground against deep freezing, it was a dry winter as well. The weather station at the Fairbanks International Airport recorded below-normal snowfall from December through March. Breakup came early; the Tanana River at Nenana lost its ice cover on April 29. The average temperature for the month of April 1983 was 7.2°F above normal. By the end of May, the combination of early snowmelt, very low spring precipitation, warm weather, and drying winds produced a high fire danger.

Many people near Fairbanks were looking ahead to a busy construction season or to establishing or expanding cultivated areas. They took advantage of the warm, dry early spring to clear land. Most obtained open-burning permits from the state Division of Forestry (DOF) to burn the slash and clearing debris. Most followed common sense and stopped burning when warm temperatures and high winds caused extreme fire danger after May 28. But on Sunday, May 29, a man set fire to his land-clearing debris on the Tanana River lowlands near the mouth of the Rosie Creek. Carried by a powerful east wind, the fire escaped and began to race across the highly flammable black spruce-covered permafrost flats, headed west. Above the flats to the north, on the deep wind-deposited silt soils of the south-facing ridges, grew some of the largest and most productive white spruce forests in northern Alaska. The demand for forest products in interior Alaska had made these stands among the most important for forest management in this region of the state. Even more alarming, if the fire shifted to the east, its path would cross a rural residential area that had expanded greatly in population in the last few years.

What follows here is a reconstruction of the events of the Rosie Creek Fire, taken from the fire narrative (Alaska Department of Natural Resources, Division of Forestry, 1983a, b) and fire night reports. The chronology of this fire provides a good opportunity to see how a modern, wildland-fire-control organization works.

*Visiting Associate Professor and Coordinator, Rosie Creek Fire Research Project, Agricultural and Forestry Experiment Station, Fairbanks.

The Fire

Sunday, May 29: Day 1

The Alaska State Division of Forestry, reduced to a skeleton crew for the Memorial Day weekend, received a report of a fire at 2:28 p.m. at its Airport Road office in Fairbanks. At 2:33 p.m., a helicopter under state contract for fire-suppression duty took off from the office complex. According to contingency plans always in effect, a DOF employee aboard, Jim Colla, automatically became initial-attack fire boss.

As with all forest fires, the first task Colla faced was to size up the situation. The fire was moving rapidly. An immediate decision was made to protect private property and structures. An initial order went out for six crews, two helicopters, firing equipment (to light backfires on control lines), and bulldozers. A request was made to call out local volunteer fire departments under a standing, mutual-aid agreement. A transition team arrived at 3:50 p.m. to put the fire-suppression effort under a complete organizational structure of specialists. Fire retardant was dropped. The fire by then had covered 250 acres. Fire lines were holding along the eastern perimeter near homes and developed property but were only marginally secure.

The fire ran out of control all afternoon. By 5 p.m., the estimated burned area was 1,200 acres and had entered the Rosie Creek wood-cutting area. A prediction was made that the fire would jump to the next drainage if the extreme burning conditions persisted. Retardant drops to the west were cancelled; it was felt they "would be futile due to extreme fire behavior." By 9 p.m., the fire-suppression effort was big enough to be organized into two divisions. The cooler, twilight hours of higher humidity would be useful in the suppression effort, so Dick Jackson of DOF and a highly trained BLM hot shot crew went to the Rosie Creek area near the head of the fire to construct "indirect" control lines and burn out the area between them in an attempt to cut off the fuel supply ahead of the fire.

Monday, May 30: Day 2

At the latitude (65° north) of the Rosie Creek area, it doesn't get fully dark at night at the end of May. All through the long hours of low sun or reflected light of the early morning of May 30, crews and equipment continued to arrive. Jackson and his crew made some progress. The east end of the fire, near homes and other structures, was stabilized. Fire trucks and pumpers were effective in spraying down vegetation with water and knocking flames down there. Smoke was a problem; it was hard to estimate the size and the rate of spread of the fire. Extreme fire behavior continued until sometime before 5:00 a.m. The fire had now covered 2,000 acres. By now the fire-control effort was so large that an expanded administrative structure, called a *class II overhead team*, was called for. This group took responsibility for the fire at 8:00 a.m.

The weather outlook for May 30 was for temperatures near 80°F, low relative humidity, and winds near 15 mph. Rod Norum, the fire-behavior officer, predicted the fire would run west-northwest, crown near 10 a.m., and move at 6 to 8 ft/sec. The extended outlook was for no letup for 3 days.

Newly arrived crews were assigned to the fire as they arrived. Bulldozers ("cats") were building fire-control lines along the north flank in order to keep the fire from moving any closer to the prime commercial timber, the Parks Highway, and the main powerline feeding Fairbanks (fig. 1). Soon the fire had burned nearly 2,200 acres and was

Figure 1. The Rosie Creek fire at an early stage (May 30: Day 2), burning upslope toward the Parks Highway and main powerline serving Fairbanks. Wind is from the east; view is to the south.

threatening forestry research plots in the Bonanza Creek Experimental Forest.

At 10 a.m., fire activity began to increase. Ground crews were working to hold lines on the east end of the fire to protect threatened private property. Trouble began to develop on the north cat line. At 11:05 a.m., retardant-dropping aircraft were requested for the north flank; they were to arrive at 11:50. At 11:37, spot fires appeared across the north cat lines. The retardant aircraft were requested as soon as possible. But by now other fires were appearing in developed rural areas around Fairbanks. At 11:51 came the news that the retardant drop had been diverted to another fire. Plans were quickly put into motion to prepare for closure of the Parks Highway and shutdown of the powerline.

At 1:11 p.m., the fire was spotted over lines in the southeast corner of the perimeter. Crews were moved to the scene. Decisions had to be made quickly as to how to respond to the expected run of the fire up the slope to the highway and the powerline. The fire continued to endanger privately owned structures near the Tanana River, so plans were made to widen the control line on the east by burning out from the cat line.

Because there were other fires in the Fairbanks area, additional personnel requested for the overhead team were not available. The team was put on 14-hour shifts day and night. The head of the fire was still too hot to attack directly. However, the crews were beginning to control the spot fires in the southeast corner.

At 6 p.m., the fire began a run across the north lines up the slope to the Parks Highway. The powerline was turned off, and the utility companies shifted to local standby generators. By 8 p.m., the fire had expanded to cover 3,200 acres. The night shift came on the line. The fire was spotting up the slope to the powerline and highway despite control measures. The cleared powerline right-of-way became the scene of last-ditch control efforts. The only remaining fall-back position on the north, before a vast new area of forest was jeopardized, was the Parks Highway itself. At 11:30 p.m. the smoke became so dense that the highway was closed.

Tuesday, May 31: Day 3

By now, fatigue was becoming a problem for the crews, especially those engaged in the back-breaking labor of constructing firelines with hand tools. The volunteer fire departments working in the Rosie Creek subdivision were released at 5 a.m. The night crews came off the line at 10 a.m. The size of the fire was now 3,800 acres. Line construction was becoming progressively slower. Crews were holding their own or making only slight progress. Again, the fire made a run to the powerline, necessitating a shutdown. Again, retardant was ordered but, again, was diverted to higher-priority fires. Crews prepared for burnouts, but winds became unfavorable in the afternoon. The control efforts were somehow just enough to hold the lines.

By 5:30 p.m., power was restored to the powerline. Work continued on into the long evening hours. Progress was slow. By 11:30 p.m., the night crews were able to conduct some burnouts. By the end of the day, four hundred twenty fire fighters, eight ground tankers, twelve trucks, six bulldozers, and three helicopters were involved in the effort.

Wednesday, June 1: Day 4

In the early morning hours, bulldozers, running parallel to the fire, moved out across the black spruce flats. Their passage over the frozen ground produced a channel that filled with water from the thawing active layer of the permafrost (fig. 2). This "moat" made a uniquely subarctic fire-control line. Burning intensity along the northwest flank, near the forestry-research plots, picked up at 8 a.m. The fire also made a run through heavy fuel sources in the southwest corner.

All through the day, burnouts were ignited, mop-up was underway on the quieter sectors, and cat-line construction advanced. Progress was being made, although some spot fires appeared across the lines on the north perimeter (below the highway and powerline). Emergency evacuation

Figure 2. Control lines on the Rosie Creek fire, bulldozer over black spruce permafrost ground. When thawed, such channels fill with water. The insulating vegetative mat was replaced after the fire was controlled.

procedures and a Civil Defense command post were established.

The fire was at a turning point. With a slight break in the weather (even just a return to normal weather for the season) and a sustained, vigorous suppression effort, control might be possible within a few days. The burned area could probably be held close to the present amount. As the weary night crews came on the line at 8 p.m., they must have begun to anticipate a slight respite, especially as they had to discontinue burnout activity that night when the relative humidity exceeded 45 per cent. Unfortunately, the severest test was yet to come.

Thursday, June 2: Day 5

The day crews were on the line at 6 a.m. Some of them were deployed along the west perimeter where a major burnout was planned. But at 8:00 a.m. the fire-behavior officer issued a forecast for extreme burning conditions. The word was relayed to all personnel along the line, as quick evacuation might become necessary. This kind of warning is taken very seriously.

In the "old days," the chances were distressingly high that lives would be lost in a situation such as this. Modern studies in fire-behavior science, good management and organization of fire-control efforts, good communications, and good mobility (including helicopter transfer of crews), have all combined to make fire suppression a much safer occupation these days. But everyone recognized the danger.

Temperatures began to climb to 80°F. Near noon, the winds from the northeast began to increase in strength to nearly 20 mph. A fire to the east of Fairbanks, the Munson Creek fire, "blew up" and sent a huge column of smoke over Fairbanks and toward the Rosie Creek area. Cumulus clouds began to build up to the south and east, an ominous sign of convective cells. The intense winds at the leading edge of a dry convective cell produce one of the most dangerous conditions a firefighter has to contend with—wind direction may switch unpredictably and nearly any fire barrier can be breached. By 1:15, the fire began to make a run along the south flank; bulldozers attempted to outflank this movement. Winds increased to 30 mph. The fire-behavior officer issued a "Red Flag" warning—the National Weather Service had reported a large convective cell moving directly toward the fire on a westerly track.

The critical spot in which control was needed in order to contain the fire was now known to be in the black spruce flats in the southwest corner of the fire perimeter (fig. 3). All night long, the crews had attempted to burn out the fuels ahead of the southwest corner area, so that the fire would have nothing to burn through. They were not quite finished. If the fire did escape beyond the corner, the main section of Bonanza Creek Experimental Forest, with its research plots, scientific instruments, and long-term studies, would be involved in the blaze. The fire would burn up the slope, gathering force as it went. It might even be able to cross the Parks Highway on the top of Nenana Ridge. If it did there would be a huge increase in the amount of burned land.

Crews were evacuated from the western perimeter of the fire. At 2 p.m., the winds pushed the fire across the critical

Figure 3. Critical sector for control of the Rosie Creek fire on June 2: Day 5. The fire was spreading from the east (left) to the west (right) and escaped control by jumping the short sector in the center during extreme burning conditions.

Figure 4. View from Airport Way, in Fairbanks, of dense smoke from the convective column during the "blowup" of the Rosie Creek Fire on the afternoon of June 2: Day 5.

spot in the southwest corner. The lines generally held everywhere except the southwest corner, but there the fire was out of control. At 2:30 p.m., the winds shifted from the northeast to the southeast and began pushing the fire across the flats directly toward the Bonanza Creek Experimental Forest. The position of the head of the fire could no longer be determined because of dense smoke (fig. 4). Spot fires appeared across the Parks Highway at about 4:30 p.m. All available tanker trucks and crews were sent to attack them.

By 5 p.m., a report was received that crews were making progress on the spot fires across the highway. But it was becoming obvious that a convective fire storm had begun and that it was heading toward the main road through the Bonanza Creek Experimental Forest. A firestorm is one of the most awesome sights in nature. The total amount of energy released in a large firestorm can equal that of a thermonuclear explosion. A suction is created which draws combustion air into the center of the fire with hurricane force. Everything on the surface, as well as some distance down into the mineral soil, is incinerated. The intense radiant energy given off by the firestorm can cause organic material ahead of the main flame front to burst into open flame. The fire burns so intensely that oxygen needed to sustain the combustion becomes a limiting factor. As a result, a huge amount of dense, black smoke, made up of incomplete combustion products, is produced. Firestorms are often accompanied by rhythmic sounds as drafts of air first feed combustion and then are depleted. This slows combustion and produces a sound like a chugging steam engine.

At 6 p.m., Fred Bethune of DOF and Fred Arbogast, on loan from the Chugach National Forest, were working as intelligence officers on the fire. They had been sent to the main Bonanza Creek road to ensure that the road was posted "closed" and that everyone was out. At 6:15 p.m., as they were driving out, they reported by radio to base camp that there were two occupied vehicles, 4 miles down the road from the Parks Highway. They had trouble convincing one of the drivers that he was in danger and should leave immediately! The delay was almost fatal. Fred Arbogast recalls, "The fire began to sound like an old steam engine. I took that as my signal to get out. The dense black smoke produced darkness; we had to turn our headlights on. The smoke was black and occasionally red with flame and curled over like a wave. A few embers were drifting down." A few minutes after they left the area, trees began to blow down across the road. Then, the full force of the firestorm hit.

Aluminum rain gages and seed traps in study plots were reduced to molten puddles (fig. 5). A recording temperature gage in an instrument shelter at the top of the slope edged up to 140°F and then leaped off the scale. A beetle grub, recovered later in a burrow 2 inches down into the mineral soil, was cooked. As the winds of flame lashed and whipped through prime mature white spruce forest, nearly 40 acres of trees were toppled with their entire mound of soil near the roots intact and tilted over (fig. 6). The soil of exposed

Figure 5. Puddle of molten aluminum from a research plot's seed trap in the path of the Rosie Creek fire.

root mounds was baked. The leaves of paper birch trees on a north-facing slope at the edge of the firestorm were dehydrated and crinkled. Trees at the edge of the firestorm were "sprung" or permanently bent as the wood fibers were pulled apart by the force of drafts feeding the combustion and, in effect, welded into position. They formed a pattern pointing inward to the center of the firestorm. At 6:25 p.m. a helicopter flying at the edge of the fire reported winds of 100 mph.

Slowly, the firestorm spent itself. The fire-control organization, forced to retreat in the face of what one observer called "a sustained explosion," pulled itself together and got back into action. At 6:50 p.m., a tally showed all personnel and equipment accounted for. They had faced the worst possible circumstances and survived. But there was no time for celebration.

Downdrafts from the firestorm were showering sectors of the landscape with sparks and embers. At 7:40 p.m., spot fires across the Parks Highway increased in intensity. Air-

Figure 6. Mature white spruce toppled by indrafts feeding the firestorm of June 2: Day 5, Rosie Creek fire.

craft fire-retardant drops were available. They proved extremely helpful in controlling spot fires that had jumped the highway. At 8 p.m., the location of the head of the fire was still not known for certain. It was thought to be at or just over the Parks Highway west of the experimental forest. Nobody knew how much of the experimental forest was left unburned, if any. Finally, at 10 p.m., smoke began to lift from the head of the fire. It was estimated that the fire now covered 7,000 acres. The weather forecast was for temperatures in the low 70's°F with moderate winds and low humidities. At 11:30 p.m., crews attempting to ignite backfires on the south flank of the fire reported limited success because of rising humidities.

Friday, June 3: Day 6

There was a frenzy of activity as crews in all sectors scrambled to use the cooler and more humid hours of low light ("night") to mop up and reestablish control in their sectors after the blowup of June 2. New lines were constructed along the flanks of the expanded fire perimeter. Contingency plans were made to build a whole new fire-control line on the western and northern perimeters of the newly expanded fire, several miles further down the Parks Highway.

At 2 a.m., a light rain began to fall. Crews and bulldozers pushed closer and closer to the area where the firestorm spent itself in the Bonanza Creek Experimental Forest, mopping up their sectors as they went. It was an eerie scene. Smoking, dark, black hulks were hardly recognizable as trees. Embers crackled in the blackened, crisped, forest understory.

When the day shift came on the line at 6 a.m., the fire had stopped spreading; a test backfire would not spread. The light rain was continuing. The control lines now encompassed 8,600 acres.

The fire was at another turning point. Continued favorable weather would allow a gradual strengthening of the control lines along the current perimeter. If the control work could be done in time, then there was a good chance that the fire could be stopped and even unfavorable weather could not cause it to spread further. Slow and steady warming and drying might even test the control lines gradually in a way that would help the fire-control organization determine how much control they had actually achieved.

Fire crews and large bulldozers made steady progress in constructing control lines through the morning hours. An isolated pocket at the new head of the fire flared up. Retardant drops were dispatched. After the overpowering event of the previous day, the crews felt a certain sense of letdown. Hacking away at foot after foot of control line for who knows how much longer paled in comparison to the hectic events of the previous days.

