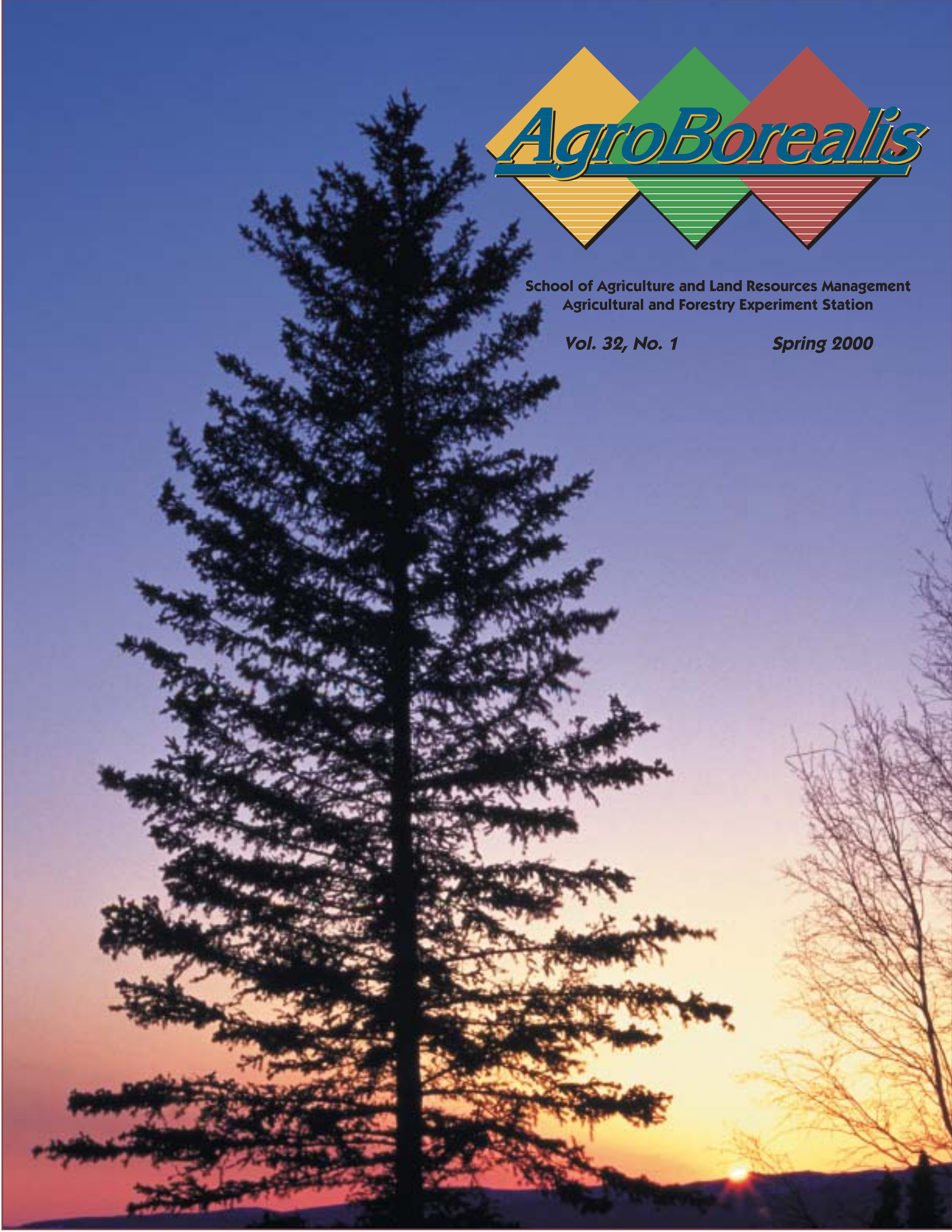


AgroBorealis

School of Agriculture and Land Resources Management
Agricultural and Forestry Experiment Station

Vol. 32, No. 1 Spring 2000

Director's Letter

The Agricultural and Forestry Experiment Station conducts research in three broad areas: plant, animal, and soil sciences; forest sciences; and natural resources management. In the pages of Agroborealis we attempt to report research progress and significant developments in all three areas. However, in this director's letter I want to target forestry research and its role in the land-grant university.

Forestry research within the Agricultural and Forestry Experiment Station is funded through a number of sources including state, federal and private sources. Federal formula funds from the McIntire-Stennis Cooperative Forestry Research program and state matching funds provide salaries for scientists and technical support. These "hard funds" provide a base from which our forest scientists may pursue additional grant-funded projects earmarked to investigate specific issues facing the state, the nation, and the world.

Examples include the National Science Foundation-funded Long-Term Ecological Research project (shared with the Institute of Arctic Biology and the Role of Wildfire in Alaska), the U.S. Geological Survey-funded Dendrochronological Studies in National Parks in Alaska, and the U.S. Fish and Wildlife Service-funded Radar Remote Sensing of Alluvial Habitat, to name a few. This allows the Experiment Station scientists to leverage the more dependable formula funds to create other federal–state cooperative programs.

In this issue of Agroborealis this synergy is illustrated in articles describing evidence that warmer and drier climate trends are resulting in detrimental impacts on productivity of white spruce in upland forests, and the use of a silviculture systems approach to regeneration for sustained yield on public and private lands. These types of cooperative efforts will increasingly involve input from private sector stakeholders, including both industrial and nonindustrial forest landowners, to help guide research efforts in the future.

I hope you enjoy these and the other articles in this report. Please feel free to contact me with questions or comments concerning our research programs.

Acting Director, AFES

About the cover: White spruce (Picea glauca) at sunset near the Bonanza Creek Experimental Forest southwest of Fairbanks, site of several ongoing forestry research projects.

Back cover: Spring display of the aurora borealis above the outskirts of Fairbanks. Displays of the aurora are frequent during spring and fall in Alaska's Interior.

The photos in this publication are by AFES publications staff except where otherwise credited.

Editorial Staff

Agroborealis is published by the Agricultural and Forestry Experiment Station, University of Alaska Fairbanks. A written request will include you on the mailing list. The address is:

PUBLICATIONS, AFES
P.O. BOX 757200
FAIRBANKS, AK 99775–7200

e-mail: fynrpub@uaf.edu

or visit our web site at:
http://www.uaf.edu/salrm

To simplify terminology, we may use product or equipment trade names. We are not endorsing products or firms mentioned, nor is criticism implied of those not mentioned. Publication material may be reprinted provided no endorsement of a commercial product is stated or implied. Please credit the researchers involved and the University of Alaska Fairbanks and the Agricultural and Forestry Experiment Station.

The University of Alaska Fairbanks is accredited by the Commission on Colleges of the Northwest Association of Schools and Colleges. UAF is an AA/EO employer and educational institution.

Contents

Volume 32, Number 1
ISSN: 0002–1822
Spring/Summer 2000

SCHOOL OF AGRICULTURE & LAND RESOURCES MANAGEMENT
AGRICULTURAL & FORESTRY EXPERIMENT STATION

Planting Trees in the Aleutians

J. N. Alden

From Bering's expeditions to present time, naturalists, botanists and foresters have pondered the treeless landscape of the Aleutians. In his "Journal of a Voyage with Bering 1741-1742," Georg Wilhelm Steller, the first European explorer and naturalist to describe the coastal flora and fauna of northwest America, attributed the absence of woodland vegetation in the Aleutians to several factors. These included the northeast-southwest orientation of the islands, their disproportionate length relative to width, the north-south openness (exposure) of the lands to extreme storms, and the cooling effects of wind and wetness (Frost 1988, Golder 1968) (Fig. 1).

Nearly a century later, Veniaminov (1840) noted the relatively recent formation of soils and arrival of vegetation in the Aleutians. He concluded that time was a major factor in the arrival and establishment of forests because the vast expanse of oceans between the islands and forested mainland to the northeast slowed the migration of trees. Unfavorable prevailing winds during the autumn also reduce seed dispersal along the southwest coast and offshore islands of the Alaska Peninsula (Fernow 1902), and well-established tundra inhibits tree seedling establishment, also slowing tree migration.

Today, after nearly two centuries of trial and error tree planting, recording weather observations (National Weather Service 1988), and even surveying soils for essential nutrients (Bruce 1944), we know that trees adapted to cold maritime climates are capable of surviving and growing upright on many protected (sheltered) sites throughout the Aleutians.

Site selection

The first step in establishing forests in treeless environments is selecting favorable habitats for tree survival and growth. Favorable sites in cold maritime climates usually have topographic or artificial (e.g., buildings and fences) shelter from prevailing winds and wind storms. Favorable sites also have well-drained fertile soils of at least moderate depth. They may support plant species that indicate a forest site, i.e., "indicator species" such as crowberry (*Empetrum nigrum*).