Then came word from the District Forester Les Fortune that a new class I overhead team would arrive to assume control of the organization. This was simply a reflection of the size and complexity of the control effort. The equipment involved at this stage included five helicopters, fifty-six radios, seven pumper trucks, seven bulldozers, four all-terrain vehicles, and seven pumps. There were five hundred twenty people on the payroll including thirty-eight Alaska DNR staff, thirty-two resource professionals from other agencies, four hundred fifteen emergency firefighters, and thirty-five operations staff. Hundreds of thousands of dollars were being spent each day. This scale of effort simply demanded a bigger administrative group, with experience in running very large fire-fighting operations.

Inevitably, members of the class II overhead team felt depressed. All firefighting teams develop an intense personal commitment to "their" fires. The exhausted Rosie Creek team knew that they were being given a rest so that they would be available for other fires, which seemed likely. They knew their good work in initial control, their safe handling of a very dangerous fire blowup, and their quick efforts which had held the fire were recognized. But, there was still a sense of loss. It is this pride and dedication which drives forest firefighters to do their work.

Saturday, June 4: Day 7

The whole control effort now shifted to the western perimeter where the firestorm had played itself out. Spike camps were set up closer to the new scene of action. Hot spots appeared along the generally stable perimeter, and they were vigorously attacked by bulldozers constructing a new control line. A high-technology, infrared heat-detection device, a Pyroscan, was used to locate the hot spots quickly. It was a long day of hard work.

Sunday, June 5: Day 8

The Alaska Society of American Foresters convention was in Fairbanks for the weekend; a field trip to the fire area was quickly arranged once it was clear that the fire-control organization was no longer confronting an emergency. Several forestry-research scientists who had been conducting major studies in the just-charred Bonanza Creek Experimental Forest were along on the trip. They had only a general idea about how much of their forest had been burned. Were years of work ruined?

The group was briefed by the overhead team and then made its way to the main Bonanza Creek road. The familiar early stretches of the road looked normal enough. Slowly, as the group moved on, an acrid pall of wood smoke thickened and hung over the road. Around one more corner—and there it was. The full force of the firestorm had burst across the road. Quietly, deliberately, the foresters got out of the vans and walked among the still-crackling hulks, snags, and remnant trees. Mostly, they stood and absorbed the scene. Eventually one made an observation here, another, a comment there. Stories of other fires in other places were heard, and the busy hum of professional conversation began. But most of them, at the very first sight of the charred forest, felt the elemental response that an overpowering force of nature can still dredge out of the soul of twentieth-century man.

Monday, June 6: Day 9

The fight to control the Rosie Creek Fire took on aspects of a long siege (fig. 7). Conditions had eased to the point that crews were back down to 12-hour shifts. But the morning Pyroscan revealed numerous hot spots, especially in one sector in which there was still the potential for a major flare-up and run up the main slope in the center of the experimental forest. The evening Pyroscan still showed many hot spots. In the late-evening hours, the crews completed hand line and bulldozer construction around the new northwest perimeter which the firestorm had created. This was the first real margin of safety in days. The character of the effort was beginning to change. Near midnight, bulldozers began the construction of water bars (erosion-control diversions on steep slopes). Rehabilitation efforts, the first signs of a real shutdown, were slowly getting underway.

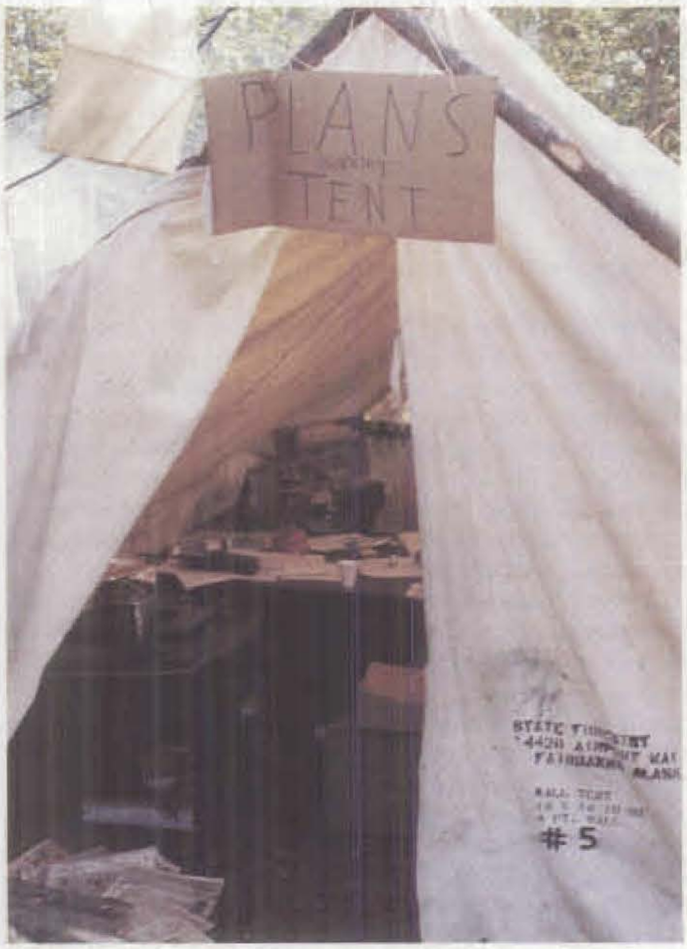

Figure 7. Plans tent, late in the Rosie Creek fire.

Tuesday, June 7: Day 10

Administrative decisions focused on paring down resources so that unnecessary expenses were not incurred. One of the original sectors of the fire lines, the one protecting the Rosie Creek Subdivision, was cold enough to be left unmanned. Folding water tanks on loan from volunteer fire departments were returned. Plans for the orderly release of crews were made.

Out on the lines, it was a routine of chasing smoke, grubbing, and digging. Again and again.

Wednesday, June 8: Day 11

A stubborn pocket of hot spots was persisting in the middle of the experimental forest. The weather forecast indicated warm conditions with isolated showers. The potential for reactivation of the fire was suddenly greater. The fire wasn't over yet.

Crews were pulled off other sectors and concentrated in the sector with problem hot spots. The overhead team put smokejumpers and a helitack crew in Fairbanks on standby in case the unmanned sectors should flare up. At about noon, fire activity did pick up. At 2 p.m., the standby forces were brought to the fire. The Pyroscan began to pick up hot spots in birch tree tops. It was hard for crews to find these and time-consuming to put them out. The fire was just going to be stubborn at this stage.

Thursday, June 9: Day 12

In the early morning hours, crews came upon a charred weather-instrument shelter in an experimental area posted with radioactive-hazard signs. The organization scrambled to get in touch with research scientists. It was soon learned that micro amounts might not even be detectable. The crews might have been forgiven a brief thought on the symmetry between man-made and natural hazards.

Any such thoughts would have to be brief; there was work to be done. The overhead team was looking for containment of the fire the next day.

Friday, June 10: Day 13

It was a day of solid progress. Control lines around the entire fire perimeter were completed. Now it was a job of completing a cold mop-up to a depth of 300 feet inward from the lines. All but a skeleton crew were put on day shifts.

Saturday, June 11: Day 14

On the two-week anniversary of the start of the fire, it was sunny and clear. Some sectors of the fire showed no hot spots in spite of this test. A competition broke out among the crews to see which could take the most hot spots off the map.

Sunday, June 12: Day 15

Crews were on the line, but the overhead team was planning demobilization of the fire. The weather again tested the integrity of the control. It was sunny, warm, and windy. The only open flames were in the very center of the burned area. Further progress in mop-up was made through the day, and several crews were scheduled for release.

Monday, June 13: Day 16

Several crews were released in the morning, although others were sent to attack numerous small hot spots during the day. The fire was declared controlled at 7:30 p.m.

Tuesday, June 14: Day 17

There were still hot spots to be mopped up, but the end was near. Demobilization was rapid. Many crews were released, the class I overhead team began to pass the fire back to a class II team. The total number of firefighters was down to two hundred eight and declining rapidly. The base camp was shut down, and all operations moved to a spike camp near the northwest perimeter of the fire.

Wednesday, June 15: Day 18

There was as much activity in packing and moving equipment and cleaning up camps as in patrolling the fire and mopping up hot spots. Crews were released wholesale throughout the day. The entire operation was down to a skeleton crew at the end of the day.

Epilogue

And so the Rosie Creek Fire ended—not with a bang, but a whimper. The loss was nearly 5 million dollars in direct suppression costs and lost timber value. Several harvest areas with young regeneration, still rare in interior Alaska, had been lost. Nearly one-third of the Bonanza Creek Experimental Forest had been burned. A major subdivision had been threatened.

On the other hand, a new laboratory/demonstration area for reforestation was created right next to other, continuing forestry projects. Grasses and aspen trees were sprouting within a matter of days after the fire (fig. 8), and

Figure 8. These mature aspen, toppled by the Rosie Creek fire in June of 1983, originated from a fire over 80 years ago. In this picture, taken in August 1983 new aspen sprouts carpet the forest floor.

*Figure 9. A golden cordalis (*Corydalis aurea*) plant in flower on the Rosie Creek burn in August of 1983. Seeds of this plant lay dormant in the former forest understory for at least 160 years, finally germinating in the new environment created by the Rosie Creek fire.*

moose were beginning to move into the area. Seeds of wild geranium and other herbs that had lain dormant for more than 150 years began to germinate (fig. 9). By the end of the summer, black-backed and three-toed woodpeckers were congregating in the area. Perhaps most important of all, the soils of the burned area began to soak up heat, which speeded up reactions that were increasing the productivity of the site. Nature was setting the stage for the growth of a new forest, another link in an unbroken chain of renewal which led to this day. But this time man was planning to be a partner in the development of the new forest. One can hope that we will be a sensitive and constructive partner. Our success will be judged by future generations. □

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The Critical Importance of North-Latitude Adaptation for Dependable Winter Survival of Perennial Plants in Alaska

By

L.J. Klebesadel*

Adaptation: *Modification of an organism or of its parts or organs fitting it more perfectly for existence under the conditions of its environment and resulting from the action of natural selection upon variation . . .* (Webster's Third New International Dictionary, 1968)

This dictionary definition could be mistakenly interpreted to mean that adaptation involves only the physical or outwardly visible aspects of plants (parts or organs) for suitability to their environment. As the following discussion will show, the composition of the inner genetic mechanisms that control the plant's invisible physiologic processes at the cellular and tissue levels are of much greater significance in plant adaptation, especially as adaptation determines winter survival in Alaska's north-latitude environment.

Latitude and Photoperiod

The single meteorologic parameter that varies most dramatically with latitude (north-south distance on the earth's surface), and that also imposes major influences on certain plant behavioral phenomena, is the seasonal pattern of the daily duration of light, or daily "photoperiod" (fig. 1). This pattern of seasonally changing photoperiod is consistent from year to year for any given latitude on the earth's surface.

At the equator (0° latitude), the daily duration of light and darkness is virtually constant throughout the year (12-hr photoperiod + 12-hr nyctoperiod). At progressively more northerly latitudes, the seasonal changes in daily photoperiod become amplified, with increasingly longer photoperiods in summer and shorter ones in winter (fig. 1).

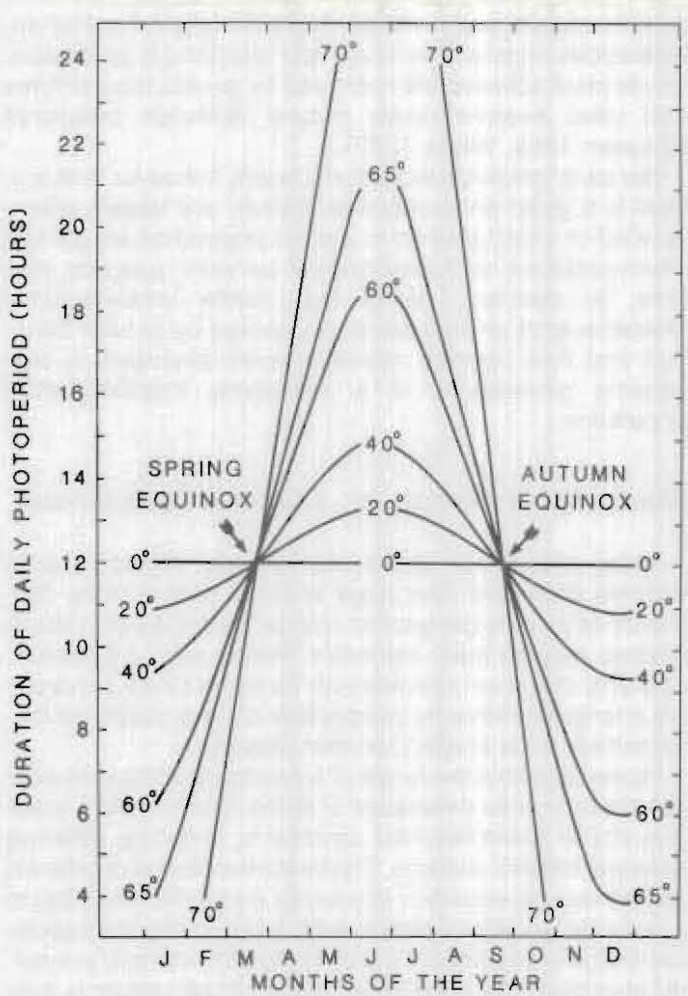

Figure 1. Annual pattern of daily hours of daylight (photoperiod) at six different latitudes.

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The 24-hour cycles we call "days" are caused by the spinning or revolving of the earth, exposing different areas of its surface to sunlight as it does so. Seasonal changes in daily photoperiod are caused by the changing tilt of the earth's axis in relation to the sun as the earth travels around the sun in its year-long orbit. By this behavior, northern latitudes are exposed to sunlight for a longer period each day in midsummer (and for a shorter period each day in midwinter) than equatorial locations. This same tilt of the earth's axis alters the amount of heat received during different portions of the year at various latitudes, creating our warm summers and cold winters. The influence of these and other global characteristics (sea and air currents, precipitation, size of land masses, altitudinal effects, etc.) interact to create the total array of different climates that exist over the surface of the earth.

Natural Selection

The effects of natural selection through thousands of years have produced plants ideally suited to their respective environments all around the world, especially so to the specific climatic pattern to which plants respond in their annual cycles of growth behavior and physiologic processes. These plant activities are controlled by genetic mechanisms that have evolved under natural selection pressures (Clausen 1958, Wilsie 1962).

Genes or genetic mechanisms poorly suited for best survival in a given environmental "niche" are largely subordinated or eliminated from a plant population as genetic recombinations and generational turnover proceed over time. In contrast, genes that confer advantageous characteristics or processes are favored by natural selection and thus become relatively more abundant in succeeding generations of a selectively modified plant population.

Geographic Range vs. Climatic Differences

Many species of plants, during past millenia, have become dispersed over large areas of one or more continents so that the geographic "range" occupied by a single species may be quite extensive. Within such a situation, all plants of a given species over its entire range generally are interfertile (sexually compatible) and are classified taxonomically as a single Linnaean species.

However, within the range of a species that extends over hundreds or even thousands of miles, there exists a great diversity of environmental conditions, including differing seasonal climatic patterns. These environmental conditions impose natural-selection pressures on plants, resulting in a particular genetic constitution for a localized plant population that is in equilibrium or harmony with normally prevailing environmental conditions. Since climatic patterns may be quite different in different areas of the total range of a species, the particular genetic constitution (which controls specific physiologic processes) of plants in one geographic area of the range may be quite different from the genetic makeup of plants of the same species in a distant area.

The differences in genetic constitution understandably are *gradual* across the length and breadth of the range of a species, in concert with gradual differences in climatic conditions. Such gradual genetic differences over the range of a species have been described as having a continuous gradient of change, or possessing "clinal" variation (Lindgren 1983, Wilsie 1962).

Localized plant populations within a given species have been referred to as "climatypes," "ecologic races," and "ecotypes," each term having a somewhat different connotation or meaning (Wilsie 1962). The term "ecotype" has been defined as a "plant type or strain within a species, resulting from exposure to a particular environment." The term ecotype is used in this discussion to refer to either a naturally occurring plant population or a selected crop variety (cultivar), either of which is adapted to a specific environment.

Latitudinal Ecotypes vs. Performance in Alaska

There are a multitude of different geographic configurations to the natural ranges occupied by plant species around the world. Several investigators in the lower 48 states have grown and compared at a single location numerous ecotypes collected from diverse geographical origins within the range of a species (Cornelius 1947, Larsen 1947, Olmsted 1944, Rogler 1943). Each reported differences in performance among ecotypes, differences directly related to latitude of origin and, hence, to accustomed seasonal photoperiodic patterns. Similarly, our studies in Alaska have determined that latitude of origin and, hence, photoperiodic adaptation influences performance of latitudinal ecotypes here, especially their winter survival (Klebesadel 1970, 1971a, 1971b, 1983, 1984a, 1984b). General performance patterns in Alaska of latitudinal ecotypes within several species are summarized in the following discussion.

Figure 2 presents examples of hypothetical ranges in North America for two perennial plant species, I and II. Species II likely would be totally unsuited for use as a perennial in Alaska because even the northernmost extent of its range is far south of Alaska. Hence, no ecotypes within its total range would be adapted to Alaska's seasonal photoperiodic pattern.