Fertile soils are usually loams with high organic content and base exchange capacity. On Unalaska and throughout the Aleutians, soils originate from recent volcanic activity, and most nutrients are confined to the sod layer. The most productive forest sites are protected from frosts, usually at the toe or slightly above the toe of moderate slopes well below altitude tree limits and ridge tops.

Until recently, favorable sites were identified only after trial and error planting of trees. The trees either survived from undetectable shelter, or in time, perished from "exposure" to wind and other unfavorable elements. If the trees survived, wind speed and direction could be estimated by observing wind-induced tree forms, stem (bole)

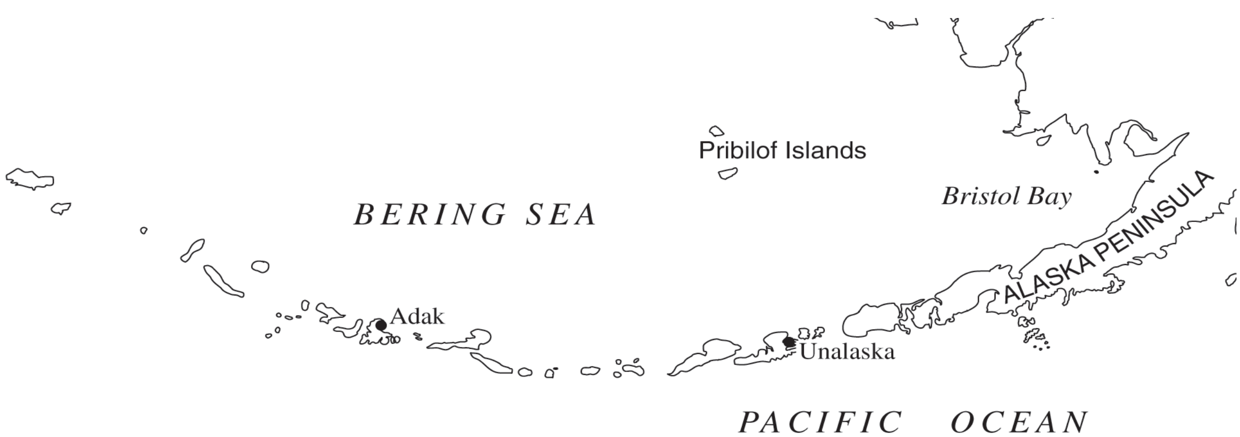


Figure 1. The Aleutian Islands extend 1100 miles from the Alaska Peninsula in the east to Attu in the west, and separate the Bering Sea from the Pacific Ocean.

shapes, and flagging of branches as indices of wind effects (Hewson and others 1977) (Fig. 2).

Wind is associated with altitude, distance to the ocean, atmospheric salts, low temperature, low insolation, and excessive rain, all adverse elements of tree exposure. To assess the variation and effects of exposure on tree survival and growth in the Orkney and Shetland Islands in the North Sea, members of the British Forestry Commission found that the tatter rate of uniform cotton flags provided a reliable measure of relative exposure and growth of lodgepole pine (*Pinus contorta*) and Sitka spruce (Lines and Howell 1963).

The idea of using tatter flags to estimate exposure stemmed from the success that the founders of the Binscarth House in the Orkney Islands had in locating a sheltered site by observing the tatter of a series of un-hemmed flags during winter. Tatter flags are simple, inexpensive implements for objectively assessing exposure and identifying suitable sites for growing trees. With present technologies, inexpensive electronic anemometers may complement tatter flags, but they only record the wind component of the exposure complex.

Favorable sites in the Aleutians must also have sufficient organic deposits and ground cover to insulate the underlying mineral soil from repeated freezing and thawing throughout the winter. Until roots grow into the surrounding soil, repeated freezing and thawing of fine textured soils at field moisture capacity often lift recently planted trees entirely from the ground. Frost lifting from freezing and thawing cycles is a major cause of plantation failure in subarctic maritime climates.

Fig. 2. A 52-year-old Sitka spruce from Juneau, Alaska, planted on a north slope on Adak Island in 1943.