In contrast, the range occupied by hypothetical species I in Figure 2 spans a considerably greater extent of latitude and reaches northward into Alaska. Many actual plant species do occupy ranges that extend over extensive north-south distances, on this continent as well as in Europe and Asia.

Within the range of such a species, there is a continuous or clinal gradient of photoperiodic/growing-season adaptation to harmonize with the considerable range of climatic

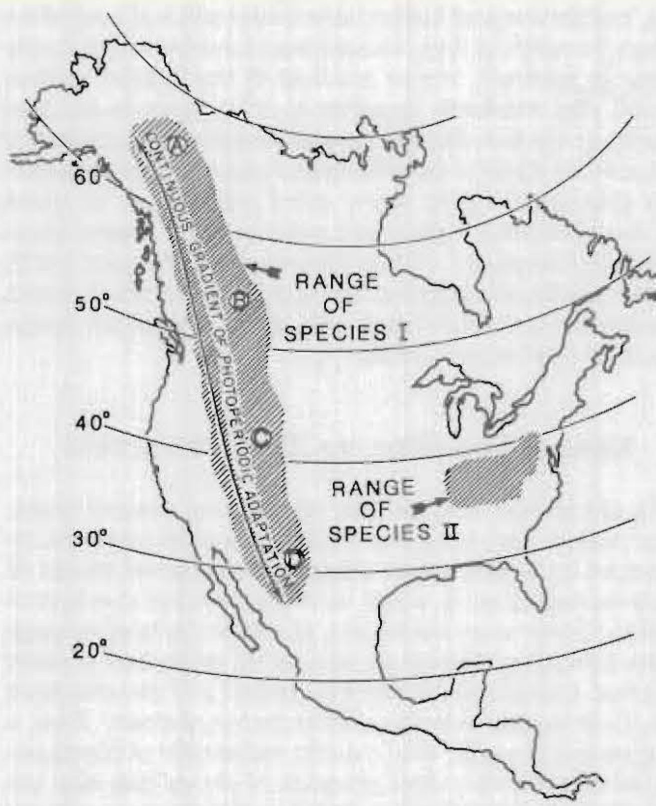

Figure 2. Hypothetical natural ranges sketched for two theoretical plant species in North America, the two being vastly different in north-south (latitudinal) extent. Ecotypes selected from widely separated locations within the range of species I (at A, B, C, and D) would differ greatly in seasonal/photoperiodic adaptation. In contrast, relatively minor differences would be found with different ecotypes within the range of species II.

differences prevalent over the entire range of the species. Ecotypes selected at locations A, B, C, and D, however, would possess discrete photoperiodic adaptation, each quite different from the others, and each in equilibrium with its locally prevailing climatic and photoperiodic parameters.

Understandably then, an ecotype from A would be well adapted to Alaska's photoperiodic conditions, while ecotypes from B and C typically would be progressively less well adapted if grown in Alaska. Ecotypes collected at locations B and C likely would perform somewhat better in Alaska if collected at high altitudes than at low, for growing seasons terminate earlier at high altitudes in temperate latitudes, more like conditions at the relatively low altitudes where plant culture is practiced in Alaska. An ecotype from location D would be totally unsuited for use in Alaska if winter survival is desired.

Natural Ecotypes vs. Artificial Cultivars

Just as natural selection pressures can modify the genetic constitution (genotype) of a natural ecotype, so too does the influence of a plant breeder alter crop genotype as that person selects for harmony between plants and the specific set of climatic conditions prevalent in the geographic location where the breeding or selection work is done.

In early evaluations (1940-42) of Russian wildrye (*Elymus junceus*) in the Matanuska Valley, Irwin (1945) reported that it was the "best perennial grass yet tried at the Matanuska Station," and ". . . yields of this grass have been higher than those of any other grass tried."

Yet when the Canadian cultivar of Russian wildrye named 'Sawki' was grown here more recently, it was poor in winterhardiness, subject to foliar disease, and produced low forage yields (Klebesadel 1969). It is quite certain that those two strains, Sawki and the material of the same species rated so favorably by Irwin in earlier trials, differed significantly in adaptation and therefore suitability to our northern conditions. The earlier evaluations probably involved relatively unselected material with a broader gene base and, perhaps, from a more northern source in the U.S.S.R. In contrast, selection of the cultivar Sawki for good performance at Swift Current, Saskatchewan, (50.4°N.) probably discarded genetic material suited to this more northern location (61.6°N.) with different climatic conditions; therefore, it is not surprising that Sawki, as well as other crop cultivars developed for compatibility with other, especially more southern, climatic conditions should perform poorly here.

Evaluating Ecotypes for Alaska

An early weakness in crop-plant evaluations in Alaska was the failure to recognize that the total natural range (especially the north-to-south, or latitudinal, extent) of a species must be considered. Crop ecotypes included in early evaluations in Alaska frequently originated from midtemperate latitudes. Poor performance of one or more of such ecotypes resulted in categorizing the *entire species* as unsuitable for Alaska's climate. Gradually, however, the realization has emerged that, for maximum success in Alaska, crop ecotypes within all species should be evaluated from the northernmost extents of their natural range.

A single example among several that might be cited, is that of timothy (*Phleum pratense*). Reports from early trials with that species in Alaska were generally pessimistic (Irwin 1945). No records were reported of the origins of the timothy evaluated at the seven different trial locations in Alaska, but the seed probably came from ecotypes or regional strains adapted to the northeast quarter of the 48 states.

In a recent field test here, winter survival differences among timothy cultivars from five different latitudinal origins confirm the importance of securing ecotypes or cultivars from northern origins for best performance in Alaska (table 1). This same pattern of performance has been seen in bromegrass (*Bromus* spp.) and other grass species from

Table 1. Winter survival in spring, 1982, of five different timothy varieties from a wide range of latitudinal origins.[1]

Timothy variety	Origin: Country and area	Origin: Degrees north latitude	Percent winter survival (spring 1982)[2]
'Engmo'	Northern Norway	69-70	86
'Tarmo'	Southern Finland	60-62	51
'Bottnia II'	Southern Sweden	58-60	42
'Climax'	Southern Canada	44-46	27
'Clair'	Mid-U.S. (Kentucky)	38-39	4

[1]Broadcast-plot field test was planted 11 July 1979 at the Matanuska Farm (61.6°N) in the Matanuska Valley of southcentral Alaska. Winter injury was relatively minor during previous two winters.
[2]Mean values for four replications.

various latitudes when grown in Alaska (Klebesadel 1970, 1984a, 1984b; Klebesadel et al. 1964; Wilton et al. 1966).

A legume crop that illustrates how selection for adaptation to specific latitudinal conditions can greatly influence winter survival is seen with alfalfa in Figure 3. The three plots shown were part of a four-replication test comparing seventeen alfalfa strains from Alaska, Canada, the conterminous 48 states, and northern Europe. All strains established well and grew vigorously during the seeding year; the three cultivars shown, 'Agate,' 'Denali,' and 'Roamer,' produced 1.17, 1.01, and 1.35 tons of forage dry matter per acre, respectively, when harvested 23 September 1980.

Although Agate is described as "hardy" and Roamer as "very winterhardy" for their respective areas of adaptation, neither showed appreciable winter survival here when grown far north of their accustomed environmental conditions. In contrast, winter survival of the Alaska cultivar Denali was markedly superior to all temperate-adapted alfalfas in the test. Denali represents enhanced adaptation to subarctic climatic conditions as a result of natural selection pressures during many plant generations at these northern latitudes; Denali was selected from Alaska strain A-Syn.B (Klebesadel 1971b, Klebesadel and Taylor 1973). These results with adapted and unadapted alfalfa in Alaska parallel earlier results here with alfalfa and other forage legumes (Klebesadel 1980).

Figure 3. Comparative winter survival of three alfalfa cultivars in broadcast-seeded plots at the Matanuska Research Farm: left, 'Agate,' developed in Minnesota near 45°N.; center, 'Denali,' selected in Alaska at 61-65°N.; right, 'Roamer,' developed in Saskatchewan near 50°N. Planted 23 May 1980; photo 23 June 1981.

Natural Migration vs. Seed Shipment

As plants migrated on their own during ancient times, they moved only very short distances each year, as influenced by where seeds dropped from parent plants or were carried by wind, water, animals, or other distribution agents. Under such conditions, plants at the leading edge of plant migration did not abruptly enter totally new climatic regimes. Consequently, plant migration and the attendant effects of natural selecton proceeded very slowly. Over a long period of years, only modest movement of plants occurred and the very slow advance of plants into new environmental conditions required only gradual genetic change to adjust to minor environmental change.

In contrast, when an Alaskan grower orders seed from Minnesota (or Oregon, or Montana, etc.), or purchases seed from an Alaskan retailer who has obtained seed from similar far-away sources, plants grown in Alaska from that seed are subjected *immediately* to an *unaccustomed* pattern of seasonal climatic effects. This pattern of environmental influences, especially during late summer/autumn, is critically different from that which they were accustomed to responding to effectively in preparing for winter in their area of origin.

Growers Travel North More Easily than Plants

North America was settled largely by Europeans, and the farmers traveling to the New World brought their conventional crops with them. In fact, most of the perennial agricultural crops grown today in the northern half of the conterminous 48 states and Canada are species introduced from Europe and Asia (alfalfa; alsike, red, and white clovers; birdsfoot trefoil; smooth bromegrass; timothy; orchardgrass; meadow and creeping foxtails; tall and meadow fescues; perennial ryegrass; several of the wildryes and wheatgrasses; etc.).

However, with the northward migration to Alaska of farmers versed in the culture of temperate-adapted perennial crops, many tried unsuccessfully to grow those same crop varieties or regional strains on their Alaskan farms. The Europe-to-America crop transfers were largely successful because those crops, even though taken longitudinally for thousands of miles, remained at similar latitudes and therefore within accustomed seasonal photoperiodic patterns. In contrast, attempts by U.S. farmers to take temperate-adapted perennial crop strains northward over several degrees of latitude have proven largely unsuccessful because such movement violates natural principles of crop adaptation.

The alternative has been for Alaskan plant specialists to select or develop subarctic-adapted plant strains, drawing upon (a) plant introductions from other northern regions, or (b) the indigenous Alaskan flora. Another avenue for development of subarctic-adapted crop strains is the one that was followed to formulate the Denali alfalfa discussed previously. This entails planting large plant populations of temperate-adapted crops; seed harvested from the few "winter survivors" is then planted for another cycle of natural selection. Repetition of these cycles over time gradually selects toward a crop strain with desirably modified genetic constitution, and hence more responsive to our northern climatological patterns in achieving adequate preparation for winter (Klebesadel 1971b; 1983).

Winter Stresses vs. Autumn Conditioning

The fundamental principle that perennial plants should possess north-latitude adaptation for dependable winter survival in Alaska is very poorly understood by many. One frequently hears enthusiastic comments from newcomers to Alaska that go something like this:

"I've purchased some little maple (or walnut, or apple, or pine, etc.) trees from a nursery in Minnesota (or Montana, or North Dakota, etc.). *I know they will be winterhardy here because winters are colder where these come from than the winters are in Alaska.*"

The superficial logic in his reasoning is good . . . but, beneath the surface, *that logic is flawed, for there is more to winter survival of plants in Alaska than just the coldness of the winters*. Much of the enthusiasm has left the grower when he finds after one, two, or three winters that all of his imported trees have winterkilled.

The same pattern generally is true with many kinds of bush-type woody ornamentals and small fruits, perennial flowers, turfgrasses, and field crops brought to Alaska from more southern origins, even though those areas have winters as cold as Alaska's (table 2).

Why this confusing and seemingly contrary plant behavior?

The answer: Perennials from more southern sources fail to survive winters here *not* because Alaska's winters are colder (sometimes they are milder) but primarily because conditions here during *late summer and autumn* are *different* from their place of origin; hence, *plants introduced from more southern latitudes are not induced to prepare adequately for Alaska's winters*. They still possess the genetic *potential* to prepare for winter, but Alaska presents an unaccustomed pattern of stimuli during late summer and autumn that does not induce plants to undergo physiologic changes

Table 2. Some temperature comparisons between the Matanuska Research Farm and selected locations in the northern tier of the 48 conterminous states (from USDA, 1941).

Location	Latitude	Temperature in °F	
		January average	Recorded minimum
Alaska			
Matanuska	61.6°	12.6	−36
Montana			
Havre	48.5°	12.9	−57
Sidney	47.7°	9.2	−47
Huntley	45.9°	19.0	−40
North Dakota			
Minot	48.2°	6.9	−49
Grand Forks	47.9°	3.7	−43
Mandan	46.8°	8.5	−46
Minnesota			
Roseau	48.8°	0.6	−52
Duluth	46.8°	9.1	−41
Brainerd	46.3°	7.8	−42

to the extent that they are genetically capable of reaching in their "home" environment.

In contrast to more southern-adapted plants, Alaska's native flora consists of plants that have evolved under Alaska's uniquely northern patterns of seasonal climatic peculiarities. Hence, they are genetically attuned to responding adequately to Alaska's autumn pattern of conditioning stimuli, they undergo adequate physiological preparation for winter's stresses, and consequently they are winterhardy here (Klebesadel 1969, 1970, 1971a, 1973, 1980, 1984b; Klebesadel et al. 1964; Mitchell 1982).

The Vital Autumn Conditioning Period

It is apparent that plants from more southern latitudes, when grown far north of their origins, experience an *inadequate period of short photoperiods* prior to killing frost (Moschkov 1935). Hodgson (1964) showed that artificial provision of a longer-than-normal term of short photoperiods here prior to winter caused overwintering tissues of a temperate-adapted alfalfa to develop an enhanced level of cold tolerance prior to onset of winter. Further proof that a longer-than-normal term of short photoperiods in autumn would contribute to better actual winter survival of temperate-adapted crops when grown in subarctic areas has been provided by Pohjakallio (1961) and Klebesadel (1971a, 1973). Such artificial provision of a photoperiodic pattern prior to onset of winter, resembling normal autumn conditions in their area of origin, is impractical on a routine basis, but it serves to illustrate convincingly why perennial plants brought to Alaska from more southern latitudes (where winters are as cold or colder) fail to survive winters here.

This is shown clearly in Figure 4 by the relative winter survival and spring growth of 'Southland' smooth bromegrass (center row in each photo) as influenced by three different late summer/autumn photoperiodic

Normal photoperiods (gradually shortening from 15 hr to 9.5 hr during treatment period).

Normal photoperiods but daily dark period interrupted with 90 min. light beginning at midnight.

Shortened photoperiods (9 hr each day).

Figure 4. Winter survival and spring growth of grass rows on 6 June at Palmer as influenced by normal versus artificially altered photoperiods/nyctoperiods during 24 August to 20 October of the previous year.

Grass rows directly below each letter: P = 'Polar' bromegrass, M = 'Merion' Kentucky bluegrass, N = 'Nugget' Kentucky bluegrass, S = 'Southland' smooth bromegrass, A = 'Arctared' red fescue, I = 'Illahee' red fescue, and Bp = native Alaskan bromegrass. (Underlined varieties are introduced from more southern latitudes.)

treatments to which the grass rows were exposed during the previous year. Southland is a variety selected in Oklahoma from seed of Kansas origin; as such it is adapted to roughly 35° to 40° north latitude. In the top photo (fig. 4), where grown under normal Alaskan photoperiods prior to winter, winter injury of Southland was significant and subsequent spring growth was weak. In the middle photo, where daily photoperiods were normal, but daily nyctoperiods (dark periods) were interrupted by artificial lighting for 90 minutes after midnight for the seven weeks prior to freeze-up, the four Alaskan grasses survived well but Southland winterkilled completely. This suggests that the daily duration of darkness also is important in causing plants to prepare for winter. In contrast to both of the above treatments, when short photoperiods (9 hr) with long nyctoperiods (15 hr) were imposed for seven weeks before freeze-up, creating prewinter light/dark conditions more similar to those in its area of origin, Southland was induced to make adequate preparation for cold temperatures and survived the winter well (lower photo, fig. 4). More detailed discussions of this experiment appear elsewhere (Klebesadel 1971a, 1973).

It is not known exactly what length of photoperiods are critical for initiating the biochemical changes that result in winterhardiness, but Figure 4 suggests that plants from different latitudes differ as to critical photoperiod. The four Alaskan grasses prepared adequately for winter under 15.5-hr photoperiods, while shorter daylight periods were required for Southland brome.

Moreover, it is not known precisely how many days plants should be exposed to those critical-length photoperiods, before the annual destruction of their receptor apparatus (leaves) by killing frost, in order to cause overwintering tissues to be brought to maximum hardiness levels.

Table 3, however, illustrates the very marked differences among diverse latitudinal locations in the number of days with photoperiods shorter than certain durations that plants will be exposed to prior to killing frost. These differences are imposed by the combinations of (a) the seasonal pattern of photoperiods at different latitudes (fig. 1), and (b) the different normal dates of occurrence of killing frost, which are occasioned by generally shorter growing seasons at progressively higher latitudes.

Table 3. Average number of days during late summer/autumn between time that shortening photoperiods reach a specific photoperiod and that location's mean date of first killing frost (28° F.).

	Days after each photoperiod until killing frost		
Photoperiod (hours)	Palmer, AK 61.6°N.	Fargo, ND 46.9°N.	Springfield, IL 39.8°N.
16	35	[1]	[2]
15	24	64	117
14	14	42	74
13	4	24	49
12	[3]	5	27

[1]No 16-hr photoperiods: maximum = 15 hr 54 min.
[2]No 16-hr photoperiods; maximum = 15 hr 1 min.
[3]Mean killing-frost date precedes 12-hr photoperiod by 7 days.

Exchanges of North-Latitude Ecotypes

Both woody and nonwoody perennial plant species are subject to the same basic natural principles of north-latitude adaptation. Exchanges of ecotypes from one circumpolar location to another can be successful over thousands of miles if near-similar latitudes (hence, similar seasonal photoperiodic patterns) are involved. Many investigators have studied the adaptational significance of latitudinal races and photoperiodic ecotypes in woody species, including Langlet 1943, Lindgren 1983, Moschkov 1935, and Vaartaja 1954.

Pines

Examples of successful north-latitude ecotype exchanges can be seen in pines (*Pinus* spp.). Except for the occurrence of shore pine (*P. contorta* subsp. *contorta*) and lodgepole pine (*P. contorta* subsp. *latifolia*) in the southeastern Panhandle area of Alaska (an area of mild winter stress), there are no native pines in the entire state (Viereck and Little 1972). The desire of some Alaskans to grow pines as ornamentals has led to importations and grower evaluations of numerous pine species and ecotypes from various areas of the world. Only a very few have been found to be dependably to marginally winterhardy here (Epps 1980). Some that are marginally winterhardy may survive several consecutive mild winters but succumb during a winter that imposes greater than average stress (fig. 5).

An outstanding example of successful importation into Alaska is scotch pine (*P. sylvestris*) from near the northernmost limits of its natural range in Europe. The tree shown in Figure 6 was grown from seed acquired from above the Arctic Circle (66.6°N.) in northern Finland. This ecotype is inherently and ideally adapted to prepare adequately for winter under the late summer and autumn conditions encountered in Alaska. Consequently, approximately forty trees of this ecotype, grown for over 10 years in the Matanuska Valley, have shown no evidence of winter injury.

Reciprocal exchange at northern latitudes can be equally effective and satisfactory. Scandinavian foresters have found that seed collections of lodgepole pine from the northernmost extent of the range of that species in Yukon, Canada, (about 63-64°N) produce trees in Scandinavia well adapted to their north-latitude conditions (Lindgren 1983). Some of these northernmost lodgepole pines from Canada have been grown in Alaska with equal success (Alden and Zasada 1983).

Grasses

The aforementioned Engmo timothy (table 1) from northern Norway has been superior in winterhardiness here to any of the cultivars available from North America, all of which were developed for and are adapted to latitudes more southern than Alaska's agricultural areas. Moreover, one of the most winterhardy and best adapted strains of Kentucky bluegrass tested in southcentral Alaska originated in Iceland (Klebesadel 1984a).

As with the pines, reciprocal exchanges of grasses have been successful also. Collections of Bering hairgrass (*Deschampsia beringensis*) from 60-62°N. in Alaska, have performed well not only in Alaska (Mitchell 1982) but also in Icelandic trials at 63.5° to 65°N. (Tomasson 1984). Similarly, 'Nugget' Kentucky bluegrass, an extremely winterhardy cultivar selected in southcentral Alaska, has been found well adapted to conditions in Norway and is becoming increasingly used there[1].

[1]Personal communication, 1983: Øystein Simonsen, Norway Director of Plant Breeding Research, Vagønes Agricultural Research Station, Bodø, Norway.

Winter Climate

With high-latitude transfers of plant materials, however, another facet of adaptation besides accustomed photoperiod must be considered: *the nature of the winter climate*. Although the annual pattern of photoperiods at a given latitude is similar around the world, actual winter conditions, e.g. temperature patterns, winds, snowfall, of different locations at the same latitude may differ greatly.

This holds considerable significance for plant adaptation and success of plant transfers. For example, a plant ecotype from a northern area in a midcontinent area of the Soviet Union, where extremely low and relatively constant winter temperatures are the norm, may fare especially well in the central, interior area of Alaska, where similar winter conditions prevail.

In contrast, plants from Iceland or coastal northern Norway fare relatively better in Alaska's Matanuska Valley than ecotypes from other northern sources because of superior

Figure 5. A marginally adapted pine that grew for several years in the Matanuska Valley. Many such ecotypes will grow for a few years during a period of mild winters, but succumb during a winter of severe stress.

Figure 6. An extremely winterhardy Scotch pine grown in Alaska from seed obtained from near the northern extent of the species range above the Arctic Circle (66.6°N.) in Finland.

adaptation to a different type of winter conditions (Klebesadel 1983); the latter three areas record relatively milder winter temperatures than the more continental locations, but also experience a more changeable winter climate with considerable amplitude to some midwinter temperature oscillations, including occasional thaw intervals (Klebesadel 1974).

Therefore, it is not accidental that several plant-ecotype exchanges have been successful among the Matanuska Valley, Iceland, and northern Norway. All are at northern latitudes and are characterized by relatively analagous winter conditions. Understanding these relationships provides the rationale for the successes encountered in reciprocal exchanges of grasses among these three locations, as discussed in the previous section.

Conclusions

Differences in seasonal photoperiodic patterns associated with different global latitudes have exerted profound influences through the ages on perennial plant adaptation and the evolution of latitudinal ecotypes. These influences were of little significance when plants continued to grow in the geographic area where they had evolved. However, with artificial movement of plants, the practical significance of latitudinal adaptation must be recognized in modern-day uses of perennials in northern latitudes, including field-crop production, landscape horticulture, forestry, and revegetation.

For best winter survival in Alaska, plant germplasm should be of native Alaskan origin or should be secured from other high latitudes. Such plant material possesses inherent adaptation to the peculiarities of north-latitude growing-season/annual-photoperiodic patterns and the environmental characteristics resulting from the interrelationship of these two variables. This adaptation confers the ability to respond adequately to the pattern of late summer/autumn conditioning stimuli peculiar to northern latitudes. Such genotype-environment harmony induces plants to achieve physiologic changes at cellular and tissue levels necessary to adequately prepare overwintering tissues to tolerate cold temperatures and hence to permit such plants to survive northern winters.

Recognition of the importance and implications of both autumn conditions and the nature of the winter climate to successful winter survival at northern latitudes informs us what northern areas of the world likely can best supply ideally adapted plants for use in Alaska and, reciprocally, which circumpolar areas should find plant germplasm from various areas of Alaska to be well adapted and useful. □

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Findings on Turfgrasses and Their Management

by

Wm. W. Mitchell*

Introduction

We are fortunate that grasses have developed with a leafy, low growth habit that enables them to withstand frequent clipping and tolerate considerable wear. Such grasses have provided mankind with aesthetically pleasing and functionally useful ground covers. The adaptability of certain grasses for turf purposes was probably indicated by their behavior under grazing. Fields used for grazing, which for security reasons were often close to living quarters, also have been used for sporting events and other purposes. The "village green" supported animals and was a common meeting and trysting place (Huffine and Grau 1969). The bowling green, popular in Europe for hundreds of years, was the forerunner of the modern golf green. Sheep performed the mowing requirements of some of the early golf courses. Today the grass fairways and the greens, in particular, require meticulous care.

Grasses that are best suited for turf use are those that maintain a low growing point and continue to produce leaves under mowing regimes. Many turf grasses produce stems which grow horizontally either beneath the surface of the soil (rhizomes) or on the surface (stolons). These stems have nodes at which new shoots with leaves can be produced. The end of the stem also can turn up and become a shoot. If the growing point of the shoot remains below the cutting level and thus is not clipped, it retains the capacity to produce leaves. Grasses that are not rhizomatous or stoloniferous produce new shoots (tillers) from the base of the plant, thereby becoming tufted or bunchy in nature. Some of these also maintain low growing points and are used for turf purposes.

With the proper choice of grass, many areas of Alaska can support fine-looking lawns. This article presents information gained from a number of trials with turfgrasses at the Palmer Research Center and from observations of revegetation and forage plantings at various locations in Alaska. The information is pertinent to the selection of particular turfgrass varieties and to their management. (Also see Sparrow and Wooding 1977, Coop. Ext. Service 1983.)

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Criteria for Turfgrass Selection

In order to tolerate the mowing and wear that they receive, turfgrasses must be adapted to the locale in which they are being used. In Alaska there is a premium on winterhardiness (fig. 1). Most of the turfgrasses available for our use have been developed or selected for temperate regions. The effect of day-length differences in conjunction with lowering temperatures at our more northern latitudes causes these grasses to become less prepared for winter than they would be in their region of origin (see L.J. Klebesadel, this issue). Thus, turf grasses must be selected in view of their hardiness.

Other characteristics for which turfgrasses are judged include their texture (fineness or coarseness of leaf), color

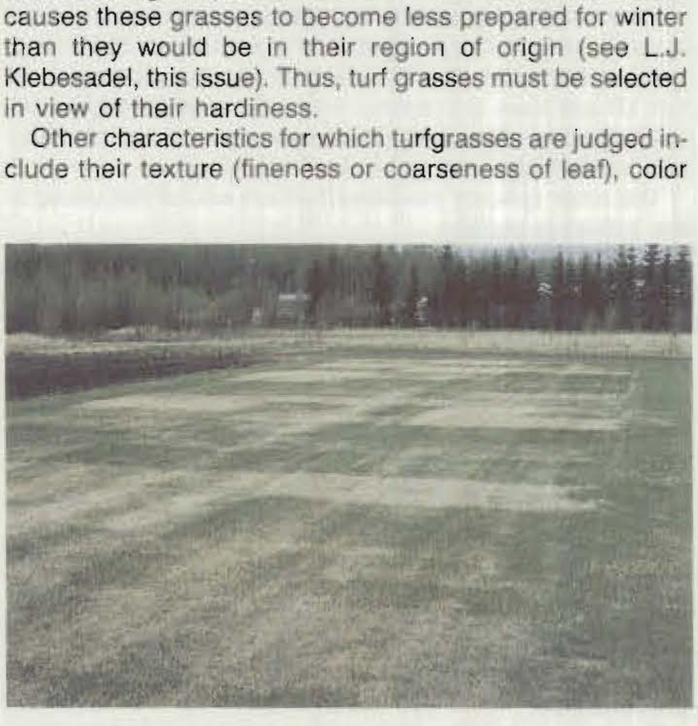

Figure 1. Differences in the amount of winter injury are evident among these plots of Kentucky bluegrass, red fescue, and hard fescue in a turf trial at the Palmer Research Center. Winterhardy varieties will provide an earlier and more reliable growth when winter stress is a factor.

(light to dark green with some variations), denseness and competitiveness, disease resistance, and early- and late-season growth. A desirable lawn presents a uniform appearance that is not overly coarse textured. It maintains sufficient density to impede weed encroachment and resists disease infestation. It remains verdant while growing conditions permit. However, the most winterhardy ones may show signs of senescence in early fall.

Turf Species

The most important species for general turf use at our northern latitudes are Kentucky bluegrass (*Poa pratensis*) and red fescue (*Festuca rubra*), both rhizomatous species. Chewings fescue is a nonrhizomatous, tufted version of red fescue. Others that have been evaluated in turf trials or other plantings include hard fescue (*Festuca longifolia*) and perennial ryegrass (*Lolium perenne*), both tufted types, and the stoloniferous creeping bentgrass (*Agrostis stolonifera*).

Because of its stoloniferous habit, creeping bentgrass can tolerate extremely low mowing and, therefore, lends itself to use on golf greens. While it is used on such areas in Alaska, it is only marginally winterhardy and requires special attention. Often, the greens are unplayable until the grass recovers from winter injury or a new stand is established. It and other bentgrasses (*Agrostis* sp.) are not adapted for general turf use in Alaska (except, possibly, for the southeastern region).

Perennial and/or annual ryegrasses are often included in turf mixtures. They will provide a quick cover but will not survive the winter and, thus, are of no value for perennial turf. Unless there is a special reason for establishing a quick cover, as on a site subject to excessive runoff, it is probably best to exclude ryegrasses from turf mixes.

The other species mentioned above will be discussed in the following section.

Species and Variety Performance

Grasses have been evaluated for turf quality in various trials at the Palmer Research Center. Some of the trials have included a number of experimental entries, but only the commercially available turf varieties will be discussed here. Each named variety, such as 'Nugget' Kentucky bluegrass and 'Arctared' red fescue is based on breeding stock that confers upon the variety certain predictable characteristics. The term "common" refers to material without this genetic identity because it is not based on any particular breeding stock, therefore its behavior is not predictable.

Evaluations of turf quality are shown for six different trials and of winter injury for two trials in Table 1. Some varieties have been tested over a period of years, while some new varieties entered in Test F were only recently established in 1982.

An evaluation of a turf plot early in the season can differ markedly from its evaluation later in the season. If injured but not killed by winter conditions, some grasses have the capacity to recover and produce a good-looking turf by mid to late season. Bluegrasses that have been good to superior in a number of trials include Nugget, 'Sydsport,' and 'Merion.' Another with less trial experience that shows promise is 'Touchdown.' 'Glade' received some good ratings, but on occasion has been subject to heavy mold infestation. More trial experience is needed on the varieties 'Banff,' 'Scenic,' 'America,' and 'Dormie' established in the most recent trial. Bluegrasses that have been consistently poor are 'Park' and common. 'Troy,' 'Adelphi,' and 'Fylking' also were judged inferior.

Arctared has been the most reliable red fescue variety demonstrating excellent winterhardiness and good tolerance of mowing (see also Taylor 1970). It suffers somewhat for appearance late in the season because of its senescing habits in preparing for winter. Others stay greener longer, but may pay the price for not having prepared sufficiently for winter.

Table 1. Evaluations of turfgrasses for quality on scale of 1 to 9 (9 = best), conducted near end of growing season, and for winter injury on scale of 1 to 9 (9 = most injury) conducted at beginning of growing season for various trials at Palmer Research Center.

	Trials							
Species and	Turf Quality						Winter Injury	
Variety	A	B[1]	C[1]	D[1]	E[1]	F	D	E
Kentucky Bluegrass:								
Nugget	8.7	8.5	8.7	7.3	8.5	8.3	1.2	0
Merion	5.3	6.4	8.1	6.7	8.1	7.3	4.3	2.3
Sydsport	6.3	7.9	8.3	6.8		8.0	2.8	
Park	3.3	5.9		3.2	3.0		5.0	6.7
Glade			7.4	6.3			2.7	
Troy				3.6			3.3	
Touchdown				6.5		8.3	5.0	
Adelphi				5.4			3.7	
Fylking	4.3			5.8			2.2	
Banff						7.5		
Scenic						6.0		
America						7.3		
Dormie						7.8		
Common				3.0	4.0		4.2	6.7
Red fescue (creeping):								
Arctared	7.3	7.0	6.7	5.5			1.2	0.5
Boreal	6.4			4.7			5.0	
Pennlawn	7.1	5.4	6.7	4.9			4.3	
Ensylva				5.6			5.7	
Chewings red fescue (tufted):								
Highlight	6.4	5.4		4.2			6.5	
Wintergreen	7.5	4.7						
Hard fescue:								
Tournament				5.1			6.3	
Scaldis				5.5			6.7	
Durar	3.2			2.6			6.9	

[1] Averages of scores for two years' evaluations.

Figure 2. Nugget Kentucky bluegrass, on the left, a very winterhardy turf variety, provided a dense competitive growth with a pleasing appearance in a turf trial at the Palmer Research Center. Less well-adapted entries, such as Park and common bluegrass, developed plots like that on the right, of low density and badly infested with weeds.

On the basis of its performance in the limited testing received in one trial, 'Ensylva' may merit second choice along with 'Boreal' and 'Pennlawn' to Arctared among the red fescues included in these trials. Arctared is definitely superior in winterhardiness. 'Wintergreen' and 'Highlight' chewings fescue were judged inferior to the other red fescues.

The hard fescues produce a different-looking turf because of their bluish gray-green color. Most of the plots of these grasses (Trial D) have declined further in cover since the evaluations presented in Table 1 were conducted, with many plantings being displaced by more aggressive bluegrasses in adjacent plots. The hard fescues 'Tournament' and 'Scaldis' have performed better in revegetation trials than in turf trials, suggesting a low tolerance to frequent mowing. They may perform better if mowed higher than in this trial. Tournament and Scaldis were superior to 'Durar' hard fescue, which has been used to some extent in Alaska.

In general, the bluegrasses were rated above the fescues for turf quality. The fescues are finer leaved than the bluegrasses and less competitive than the better bluegrass varieties. Red fescues often are touted as being better able to cope with shade and poor soils than Kentucky bluegrasses. Though the turf trials discussed here were not designed to test those premises, some results obtained in revegetation trials indicate that red fescue is better adapted to poor soils than Kentucky bluegrass.