Species and provenance selection

Few species and provenances are adapted to the cold maritime climate of the Aleutians. Since the first commercial forest plantation in the Western Hemisphere was established on Amaknak Island in about 1805 (Veniaminov 1840), more than 30 species have been planted throughout the Aleutians. Only Sitka spruce has been consistently successful, although several conifers from Southeast Alaska, especially western hemlock (*Tsuga heterophylla*), mountain hemlock (*Tsuga mertensiana*), and shore pine (*Pinus contorta* var. *contorta*) have potential for adaptation to sheltered habitats on Unalaska (Alden and Bruce 1989).

The hemlocks are not widely planted either in Alaska or as exotics elsewhere because they are shade tolerant and slow growing. The deciduous Siberian larches, *Larix sukaczewii* and *L. sibirica*, have been planted without success at both Adak and Unalaska. They warrant further attempts in the Aleutians, but with improved planting stocks.

The Siberian larches grow rapidly and form arctic tree limits in Russia. Since about 1970, they have been the most widely planted species in the oceanic climate of Iceland (Blöndal 1987). Other major species that might improve soil fertility, wildlife habitat, amenity, and provide shelter in the Aleutians are: Alaska-cedar (*Chamaecyparis nootkatensis*) and its spontaneous hybrid with Monterey cypress (*Cupressus macrocarpa*), Leyland cypress (*Cupressocyparis leylandii*), Sitka alder (*Alnus sinuata*), the evergreen oval-leaf southern beech, coigue (*Nothofagus betuloides*), and other tree limit *Nothofagus* in South America.

Leyland cypress is widely planted as an ornamental in Europe and New Zealand. It survives with its parental species, Monterey cypress, at about 52 degrees east south latitude in the barren Falkland Islands where the climate is similar to the Aleutians.

Among the deciduous broadleaf species with potential for adaptation to the Aleutians, Sitka alder, already endemic to the Alaska Peninsula, grows nitrogen fixing nodules and improves the fertility of impoverished soils. In addition, it pioneers soils formed from retreating glaciers and recent volcanic eruptions. Black cottonwood (*Populus trichocarpa*), endemic to Alaska's coastal spruce-hemlock forests as far west as Kodiak Island, is the fastest growing tree species in Iceland. Large planting stocks deserve provenance trials on sheltered sites in the Eastern Aleutians.

Coigue, a Southern Hemisphere beech, forms southern tree lines at about 50 degress east south latitude in Chile (Stewart 1982), Tierra del Fuego, and Argentina. It is one of only five species recommended for shelterbelts in the Falklands (Low 1986). The others are shore pine, Sitka spruce, Monterey cypress, and Monterey pine (*Pinus radiata*).

The outstanding early performance of Ponderosa and lodgepole pine, and Engelmann spruce provenances from Idaho in Pyramid Valley (Table I) is surprising because they are of continental origin and nearly ten degrees latitude south of Unalaska. Altitude often compensates for latitude of seed source, however. Engelmann spruce from as far south as Colorado grows vigorously in the cold maritime climate of Iceland, where it is commonly planted for Christmas trees. Iceland is about 10 degrees latitude north of the Aleutians and has a climate similar to the Alaska Peninsula.

As indicated by an average height growth of only 15 centimeters (6 inches) in eight years, the species in Table I are not fully established. Performance may change rapidly after they grow above the tundra and are exposed to the local weather elements. The slow upward growth is not surprising because as Veniaminov (1840) observed, the unsheltered National Historic Landmark (NHL) trees on Amaknak Island required about 20 years before the annual height growth exceeded the total height of the first 10 to 12 years. The NHL trees were also planted on a favorable site for Sitka spruce because they were the only survivors of 2- and 3-year-old trees brought from Sitka in about 1805 and planted at several locations around the main village on Unalaska (Veniaminov 1840).

Acceptable survival and growth depend on many factors including provenance or original geographical seed source of the planting stock. In the absence of provenance information, seed sources should be selected from environments (climate and soils) and latitudes and altitudes similar to the planting site. Increasing altitude often compensates for increasing growing season temperature and length incurred with decreasing latitude of seed provenance relative to the planting site. Likewise, decreasing altitude may compensate for increasing latitude of seed provenance relative to latitude of the planting site. There are no substitutes, however, for provenance tests of promising species before they are introduced to environments beyond their natural range.