The entry that has been consistently good to superior in all trials, demonstrating excellent winterhardiness, is Nugget bluegrass (also see Klebesadel and Taylor 1972, Klebesadel et al. 1964, Klebesadel 1984). Nugget forms a dense cushiony turf that is more competitive with weeds than other bluegrasses (fig. 2). In Trial D, Nugget was planted in dual mixtures with Merion, Sydsport, Park, and common Kentucky bluegrass and with Arctared red fescue and in a three-entry mixture with Merion and common. In all cases, after about three years, Nugget assumed dominance; and in many plots, after five years, Nugget appears to be the sole representative. Thus, Nugget could be seeded in a turf mix with other bluegrasses and fescues and in due time be expected to dominate the seeding. Nugget and Arctared are varieties selected and released at the Alaska Agricultural Experiment Station (Hodgson et al. 1971, 1978).

Color differences were noted for some of the bluegrasses (fig. 3). Nugget produces a dark green turf. Sydsport is distinctly lighter green in color. Merion appears somewhat lighter and Touchdown almost as dark as Nugget. Banff is a light green variety. Fertilization can influence color, with darker colors achieved at higher nitrogen rates.

Figure 3. Differences in color and density of growth serve to distinguish these Kentucky bluegrass turf plots at the Palmer Research Center. Varieties entered in the trial range from light green, as characteristic of Sydsport and Banff, to dark green, as characteristic of Nugget.

Cutting Management

In most of the trials, mowing height was maintained at about 1.5 to 1.75 inches. Trial B was a cutting-height trial in which the entries were mowed at the following heights: low - 1.2 inches, medium - 2.0 inches, and high - 2.8 inches.

Results of the cutting-height trial indicated that, under our conditions, the better-adapted varieties are able to tolerate the low-cutting height. Nugget, in particular, performed well under the low-cutting regime. Because of the dense growth of Nugget, it develops a thick thatch. Probably because of this insulating layer, thaw is delayed, providing Nugget with a late start in the spring. Other less densely growing turf grasses can provide an earlier spring growth. However, it was noted that in the height-of-cut trial Nugget began showing green growth earlier under the low cut, which produced less thatch, than under the higher cuts (fig. 4).

In a separate trial, Nugget was subjected to mowings at the lowest setting on the rotary mower (less than 1 inch) and maintained a dense cover. It spread into the neighboring plots of 'Emerald' and 'Colonial' bentgrass, which experienced winter injury each year and eventually winterkilled.

The question often arises as to whether clippings should be removed or allowed to remain. If mowed frequently enough, the young tender parts will decompose and contribute to the fertility of the soil more readily than the clippings of infrequent mowings. The return of lawn clippings should reduce necessary fertilizer treatments, but no research has been done in Alaska to quantify this. The low soil temperatures at our latitudes may slow decomposition rates and result in some accumulation of thatch. Allowing grasses to grow too tall before mowing renders decomposition of the clippings more difficult because of their greater age and "toughness." Furthermore, if most of the tall growth is mowed off, the bulk of the photosynthetic tissue will be removed, which can result in a brown, dead-like appearance (fig. 5). The grass must then rely on root reserves to produce new growth, requiring more time than usual.

Fertilizer Requirements

The major nutrients that need to be supplied in fertilizer for grass growth consist of nitrogen (N), phosphorus (P), and potassium (K). The amount of nutrients used by a lawn during the growing season can provide an indication of fertilizer needs. However, particular soil characteristics can further influence those needs.

To obtain an estimate of nutrient demands, in Trial E (table 1) lawn clippings were collected in 1982 and 1983, weighed, and analyzed for their contents of N, P, and K. In 1983 Trial E was mowed fifteen times during the growing season commencing on May 20 and ending on September 26. The experiment was fertilized three times during the growing season with 18-18-18 (a ration of 1:1:1 of $N:P_2O_5:K_2O$), each time at the rate of 6.89 lbs per 1000 square feet supplying 1.24 lbs of N, 0.54 lbs of P, and 1.03 lbs of K.[1]

Grasses characteristically take up a large amount of nitrogen, a small amount of phosphorus, and a medium to

[1] 100 lbs of a fertilizer mix of 18-18-18 contains 18 lbs (18%) of N, 18 lbs (18%) of P_2O_5 (of which 44%, or 7.92 lbs, is P), and 18 lbs (18%) of K_2O (of which 83%, or 14.94 lbs is K).

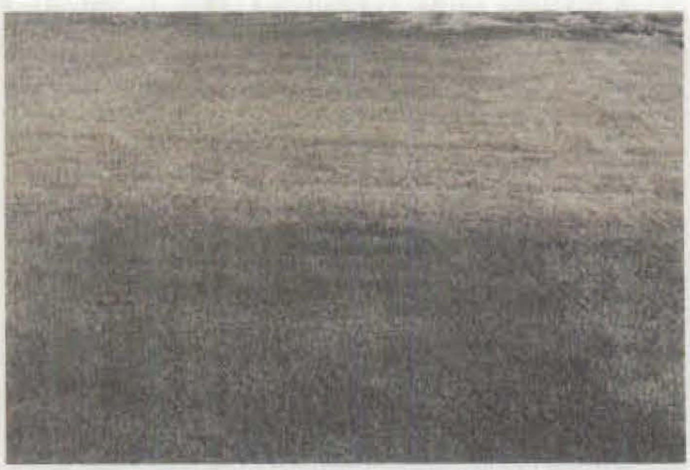

Figure 4. Nugget bluegrass cut at 1.2 inches height in the foreground has commenced growth earlier than the Nugget bluegrass in those portions of the plot in the background cut at about 2 inches and 2.8 inches. Nugget provided a healthy, dense growth mowed at the lower height.

Figure 5. A lawn allowed to grow too tall before being mowed has lost much of its ability to photosynthesize from the stem and leaf tissue that remains after mowing, as indicated by its brown color. Root reserve must be called upon to produce new growth. Recovery will take longer than if the grass had been mowed more frequently.

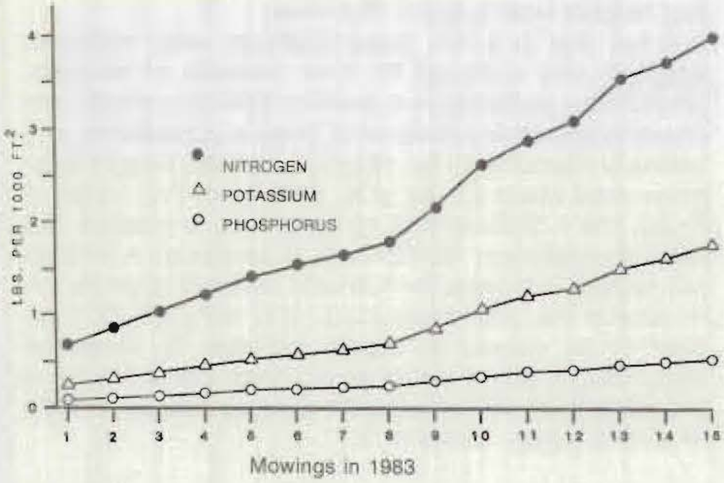

Figure 6. Cumulative amounts of N, P, and K, in lbs per 1000 ft², removed in the clippings of Nugget bluegrass during the course of the 1983 growing season.

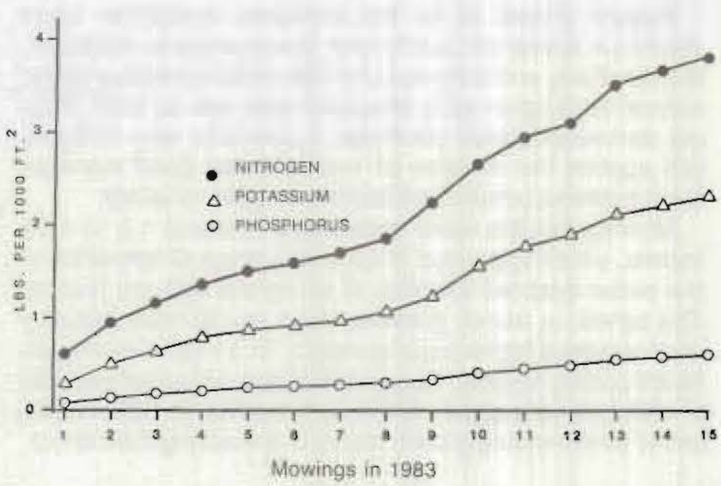

Figure 7. Cumulative amounts of N, P, and K, in lbs per 1000 ft², removed in the clippings of Arctared fescue during the course of the 1983 growing season.

medium-heavy amount of potassium, as demonstrated by the removal of these nutrients by Nugget bluegrass and Arctared fescue through the 1983 growing season (figs. 6 and 7). More N was removed in the clippings than was applied in the fertilizer (table 2), while more P and K were supplied in the fertilizer than were removed. Though Arctared and Nugget are similar in their nutrient demands, Arctared removed 17 per cent more P and 32 per cent more K than did Nugget.

A fertilizer mix formulated strictly on the basis of the amount of N, P, and K removed by Nugget bluegrass would have a ratio of 4:1.2:2.1 of $N:P_2O_5:K_2O$. But soil differences affect nutrient/plant relationships as well. Soil type has a strong influence on the availability of phosphorus, which becomes chemically bound in the soil. Strongly acidic (low pH) and highly organic, peaty soils generally render P less available than more neutral and less organic soils.

Because of the typically low phosphorus content of Alaska soils, the initial fertilizations in establishing a lawn should be higher in phosphorus than may be necessary in the maintenance fertilizer to be used once the lawn is well established. A fertilizer with about a 1:1:1 to 1:2:2 ration (for instance, 17-20-20 or 12-24-24) could be used for the initial applications. A 12-24-24 fertilizer could be applied at 10 lbs per 1000 ft² at time of seeding and in the spring of the following year, followed by one or two maintenance applications. The maintenance applications could consist of a mix in the nature of 22-8-16 applied at about 7 lbs per 1000 ft² in each of three applications during the growing season.

Table 2. Amounts of fertilizer nitrogen, phosphorus, and potassium applied to turf trial (Trial E) and amounts removed in grass clippings of Nugget bluegrass and Arctared fescue in 1983 growing season.

Nutrient	Applied in fertilizer	Removed in grass clippings: Nugget	Removed in grass clippings: Arctared
	(lbs/1000 ft²)		
Nitrogen	3.72	4.00	3.82
Phosphorus	1.62	0.52	0.61
Potassium	3.09	1.76	2.33

Both Nugget bluegrass and Arctared fescue yielded about 126 lbs of dry matter per 1000 ft² in 1983, or about 2.75 tons/acre. The young grass clippings are high in feed quality, being particularly high in crude protein. One of the largest commercial sod-growing firms in the nation found it economically feasible to construct dehydrating plants for pelleting grass clippings at several of their sod farms (Seed World 1979). The pellets were destined for poultry, cattle, and horse feed, being particularly desirable for poultry feed.

Summary

Nugget Kentucky bluegrass performed consistently well in a number of turf trials, producing a dense, dark green turf with excellent winterhardiness. Other Kentucky bluegrass varieties that produced fair- to good-quality turfs include Sydsport, Merion, and Touchdown. Other varieties currently in trial need further evaluation. Arctared was the most consistent and winterhardy of the red fescues placed in trial. Other varieties, less winterhardy than Arctared, that have been used to some extent in Alaska include Boreal and Pennlawn. Ensylva performed as well as these in one turf trial.

Kentucky bluegrass turfs were judged superior to red-fescue turfs. Arctared may be better adapted to poor soils or low-maintenance situations. A mix of bluegrass and red fescue, preferably Nugget and Arctared, may be appropriate for such situations.

Nugget proved to be the strongest competitor when planted in mixes with such other bluegrasses as Sydsport, Merion, Park, and common and with Arctared fescue under normal fertilization on a deep silt loam soil. In time, Nugget dominated these plantings. It also was very competitive against the invasion of weeds under good management systems (ample fertilization, regular mowing).

Mowing heights were maintained at about 1.5 to 1.75 inches, which appeared to be in the range of tolerance of the better adapted varieties of bluegrass and red fescue. The tufted, or bunch grasses, such as the hard fescues, may require a higher cutting height. In a trial involving different cutting heights, Nugget bluegrass appeared capable of maintaining a good, dense turf mowed at 1.25 inches and of commencing growth earlier in the spring than at cutting heights near 2 and 2.75 inches.

A turf trial in which grass clippings were collected, weighed, and analyzed for their contents of nitrogen, phosphorus, and potassium provided estimates of amounts of weekly growth and amounts of nitrogen, phosphorus, and potassium removed in the clippings. In 1983, Nugget bluegrass used about 4.0 lbs of N, 0.52 lbs of P (1.18 lbs of P_2O_5), and 1.76 lbs of K (2.12 lbs of K_2O) to produce 126 lbs of dry matter per 1000 ft^2 (= 2.75 tons/acre). A fertilizer mix applied to replace the nutrients removed could be formulated in the ratio of about 2-3:1:2 of $N:P_2O_5:K_2O$. If applied in an amount to supply sufficient N, insurance amounts of P and K would be provided. About 1.5 lbs of N applied three times during the growing season on 1000 ft^2 should supply sufficient N.□

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Figure 1. Bison and other wildlife, such as the bull moose in this scene, use trails on Fort Greely which have been cleared of trees and seeded to grasses. These trails interconnect various improved range sites and the usual summer ranges along the Delta River.

Animal Distribution Limits Range Utilization

By

Jay D. McKendrick*

Instructors of general range-management courses in western universities often ask their students, What single practice could most increase livestock production from western U.S. rangelands? The expected answer is: improved livestock distribution. Herding, fencing, placement of salt blocks, burning, drinking-water developments, and other innovations comprise the array of devices commonly used to entice and/or force grazing livestock onto various portions of ranges that would otherwise remain unused. Justification of such practices goes beyond immediate economic returns from improved livestock production; it includes the conservation ethic of protecting favored grazing areas from abuse. Burning is one management practice that deserves a more thorough trial in Alaska.

Unsupervised, domestic livestock and wild grazers tend to graze certain locations habitually and avoid others. Overgrazing by bison along the Delta River in interior Alaska is a good example of wildlife concentration and overuse. Prior to recent management actions and a wildfire, some range sites beyond the river channel were usually avoided by the herd. During the summer, few, if any, bison ventured beyond their presently overgrazed habitat, disregarding the feed that existed on the bottomlands several miles upriver and on alpine ranges of surrounding mountains.

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In contrast to Alaska's bison, which must move miles to new forage, cattle in a 40-acre fenced pasture near Homer, Alaska, need to travel only a short distance to find new grazing; yet they choose annually to overgraze bluejoint grass only a few feet from untouched plants of the same species. In both of these examples, portions of the ranges are being abused, while other areas remain unused. If grazing were more uniform, the overall production of animals could increase, without overgrazing the ranges.

Coping with these two examples of nonuniform grazing is a management concern for the respective game manager and rancher. For both situations, identifying the causes of their respective animals' behavior is central to devising management solutions. Obviously the bison cannot be herded easily to their legislatively designated ranges south of the Alaska Highway, especially through dense spruce forests. Consequently, the U.S. Army, in cooperation with Alaska Department of Fish and Game, cleared and seeded trails to interconnect the bison range with the traditional river-channel grazing area (fig. 1). Bison have been successfully enticed along these trails with salt, mineral blocks, and, more importantly, by the presence of palatable grasses.

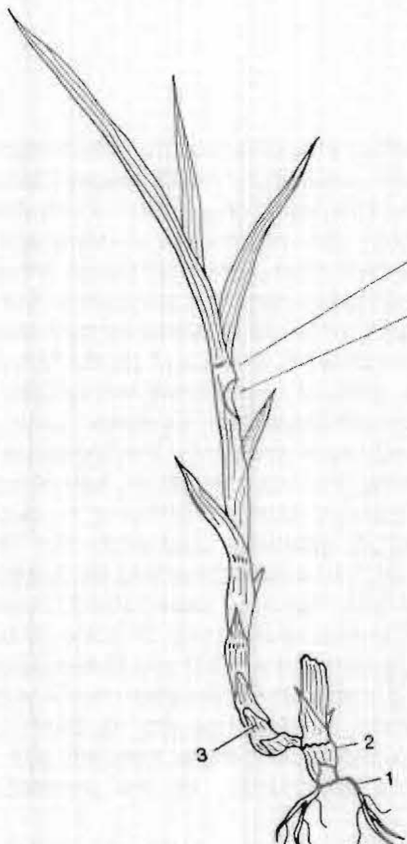
On the cattle range near Homer, placing salt blocks in and near the ungrazed grass resulted in only limited success in improving grazing distribution. Although the cattle were already aware of the forage in those unused portions of the range, luring the animals onto the site using salt still failed to encourage grazing of the plants.