Site preparation and stock types

Site preparation is the removal of established vegetation and planting obstacles to expose the underlying organic and mineral soils before planting or seeding. The natural vegetation, often considered understory weed species in reforestation, is removed to reduce or eliminate competition with planted trees for light, moisture, and nutrients. In windy maritime climates, native vegetation is removed to prevent physical damage to small trees from wind-whipping of shrubs and lodging of perennial grasses. In large afforestation programs, site preparation is accomplished by scarifying the surface soils with tractor-pulled disks or tine ploughs, or on cold, wet soils by turning a furrow to produce an elevated ridge contouring the slope. Seedlings are planted in inverted sod on the ridge, or on the south side of the ridge to improve soil moisture, temperature, nutrition, and survival. In small planting projects of several hundred trees each, scarification can be accomplished with hand planting tools.

Extensive site preparation is not recommended for planting trees in the Aleutians. Disturbance of the tundra and surface organic soils removes surface insolation and exposes the underlying mineral soil to water and wind erosion, freezing and thawing actions, and frost lifting of recently planted seedlings. In addition, removal of humus with the sod eliminates precious nutrients essential for root establishment and tree growth. On cold sites, reestablishment of natural vegetation is slow, or fails entirely, leading to wind erosion and “blow-out”of the underlying soils. Without mulch, fertilizers, and seeding of cold climate grasses, blow-outs may remain denuded for centuries, and never recover their original productivity.

Light disking of the surface vegetation and sod without disturbing the underlying organic soil reduces competition, and prevents frost lifting. If the trees fail to survive or grow slowly after planting, the native flora usually recovers from intact roots in a few years. To compensate for incomplete or no site preparation, planting stocks should be large enough to overcome competition from the native flora. Before they are outplanted, planting stocks should be two or more years old, transplanted for at least one year, 45 to 60 centimeters (18-24 inches) tall, and at least 0.75 centimeters (0.3 inches) in stem diameter at the hypocotyle, i.e., the stem between the root collar and cotyledons. For high survival and rapid recovery, the seedlings should have well-developed root systems, slow release fertilizers in the growing medium, proper care during transportation and planting, and should be dormant and fully hardened before outplanting.

In May 1988 stock-type trials at altitude tree limits (140 meters) on Mt. Moffett, Adak Island and at the Adak National Forest, one-year-old (1-0) Sitka spruce seedlings in four in^3 and 3-0 seedlings in ten in^3 containers grew 2.4 and 1.3 cm, respectively, in the first growing season. Growth (5.4 cm) was significantly ($p < 0.05$) more for 2-1 stock transplanted after two years from ten in^3 to one-gallon containers for one season before outplanting. The stocks averaged 23, 41, and 53 centimeters tall at the time of planting. Each stock type grew less than two centimeters as they struggled to survive in grass competition for the next two seasons ending in October 1990.

Planting and shelter

To ensure high survival and rapid growth in maritime climates, seedlings should be planted at 1.2 to 2 meter (4 to 6.5 feet) spacing in sufficiently large numbers (6000 to 2500 per hectare (2700 to 1200 per acre)) for mutual wind shelter among trees. The effects of mutual shelter can be observed by the convex profile of the Adak National Forest and other plantations on exposed sites in the Aleutians (Fig. 3). After 40 years, trees in the center of the plantation average one to two meters taller than those on the outer rows.

Figure 3. Adak National Forest is on an exposed ridge about 50 meters (160 feet) above sea level.

In the Shetland and Orkney Islands, plantations should be large enough for at least 10 rows of trees at two meter spacing, and if area is available, more rows are recommended (Low 1987). Bruce (1993) recommends plantations of seven or more rows. To grow tall straight stems for timber production, wind-resistant and shelter-providing species such as lodgepole pine may be planted in outer rows to buffer high wood quality species that are susceptible to wind injury and reduced growth.

In the absence of topographic shelter, wind shields constructed from burlap and laminated plastic and supported with 2 by 2-inch stakes were successful in protecting Sitka spruce seedlings from wind desiccation and physical damage on exposed sites on Adak Island (Fig. 4). Laminated plastic wind screens improved average survival of the three stock types described above nearly 30% after three years on Mt. Moffett and at the Adak National Forest. The sheltered trees averaged 4.8 cm taller than the unsheltered trees.

Figure 4. Laminated plastic wind shields aided the establishment of Sitka spruce at this altitude tree limit test site on the slope of Mt. Moffett, Adak Island.