Concentrating livestock with increased fencing to subdivide a 40-acre pasture would be a costly and currently unacceptable alternative for Alaska's cattle producers, even though intensive management would help solve the patchy-grazing problem. Judging from evidences in the field and experiences elsewhere, the patchy use of bluejoint probably stems from grazing patterns established during the first year cattle grazed our unit. Once established, these patterns persisted, (see fig. 2) apparently due to favored palatability for leafy regrowth of bluejoint and annual bluegrass, which has invaded on the overgrazed areas. If the grazing pressure could be increased to force animals to graze all plants in spring before flowering heads are produced, then subsequent grazing pressures may be lightened without major sacrifices in cattle distribution. Adjusting livestock numbers seasonally to force heavy, but uniform, use is also unlikely for most Alaska ranges, which are ordinarily understocked and unfenced. Other less-costly and effective means are needed.

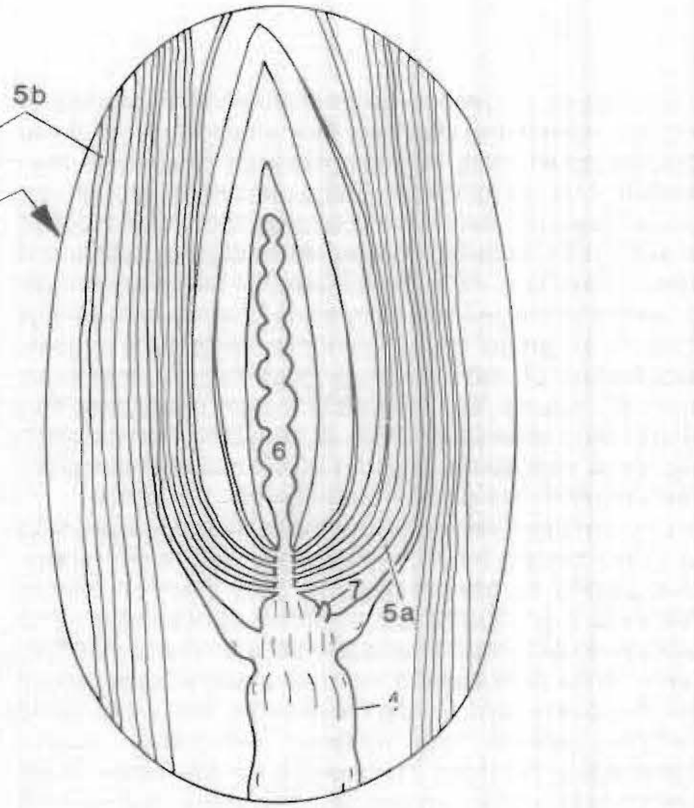
The accompanying diagram shows the structure of bluejoint's normal spring growth about the time grazing commences on these ranges. There are usually five fully expanded leaves with six or seven emerging. The apex of the stem, or growing point, is still enclosed within the sheaths of developing leaves. If the plant is cut off above the growing point, either by grazing cattle or by mechanical mowers, the shoot will continue growing, culminating in a plant with parts of most leaves missing but with a flower head. Stockmen readily recognize such plants as being unpalatable to cattle late in the summer.

In contrast, if the young shoot is cut below the growing point, further development of that shoot ceases, forcing buds on the lower stem and/or rhizome (underground stem) to commence growth. This form of regrowth does not culminate in a flower head. Instead these plants, with rare exceptions, continuously produce leaves throughout the remainder of the growing season. Very minor stem development occurs. Such leafy specimens are more attractive to livestock than their coarse, naked-stemmed, and intact counterparts which have flower heads.

During winter, these leafy shoots readily mat down under snow, while the stemy growths sometimes remain at least partially erect, not only throughout the winter, but for several subsequent seasons as well. Those standing dead residues shield tender spring shoots from grazers until these new shoots outgrow the standing dead. By then, current-year shoots have become coarse and are less palatable than leafy regrowth of plants grazed below their growing points



Line drawing shows a bluejoint shoot with five fully expanded leaves. Adventitious roots (1) produced during the previous growing season from nodes on stem base of mother shoots (2). Roots have not yet developed on daughter shoot. Leaf scales (cataphylls) (3) on underground portions of stem. Stem or culm (4).



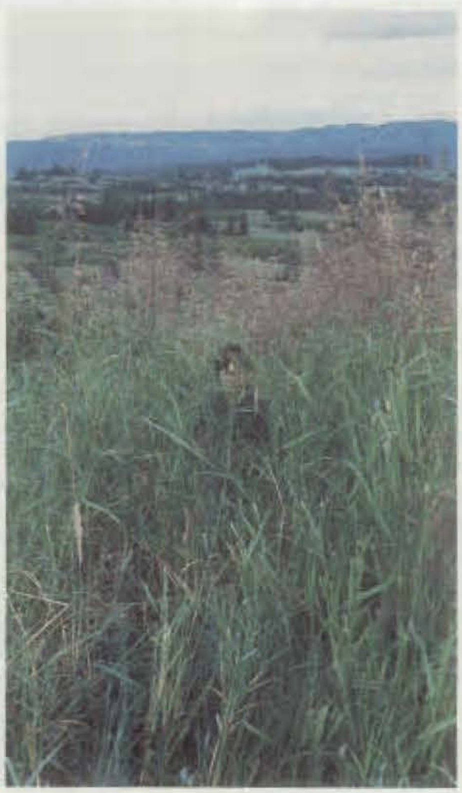
Leaves not yet emerged (5a); fully expanded leaves (5b), which are distinguished from unexpanded leaves by appearance of collar separating sheath from blade. Flower head (6) enclosed in leaves. Axillary bud (7) in axil of developing leaf.

(1)

(2)

(3)

(4)



(5)

Figure 2. This series of five photos taken at the 40-acre range unit near Homer shows five stages of range utilization near the end of the fifth grazing season in the study. The height of the boy is 53 inches.

(1) This area has been grazed heavily each year, resulting in a weakening of tall-grass plants and the invasion of such short-growing species as annual bluegrass.

(2) This is an area which has been grazed moderately and is composed of leafy regrowth.

(3) This area with a stemmy stubble was grazed moderately, fairly late in the season.

(4) This area was also grazed late in the season; after light grazing, it is comprised mostly of stems.

(5) This photo shows an ungrazed area with fully developed shoots.

Figure 3. Burning the True Prairie range type of the Kansas Flint Hills results in a patchy pattern with fire carried only in the areas having dead grass remaining from the previous growing season. Growth on burned patches will be more attractive to cattle than that on unburned areas. Annual burning has not caused deterioration of soil fertility and has eliminated most undesirable plants on these prairie pastures.

earlier in the season. Consequently, animals concentrate on formerly grazed areas, perpetuating patchy grazing patterns of prior years.

One solution might be burning Alaska's tall-grass ranges in early spring to remove standing dead growth and increase relative palatability of shoots on formerly ungrazed areas. Burning is commonly used on the tall-grass ranges in the Kansas Flint Hills (fig. 3). Timing of the Kansas burns is aimed at limiting exposure of bare soil to prevent erosion and moisture losses and to discourage unwanted cool-season plants. Research has shown that late spring, just as the preferred warm-season grasses are emerging and when soils are moist, is the best time to burn those ranges. Cattle on burned ranges individually outgain those on identical but unburned ranges, probably because animals on the burned ranges consumed more forage (Launchbaugh and Owensby 1978). More important, grazing patterns are altered from area to area over the years, because animals prefer grazing the burned sites, which usually are patches not grazed during the previous season.

Over 50 years ago, there was an Alaska Agricultural Experiment Station facility on Kodiak Island. At that station, range-burning experiments were commenced on plots 1/40 acre in size, in part to remove dead bluejoint grass, which had been causing livestock deaths due to impaction (Snodgrass, 1910). The only report available on that work indicated that "burning dead grass early in the spring increases the stand" (Alberts 1930). Ranchers on the Kenai Peninsula and in the Matanuska Valley are known to have used fire occasionally to remove trees and shrubs for improving ranges.

Improving livestock distribution on Alaska's bluejoint ranges appears necessary. Based on experiences with burning prairie tall grass and bluejoint on Kodiak, controlled fire might be a reasonable tool for improving animal distribution. Burning shrubland and scrub forest in the Interior has been observed to improve bison distribution and carrying capacities of those ranges (McKendrick 1982; Campbell and Hinkes 1983). The Alaska Department of Fish and Game and U.S. Forest Service have been cooperatively burning areas on the upper Kenai Peninsula to improve range for moose for the past few years. Quantitative measurements of those efforts are just becoming available. Even though the practice is not widely used, there is mounting evidence favoring controlled burning as a technique for range improvement on certain Alaska vegetation types.

Perhaps someday the question posed to range students may be, What single practice most improved livestock (bison or moose) distribution on rangelands in Alaska's boreal zone? The correct answer may be "controlled burning."□

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In the study reported here, selenium levels of several growing plants commonly used as forages were measured. One of the four areas in Alaska where such testing was conducted was the Kenai Peninsula, above.

Status of Selenium in Alaska

By

A.L. Brundage*

Selenium is included in the class of nutrients which are essential in the diet, and which are also toxic when dietary amounts exceed certain limits. The status of selenium in animal nutrition has been reviewed in detail in the National Research Council publication, "Selenium in Nutrition," revised edition (1983). This review considers the chemistry, distribution, biochemical functions, metabolism, and nutritional aspects of selenium. It also includes commentary on the effects of excess selenium in the diet, and interrelationships of selenium and human health, as well as an extensive bibliography of literature pertaining to selenium. This publication is the source of background information included in this report on the status of selenium in Alaska.

Dietary requirements for selenium are difficult to define empirically because of interactions of it with other dietary constituents, especially vitamin E. In addition, the lower absorption of selenium in ruminants than in nonruminants is probably due to the reduction of much of the dietary selenium to insoluble forms by rumen microbes. Depending on these and other variables, dietary requirements for selenium are 0.05 to 0.3 parts per million (ppm) in the dry ration. As little as three to five ppm selenium in rations can produce toxic symptoms in livestock. (One ppm is equivalent to 1 pound in 500 tons.)

The selenium content of growing plants is dependent on soil concentrations of selenium, availability of soil selenium, and the ability of different plant species to accumulate selenium selectively. Original concerns with selenium in animal nutrition were focused on problems of selenium toxicity in regions where specific plant groups accumulated selenium in toxic amounts. Three distinct forms of selenium poisoning have been defined: acute, chronic of the blind-staggers type, and chronic of the alkali staggers type. Signs of selenium toxicity include: dullness, ataxia, rapid but weak pulse, labored respiration and respiratory failure, diarrhea, lethargy, lameness, loss of vitality, loss of appetite, emaciation, sore feet, deformed and cracked hoofs, and loss of hair. Acute selenium toxicity can lead to death in a few hours; chronic selenium toxicity can extend over periods of time with limited to major consequences on animal health and performance depending on the level of excess in the diet and interactions of selenium with other components of the diet.

The status of selenium in plants grown over much of the USA and Canada has been determined. With the exception of the southern half of the Prairie provinces, forages and grains grown in most of Canada contain 0.10 ppm selenium, or less. In the USA, less than 0.10 ppm selenium is found in grains and forages grown in states east of the Mississippi, especially those in the north-central and northeastern regions, and in the Pacific Northwest. Most prominent among symptoms of selenium deficiency is nutritional muscular dystrophy, a metabolic disease that has occurred most widely in sheep, but which also occurs in cattle. It also appears that certain reproductive problems in cattle and sheep are related to the muscular degeneration resulting from insufficient dietary selenium. Gross signs of selenium deficiency often do not differentiate between deficiency of selenium and deficiency of vitamin E, and are reflected in white muscle disease, heart failure, paralysis, unthriftness, diarrhea, retained placenta, and reduced performance in both ruminants and nonruminants. Liver necrosis in swine and exudative diathesis in poultry are also observed.

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A small number of Alaska grass and barley samples taken in 1979 contained 0.07 ppm and 0.5 ppm selenium respectively. When considered as the only dietary source of selenium, these feeds were marginal in their ability to meet dietary requirements for selenium. However, balanced rations of feeds obtained from within the state and elsewhere were considered to be adequate in selenium.

In 1983, however, Dr. Burton Gore, state veterinarian for Alaska, observed acute symptoms of selenium deficiency in a Delta herd of beef cattle (personal communication[1]). These cattle, which were being fed high-moisture Delta barley with 0.014 ppm selenium, barley/oat silage, and barley straw free choice, had selenium blood levels of 0.01 ppm. Coincidentally, blood samples from cattle in a Delta dairy herd being fed roughage and concentrates blended from a mixture of ingredients showed 0.16 ppm selenium. The normal range of blood selenium in cattle is between 0.1 and 0.2 ppm; the critical range is 0.04 ppm or less.

To assess the selenium status in Alaska, feed and plant samples were solicited from Cooperative Extension Service personnel, from research scientists in the Agricultural Experiment Station, and from the USDA Soil Conservation Service. One hundred eighty-one samples from four regions of Alaska were collected and sent to Oregon State University for selenium analysis. Material sampled included small-grain plants, small grains, legumes, grasses, mixed concentrate feeds, shrubs, forbs, trees, and lichens. The four regions were the Kenai Peninsula, the Matanuska-Susitna Borough, interior Alaska with emphasis on Delta and Fairbanks, and western Alaska.

Small grains are grown primarily in the Matanuska-Susitna Borough and in interior Alaska, especially the Delta area. Regardless of area of origin, small grains had only 0.01 ppm selenium (table 1). Small-grain forage grown in interior Alaska also had only 0.01 ppm selenium; that grown in the Matanuska-Susitna Borough had 0.06 ppm. The selenium content of grasses was dependent on the region in which they were grown. Grasses grown on the Kenai Peninsula had 0.25 ppm, those grown in the Matanuska-Susitna Borough had 0.09 ppm, and those grown in either interior or western Alaska had only 0.03 ppm. Mixed concentrate feeds from the Matanuska-Susitna Borough were 0.36 ppm selenium, a reflection of different origins of feeds included in these mixtures.

[1]Dr. Burton Gore, D.V.M., State Veterinarian, Sims Building, 510 So. Alaska, Palmer, AK 99645.

Table 1. Average selenium content of feed and plant samples from different regions in Alaska. The number of samples included in this survey are shown in parentheses.

Sample description	Region			
	Kenai	Mat-Su	Interior	Western
	Se(ppm)			
Grain forage	—	.0605 (8)	.0130 (2)	—
Grain	—	.0122 (13)	.0130 (18)	—
Legume	—	.0423 (3)	.1370 (2)	—
Grass	.2525 (11)	.0869 (24)	.0278 (8)	.0250 (6)
Mixed feed	—	.3645 (9)	—	—
Shrubs	—	.0140 (1)	.0257 (20)	.0260 (3)
Forbs	.0916 (12)	.1713 (16)	.0477 (7)	.0312 (5)
Trees	—	—	.1183 (2)	—
Lichens	—	—	—	.1636 (11)

Data summarized in Table 1 suggest that plant material from interior Alaska, with the possible exception of legumes and trees, which were limited to two samples of each, probably will be below minimum dietary requirements for selenium. Adverse consequences of selenium deficiency can be avoided, however, by proper supplementation with selenium or by the use of imported feeds to balance locally produced feedstuffs. This was observed in the two Delta cattle herds, where one was fed a simple ration of barley, barley/oat silge, and barley straw. That herd exhibited acute symptoms of selenium deficiency; the other herd that was fed roughages and a blended concentrate of mixed feeds did not exhibit observable signs of selenium deficiency.

Eleven grass samples and twelve samples of forbs from the Kenai Peninsula appeared to contain adequate dietary levels of selenium. Supplementation with selenium should not be necessary on the Kenai Peninsula, especially if some portion of the ration is provided from concentrates of mixed origin. In the Matanuska-Susitna Borough, many locally produced feeds appear to be marginal in selenium content, but supplementation of rations with blended concentrates of mixed origin should compensate adequately for selenium deficiencies. With the exception of lichens, plant material from western Alaska is low in selenium, and good nutrition may require supplementation with selenium on a selected basis.

The uniformly low selenium content of Alaska barley, regardless of origin, was a major observation from this survey of Alaska feeds and plant material. Barley is the major Alaska-produced grain for livestock feed. If used wisely, this information on the selenium status of Alaska barley will provide the basis for the proper supplementation of livestock rations in Alaska to meet dietary requirements for selenium. In doing so, however, one must remember that selenium is essential in the diet in minute amounts, but that it is also toxic in relatively small amounts as well. Supplemental selenium levels approved by the United States Food and Drug Administration are 0.1 ppm for cattle, sheep, swine (0.3 ppm in prestarter and starter diets), chickens and ducks, and 0.2 ppm for turkeys (National Research Council 1983). Insuring adequate, safe levels of selenium in livestock diets will require complete mixing of selenium supplements in rations, and the producer is cautioned against attempting to accomplish this by top-dressing feeds with selenium supplements. Therefore, Alaska livestock producers are urged to seek competent professional help and advice before proceeding to supplement livestock rations with selenium. □

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National Research Council. 1983. *Selenium in Nutrition*. Revised. National Academy Press, Washington, D.C.

Representative Rivers: A Research Program Based on Management Decision-Making

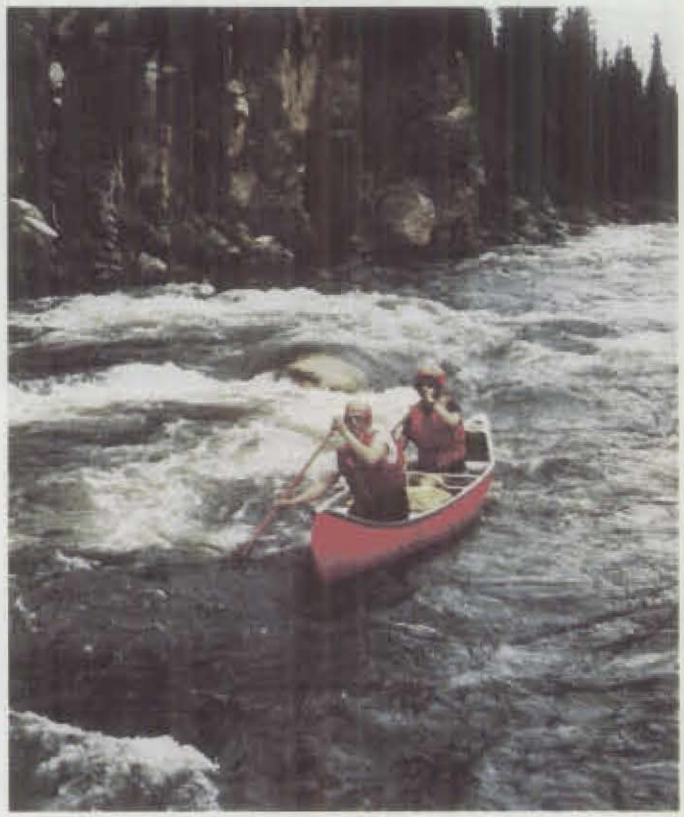
By

Alan Jubenville*

The Present Situation

At present, recreational river use in Alaska is increasing even in very remote areas. This is due both to tourists coming into Alaska and to increased use by local residents. In either case, recreational use of Alaska's rivers contributes significantly to the local economy through the development of related service industries. However, this growth is not cost free. Many people are beginning to look at the impacts or costs—like loss of quality of experience for the individual who floats the river, plus the impact on the resource base within the riverine zone.

There is very little information available to the manager to address the costs of the spiraling river use or to develop appropriate management programs. Thus, the manager often overlooks the impacts, overreacts with stringent controls, or hopes to be able to solve the problem through a survey of existing users to identify the impacts and respond to them. However, the fallacy in the thinking is that the "old timer" is still floating the river. If the impacts are significant to the "old timer," he has most likely been displaced to another, less-used river. Consequently, on-site surveys will never sample those that have been displaced. The clientele of the river are often a product of the previous management action; and, given sufficient time, those who agree or find acceptable the particular management action will become the new stable clientele.



Alaska's rivers may well become one of her recreational focal points.

The Future

Use of Alaskan rivers for recreation should continue to increase. They receive more and more publicity, and access is often not nearly as limited as that for land-based activities because of the ease of airplane landings. In addition, as more major recreational rivers in the forty-eight conterminous states are closed to additional river guides and outfitters, many of these will opt for Alaskan waters. In sum, Alaska's rivers will probably become one of the focal points of recreational use, both by residents and nonresidents. Obviously, this could be both a blessing and curse. Better information will be available to the participant on which to base choices for his recreational activites. More people will be able to enjoy many of the unique river settings in Alaska,

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The major aim of the Representative Rivers Program in Alaska is to enable recreation managers to make decisions that result in recreational opportunities that are appropriate for each user group.

and more commerce will be created. However, there will be impacts—competition with other resource users, displacement of "old timers," degradation of resource, and increased management requirements for protection of the visitor and the resource.

Managers, dealing with a limited data base, are already having to make choices on appropriate management actions. The uncertainty of the effect of a particular action the manager might take to solve a problem has encouraged management-funded research. These types of survey investigations tend to focus on unique, controversial problems with little concern for carryover or transfer of this knowledge to future situations. This "brushfire" approach to research rarely produces much long-term benefit to the user or management because there is often little transfer value to new situations. Consequently, management becomes caught in a cycle of funding similar studies throughout the state because the research designs were not sufficient to allow transfer of previous research findings to new situations. What is needed is a more systematic research program wherein fewer studies with more adequate research designs will give better transfer of results. The proposed program, called Representative Rivers, is aimed at establishing a series of research rivers representative of the types of river-recreation opportunities in Alaska. By having these representative rivers, one could hold the biophysical setting constant and vary the management actions to determine the effects of a given action on a given type of river-recreation opportunity.

The remaining discussion will focus on what actions are appropriate within the role of the manager, the proposed research program, and the potential benefits of the program to the manager and the user.

The Role of the Manager

The actions of the manager are an integral, though limited, part of the total recreational experience of the river user. That role is directed at stabilizing the physical setting and making decisions on access/facilities, visitor services, resource-management programs, and policies and regulations in relation to use. The visitor then chooses the mix of these that appear to best suit his own interests, participates in the particular setting, and produces his own experience.

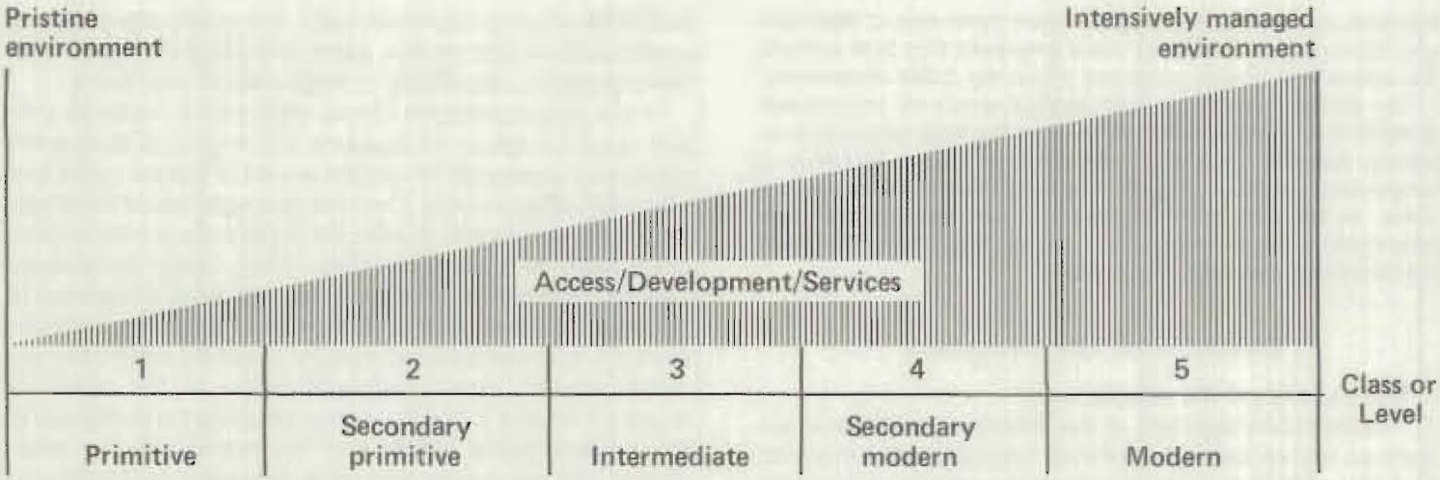

Figure 1. The recreational Experience Opportunity Spectrum, showing classes of potential experiences based on the primary management inputs. (Adapted from Becker, R.H., and A. Jubenville 1982. "Forest-Recreation Management," Introduction for Forest Science (ed. R.A. Young). New York: John Wiley and Sons.)

At present, most river-management programs outside Alaska are directed toward increasing access and facility development and subsequently restricting numbers of users, choices of campsite locations, size of parties, timing of launchings, etc. The assumption is that, if we simply protect the resource base, the manager can create any set of recreational experiences through regulatory controls. Little concern is given the effects of controls on the freedom of choice of the individual and the ultimate effects on the experience of the individual. Thus, there is a tendency to downplay the role of the individual in producing his own experience.

Obviously, different people desire different types of experiences, and any management program should respond to that variety; ideally, it should respond in terms of those initial actions that the manager can take to encourage certain types of experiences. Those initial actions are the decisions the manager should make on the level of access and facility development and associated visitor services. The Representative Rivers program focuses on those actions as experimental variables.

Representative Rivers Program

Rather than doing studies over a large number of rivers scattered throughout Alaska, this program would focus on a limited number of rivers representative of the spectrum of potential river-experience opportunities (fig. 1), and that representativeness would reflect the primary managerial decisions which create the various classes (fig. 2):

As suggested in a bulletin published by the Alaska Agricultural Experiment station (Jubenville, 1983),

> . . . the Representative Rivers program should prove helpful because the data provided can be transferred easily by the manager. He can match his river with a similar experimental river and extrapolate to his own situation. More importantly, the researcher can now address critical design issues in his dedicated long-term effort. The continual collection of verifiable baseline data prior to the introduction of some experimental variable (such as a new management program) allows the researcher to begin to control for extraneous variables, even under field conditions. (p. 19)

The assumption is that agencies, which heretofore spent monies on the one-shot case studies, would pool their monies and enter into a cooperative research effort. The representatives of the agencies would form the oversight group (board of directors) which, along with the research director, would establish the actual criteria for selecting the rivers and focus on specific research priorities. The director would be responsible for the establishment and ongoing collection of baseline data and, ultimately, for acting as a research broker. The specific research needs would be identified within the representative rivers; the research design issues would be specified; and then the request for proposals within those project design and monetary constraints would be sent out to the

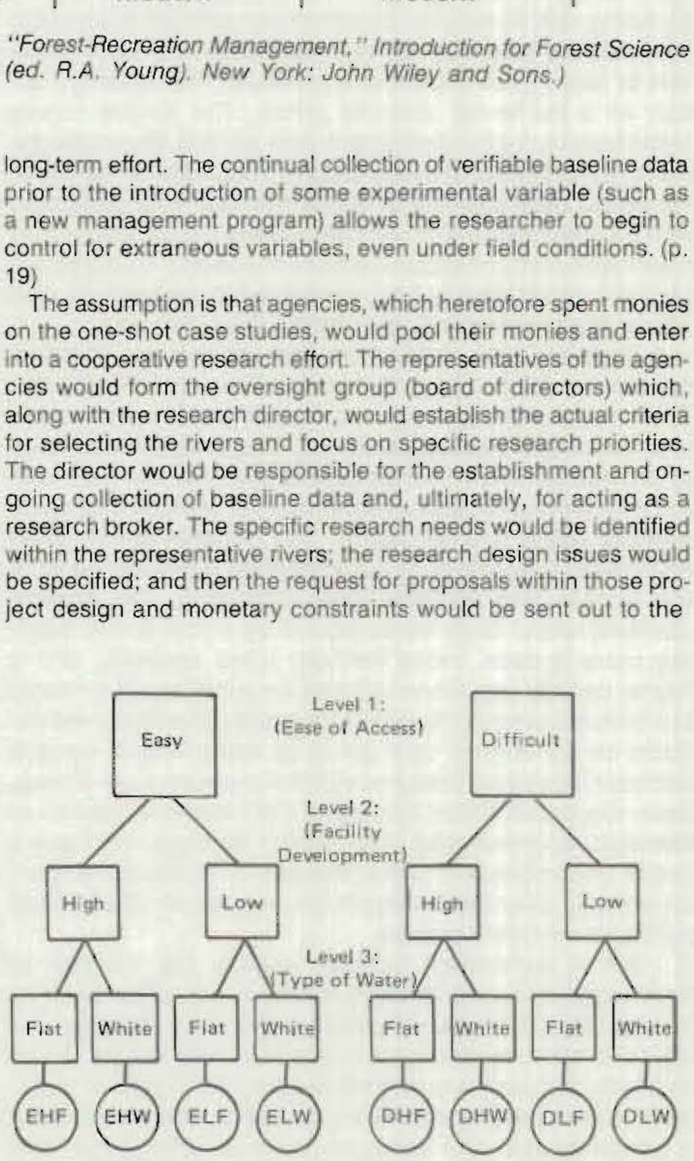

Figure 2. A theoretical system of representative rivers. Note: The circled opportunity-setting designations represent the interacting management variables and the physical setting as follows: E = easy access; D = difficult access; H = high facility development; L = low facility development; F = flat water; W = white water.

research community. A proposal review committee of scientists and managers would select those proposals that best address the topical and design questions within the dollar constraints.

The results from these river studies would be immediately available to the agencies for use in upgrading their own programs. Ideally, scientists and allied managers would be available to cooperating agencies for consulting on specific problems on other rivers. In addition, planned periodic short courses and new employee training could also be used as program techniques in the technology transfer. (pp. 24-25)

Benefits of the Program

The benefits of the program are:

1. Better understanding of the effects of managerial actions on the various types of river-recreation experiences. By being able to develop experimental controls in conjunction with the field studies, one should be in a better position to assess the impact of a particular management action on a particular clientele group. The simple survey technique typically used in the past will not allow assessment of the impact of a new program because of the possible social displacement of those clientele who disagreed with the particular action. Simple surveys almost always find a satisfied clientele group because those who disagree will probably have already been displaced to somewhere else where the program will not impact their behavior.

A good example of this is the recreational use of gravel bars in the Chena River Recreation Area near Fairbanks. The unique clientele is attracted to the gravel bars for their informal, water-oriented activities. The program has been to provide primitive auto access to many of the bars with minimal facilities (usually portable)—just enough to provide minimal safety and sanitation. The clientele are satisfied and return to the area to participate on a regular basis. If the access and facilities were upgraded, the existing clientele would likely be displaced by a new group desiring more access, more facilties, more services, and a higher-density use. None of those decisions may be wrong; but from a research viewpoint, one can never know the impacts on the original user group by doing simple surveys because those who disagree with the program have already been displaced. What is needed are long-term studies of selected representative rivers so the manager will have a better understanding of the impacts of particular actions on which to tailor the management program for one or more particular clientele groups.

2. Better technology transfer. Ideally the transfer of knowledge acquired through research would be done by the manager to his own situation, rather than being dependent upon the researcher to interpret survey results. As an example, suppose one wanted to study the impact of a permit system to limit use of rivers in Alaska. One implements a permit system and conducts a survey afterwards. The results should show that most people favor a permit system; those who do not have probably already been displaced. The survey would suggest that limiting use via a permit system is the appropriate management action. The extrapolation of such results to other rivers is very subjective and often prone to errors. In reality, the results are generally predictable—most on-site users will generally agree that the program is beneficial or they wouldn't be there.

In the Representative Rivers program, a research project could be set up to measure the impact of the permit system by measuring the displacement of current users and attraction of new users. Then the manager would have better results on which to predict the impact of a particular program such as a permit system. Thus, better technology transfer (extrapolating to new management situations) is obtained because we have better data to transfer. Furthermore the management technology would be continually updated through direct communications of the planned-research results to the agencies, employee training using the representative rivers, and the opportunity for interchange of ideas among managers, scientists, and representatives of clientele groups on the study rivers.

3. More efficient use of the management dollars. By developing field experiments whose results would be directly transferable to particular situations, the manager should be less inclined to fund simple surveys to ascertain impact by a new program after it has been implemented. Any direct manipulation of user behavior is a very expensive budget item. For example, limiting use via the permit system is both expensive and potentially undesirable from the perspective of the existing users. Thus, the manager may incur a large expense in implementing such a program and, in the process, destroy the opportunity to participate for the clientele for whom he thought he was managing the area. Yet, the one-time surveys would probably not detect this undesirable result, leading management to an erroneous conclusion and inefficient and ineffective allocation of management dollars.

4. More efficient use of the limited research dollars available for developing a data base, addressing field experimental design, and delineating rivers into classes of experience opportunities based on primary management decisions. However, it must be clearly understood that the real beneficiary of the management-research program should be the visitor, be he resident or tourist. It is for him that we manage these rivers for recreation, and the research program is designed to enhance the future management of these rivers for the variety of experiences that can be provided.

In sum, the Representative Rivers research program is similar to the research-watershed programs where sites are established as representative of the watersheds of the region. Management actions are then introduced to determine the effects of various treatments in a given watershed type. Managers can then extrapolate to their own watershed. This eliminates the need for conducting research in every watershed; so it is for river recreation research.□

Reference

Jubenville, A. 1983. Representative rivers: An experimental research program in river recreation management. Agricultural Experiment Station. Bulletin 53. University of Alaska-Fairbanks. 28pp.

Interior Alaska Crops Respond to Boron Applications

By

Frank J. Wooding*

Introduction

Boron is classified as an essential plant nutrient. Since boron is required in very small amounts, it is referred to as a trace nutrient or micronutrient. In agricultural areas where soils are depleted of boron, this nutrient is frequently applied to cropland along with other, more common fertilizer materials. Low rates of boron application can be quite beneficial to some types of crops; however, too much can be injurious to plant growth. Plant species differ in their requirements and tolerances. Tolerant plants, such as alfalfa, can be subjected to applications of up to 4 pounds elemental boron per acre without adverse effects. For sensitive plants, such as potatoes, boron rates exceeding .5-pound per acre can depress yield. For many crops, the difference between optimum amounts of boron in the soil and toxic amounts of boron in the soil can be very small. Also, there can be substantial carryover of applied boron in the soil from one year to the next, particularly in low-rainfall areas.

In 1982 and 1983, rapeseed, barley, and potatoes were evaluated for response to boron applications at a test site near Fairbanks and at two test sites near Delta Junction. The Fairbanks site was situated on a Tanana silt loam soil, and the land had been in production for about 60 years. The two Delta Junction sites were on Nenana silt loam soils, and the land had recently been cleared. One of the Delta Junction sites had received a limestone application (3 tons per acre) prior to the initiation of the research. Boron was supplied at rates of 0, .5, 1, 2, and 4 pounds per acre from a boric acid fertilizer material. In addition to boron, all treatments received uniform applications of nitrogen, phosphorus, potassium, and sulfur.

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Rapeseed

Of the three crops tested, rapeseed responded most to boron application (table 1). The .5 pound-per-acre rate produced the greatest yield increase, but some benefits were gained from each added increment of boron up to 4 pounds per acre. During two years of testing at three sites, the .5-pound boron rate resulted in an average yield increase of 58 per cent when compared with the control treatment receiving no boron. The 1-, 2-, and 4-pound boron rates increased yields by 64, 71, and 77 per cent, respectively. Boron-toxicity symptoms were not observed on rapeseed plants even at the highest level of boron application. Rapeseed is a heavy feeder of boron; further, it does not have the sensitivity that many other crops have to excessive amounts of this nutrient.

Boron was severely deficient on the newly cleared Delta Junction soils. However, deficiency symptoms did not appear on rapeseed plants until the reproductive growth stages. At this time, the upper parts of plants growing on test plots which had received no boron formed pods but failed to set seed. Seed developed only in pods located on lower parts of the plant. Also, boron deficiency kept the

Table 1. Response of rapeseed to boron applications in interior Alaska.

Boron rate	Seed yield[1]
(lbs B/acre)	(bu/acre)
0	21.1
.5	33.4
1	34.5
2	36.0
4	37.3

[1]Yields are an average of three test sites during a two-year period.

Figure 1. Boron-deficient (left) and normal (right) rapeseed plants.

plants in an indeterminate state of growth with flowers forming up to the time of the first killing frost (fig. 1).

Barley

During both years of testing, some response of barley to boron applications was obtained at all three sites. The .5- and 1-pound-per-acre boron rates produced average gains in grain yield of 10 and 15 per cent, respectively (table 2). Two pounds of boron resulted in no additional benefits when compared with yields obtained from the 1-pound rate. For all three sites, throughout the growing season, no boron-deficiency symptoms were observed on barley plants. This might be described as a case of "hidden hunger."

Four pounds of boron per acre resulted in a slight depression in barley yield as compared to .5-, 1-, and 2-pound application rates. Symptoms of boron toxicity were observed at Fairbanks beginning about midway in the growing season. This occurred only with the highest boron application rate and resulted in small, light-brown spots near the edges of the upper leaves. Barley is considered to be a crop sensitive to boron; it has a low tolerance to excessive boron.

Potatoes

In 1982 and 1983, beneficial effects were obtained for potatoes when boron was applied at the rate of .5 pound per acre (table 3). This application rate resulted in a 10 per cent average increase in tuber yield during two years of testing at three sites. Yield benefits at individual sites varied from 5 to 15 per cent during the two years. Boron-deficiency symptoms were observed at Delta Junction on potato plants when no boron was applied. The symptoms appeared in

Table 2. Response of barley to boron applications in interior Alaska.

Boron rate	Grain yield[1]
(lbs B/acre)	(bu/acre)
0	63.6
.5	69.9
1	72.9
2	72.7
4	67.4

[1]Yields are an average of three test sites during a two-year period.

Table 3. Response of potatoes to boron applications in interior Alaska.

Boron rate	Tuber yield[1]
(lbs B/acre)	(tons/acre)
0	12.4
.5	13.6
1	12.7
2	11.8
4	9.9

[1]Yields are an average of three test sites during a two-year period.

Figure 2. Boron-deficient (left) and normal (right) potato plants.

mid-July and resulted in browning (necrosis) around the edges of the uppermost leaves (fig. 2). However, tuber yields were not drastically reduced by lack of boron, as in the case of rapeseed.

Rates of boron application greater than .5-pound per acre resulted either in no additional benefits or in detrimental effects. At all three sites, boron toxicity was very noticeable at the 4-pound rate. When compared with the control treatment receiving no boron, this application rate reduced tuber yields by 20 per cent. Too much boron resulted in delayed sprout emergence and slower initial growth during the early part of the growing season. Although topgrowth eventually caught up with the other treatments later in the growing season, there were still significant reductions in tuber yield. The results demonstrate the high degree of sensitivity of potatoes to excessive boron.

Summary

Boron was found to be deficient for three crops in the Tanana Valley. Rapeseed responded most to addition of boron: yields were substantially increased, and maturity hastened. Rapeseed did not show sensitivity to high rates of boron. Boron deficiency markedly delayed maturity with lack of seed formation in the pods. Barley and potatoes benefited from small additions of boron, but the gain in yields were not of the same magnitude as for rapeseed. These crops had less tolerance than rapeseed to higher rates of boron.

Precautions must be taken so that excessive amounts of boron are not applied to sensitive crops. Many crop plants are affected as adversely by too much boron as by a deficiency. A high application to a crop with a high boron requirement might adversely affect subsequent sensitive crops the year following and, possibly, several years following boron application. An extension circular is being prepared which will provide guidelines for safe use of boron on vegetable and field crops. The circular will include such topics as fertilizer materials containing boron, recommended boron-application rates for different crops, methods of application, and use of soil analysis for determining boron status of soils.□

agricultural researchers attended this workshop. Snow mold is a serious problem on winter wheat in parts of Idaho, Utah and North Dakota.

The Agricultural Experiment Station and the School of Agriculture and Land Resources Management hosted the Western Region Coordination Committee 29th annual meeting last July. Aproximately eighteen delegates from Arizona, California, Colorado, Idaho, Oregon, Montana, Utah, Wyoming, and Washington joined in Fairbanks for the first time for a three-day conference discussing small grain disease problems in the western states. Included in the conference was a full-day field trip to the Delta Agricultural Development Project and the UAF agricultural research programs at Delta. Dr. McBeath, the official delegate of the state of Alaska to the committee, was the local chairperson. Dr. McBeath has served in the capacity of secretary since June, 1983, and became chairperson this last July.

Dr. Edmond C. Packee, assistant professor of forest management at the Agricultural and Forestry Experiment Station, Fairbanks, has begun work on predicting the growth and yield of interior Alaska forests. Preliminary results indicate that tamarack, a native species that has been largely ignored but which has potential for lumber, fence-posts, and firewood, is the fastest growing conifer native to interior Alaska. Tamarack grows rapidly on a wide range of sites, including many with permafrost near the surface.

Dr. Packee observed the growth of tamarack and spruce plantations in Quebec and New Brunswick, Canada, during the summer of 1984. These observations confirm the potential of tamarack.

In another new project, Dr. Packee began a survey of the sources of softwood construction lumber imported into interior and southcentral Alaska. The major source of lumber is the interior of British Columbia and Yukon. Canadian imports into Alaska arrive by railbarge via Prince Rupert and Seattle and by truck via the Alaska and Stewart-Cassiar highways.

In late October of 1984, Governor Bill Sheffield of Alaska appointed Dr. Packee technical advisor to the state's Timber Task Force. The report of the task force was submitted to the governor in mid-December.

Under a grant from the Bureau of Land Management, **Dr. Glen Juday,** visiting associate professor, evaluated four proposed Research Natural Areas on the Seward Peninsula. The evaluation team looked at two sites which support previously undescribed plant taxa which may be unique to the Bering Straits region.

Under a contract with the Alaska Region of the USDA Forest Service he is also preparing a report on the proposed Pete Dahl Slough Research Natural Area on the Copper River delta in the Chugach National Forest. Managers there are concerned about the low population level of the dusky subspecies of the Canada goose, which nests only on the delta. The study documented rapid shrub enchroachment onto former wetland surfaces which were permanently raised by the great 1964 earthquake; shrub encroachment may be partly responsible for the goose decline by reducing habitat quality.

Dr. Juday was appointed by Dean James V. Drew to serve as coordinator for the Rosie Creek Fire Research Project, funded by a special $169,500 appropriation from the Alaska Legislature. He organized and chaired a December

. . . Continued on page 55

Above: Artist's conception of the new AFES laboratory building now under construction at Palmer. Located at the Matanuska Research Farm, the 12, 800-square-foot facility will be completed in May 1985.

Publications List for 1984

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4, 1984, Rosie Creek Fire Research Progress Meeting, which was attended by over sixty resource professionals from the Alaska Division of Forestry and three other agencies. (See related stories, this issue.)

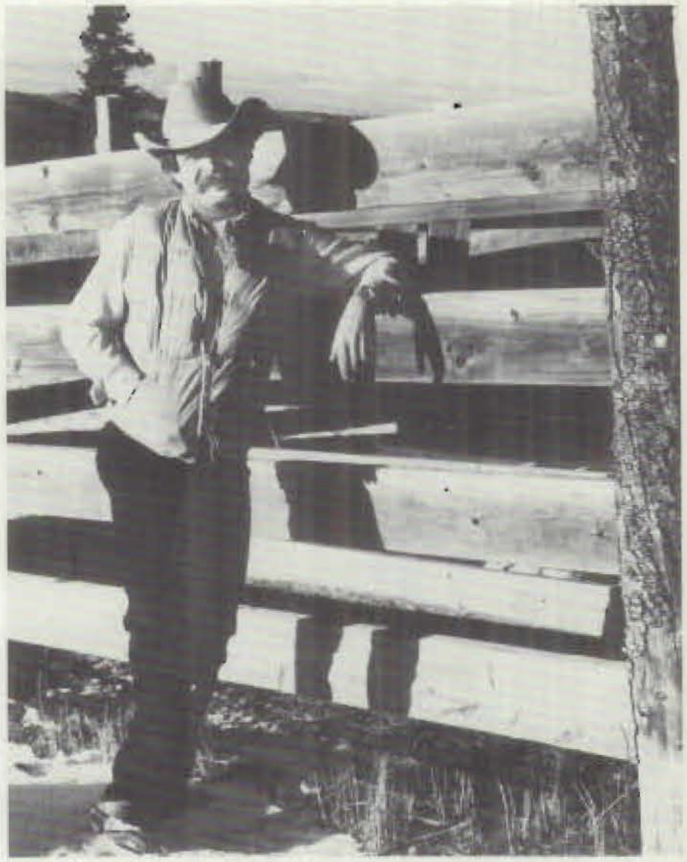
Dr. Gary Laursen is continuing his DOE supported research on fungal decomposition near Toolik Lake on the north slope of Alaska. In conjunction with his research, Dr. Laursen effected the last of five equipment transfers from the Naval Arctic Research Laboratory in Barrow to UAF. The equipment, worth an estimated $600,000, is being used in his fungal research projects that most recently include investigations of the role of higher fungi in areas destroyed by the Rosie Creeek Fire near Fairbanks. (See related stories, this issue.)

Jimmie Ross became farm manager of the Matanuska Research Farm in April 1984 after Floyd Perkins retired. Mr. Perkins had been with the Agricultural Experiment Station system for thirty years. Mr. Ross transferred from the Kuskokwim Community College at Bethel to take the position. He has a B.S. degree in agriculture from California and several years of farming and farm management experience in addition to three years with the University of Alaska system at Bethel.

Darlene Masiak recently joined the AFES as an agricultural laboratory assistant working under the direction of agronomist Steve Sparrow. Darlene grew up on a farm in Wisconsin, where she graduated from Beloit College after majoring in art and biology. Before she joined AFES, Darlene worked at the institutes of Northern Forestry and Marine Science. She does woodcuts which she has displayed at local Fairbanks art galleries.

Darlene replaces Joan Forshaug-Braddock who has transferred to UAF's Institute of Water Resources and Engineering Experiment Station where she will work as a microbiologist with Dr. Ed. Brown.

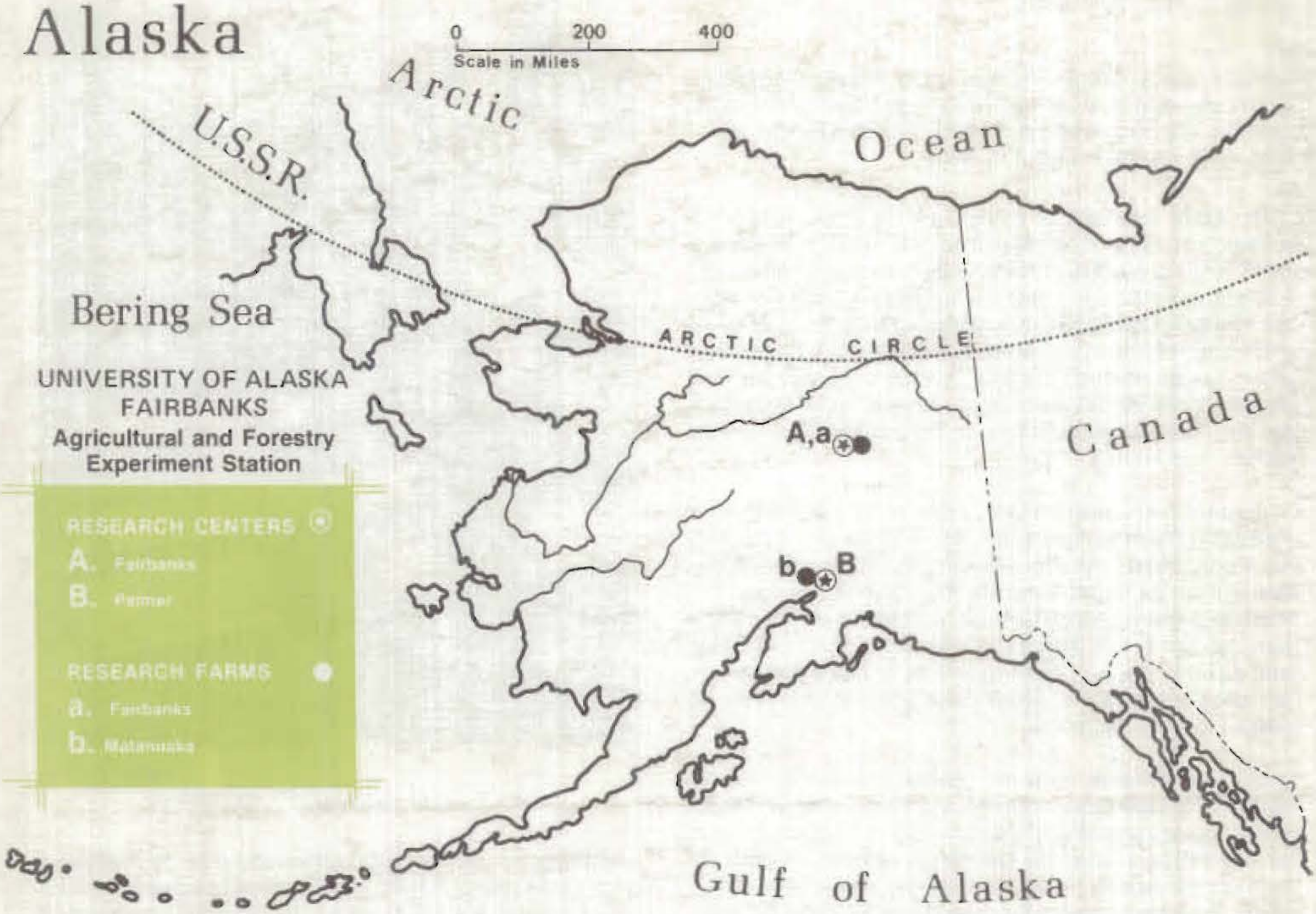
Ben Bruce joined the AFES as beef cattle scientist in October 1984. Ben comes from South Dakota State University where he was employed as extension ruminant nutritionist. His other professional experiences include two years as assistant professor at the University of Hawaii at Hilo and graduate work leading to a Ph.D. degree in ruminant Nutrition at New Mexico State University. Ben has authored several scientific publications and many field-day reports, bulletins, and popular press articles about beef nutrition and beef cattle management. He has developed several computer programs in beef cattle science including programs in the AGNET system. Ben was raised on a cattle ranch in northwestern New Mexico, managed a feed store and, worked with several feedlots. His experience also includes some time with the United States Navy as a pilot.



Beef cattle scientist, Dr. Ben Bruce

Ben is working in Palmer, where he is developing a beef cattle research program. Research will eventually encompass both cow-calf and feedlot operations. Emphasis will be placed on nutrition and management studies under Alaskan conditions.

The Forest Soils Laboratory, an AFES research unit, has received a three-year grant totalling $1.2 million from the National Science Foundation to study salt-affected forest soils on the Tanana flood plain in interior Alaska.□



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