An artificial shelter manufactured from opaque polyethylene into a 24-inch long by 8-inch diameter cone and sold with the trade name “Tree Pee,” is effective in increasing the survival and growth of young seedlings. In the absence of wind, the shelters trap warm air near the ground from a “greenhouse temperature effect.” A cylindrical shelter made from blue tinted polyester film and marketed as “Blue-X” is now available in sizes from 3.5 to 6 inches in diameter (Windell 1996). The shelter is reputed to permit more penetration of photo-synthetically active light through the opaque polyethylene. Vigorous trees outgrow the shelters in two or three years, but usually not before the seedlings are well established. If adapted, the trees will continue to grow without dying-back from exposure after the shelters are removed.

Summary

Climate records and trial and error tree plantations show that Sitka spruce (*Picea sitchensis*) will grow into upright forests on topographically sheltered sites throughout the Aleutians. Several additional cold maritime climate species (*Tsuga heterophylla*, *Tsuga mertensiana*, and *Pinus contorta* var. *contorta*), and polar tree line genera (*Larix* and *Nothofagus* sp.) may have potential for introduction to the Aleutians. Trees will become increasingly important for amenity, shelter, wildlife habitat and soil enhancement, but growth and quality will limit their use for timber production other than for subsistence purposes.

Wind and growing season temperature are critical factors for tree survival and upright growth in subarctic maritime climates. Exposure is highly variable among sites in the Aleutians, and must be evaluated to ensure afforestation success. Species selection and provenance (the indigenous geographical seed source) testing are equally critical. Potential sites for afforestation and tree growth can be estimated with tatter flags and anemometers. Extensive site preparation is not recommended because seedlings planted in exposed mineral soils are prone to frost lifting. Rather, large transplant stock, 30 to 60 centimeters (one to two feet) tall, is recommended in lieu of site preparation. For mutual shelter and improved growth, trees should be planted at 1.2 to 2 meter (4 to 6.5 feet) spacing and in relatively large plantations of ten or more rows. In the absence of natural shelter, tree survivial and growth can be enhanced with artificial shelter.

Table I. Relative performance of 19 species planted in 4- and 5-tree random plots in Pyramid Valley, Unalaska on June 1, 1987. Idaho, Maine, and Saskatchewan are state tree nurseries. Numbers in parentheses were the original trees planted. Road construction after 1990 destroyed several plots.

Species and Seed Source	Number Planted 1987	Percent Survival 1997	Mean Height in 1997 (cm)	Growth since 1989 (cm)
W. hemlock, *Tsuga heterophyllia,* SE Alaska	12	100	34	19
Engelmann spruce, *Picea engelmannii*, Idaho	30(33)	97	28	12
Sitka spruce, *Picea sitchensis*, Mitkof Island, Southeast Alaska	39	98	39	8
White spruce, *Picea glauca*, Palmer, Alaska	10	100	31	11
Black spruce, *Picea mariana*, Maine	3(8)	75	32	12
Ponderosa pine, *Pinus ponderosa*, Idaho	9(14)	89	71	44
Lodgepole pine, *Pinus contorta* var. *latifolia*, Idaho	21	95	43	21
Douglas-fir, *Pseudotsuga menziesii*, Idaho	8	75	18	6
Western red cedar, *Thuja plicata*, Southeast Alaska	14(19)	71	36	6
Jack x lodgepole pine, *Pinus banksiana* x *contorta*, T-field, Fairbanks, Alaska[1]	4	100	47	16
Red pine, *Pinus resinosa*, Maine	4	100	40	20
Scotch pine, *Pinus sylvestris* var. *arctica*, 66E 30' North Latitude, Russia	4	75	39	11
Alaska cedar, *Chamaecyparis nootkatensis*, Mitkof Island, <400' above sea level	2	50	38	2
Japanese larch, *Larix leptolepis*, Maine	4	0	–	–
White ash, *Fraxinus americana*, Maine	16	0	–	–
Box elder, *Acer negundo*, Saskatchewan	4	0	–	–
Yellow birch, *Betula alleghaniensis*, Maine	8	0	–	–
Red Oak, *Quercus rubra*, Maine	8	0	–	–
Quaking aspen, *Populus tremuloides*, Interior Alaska	1	0	–	–

[1]Provenance of the seed parent, *Pinus banksiana*, is Wrigley, Northwest Territories; 63E 13' N, 123E 27' W, and 550 feet above sea level.

References

Alden J, Bruce D. 1989. Growth of historical Sitka spruce plantations at Unalaska Bay, Alaska. PNW-GTR-236. USDA, Forest Service, Pacific Northwest Research Station, Portland, OR. 18 p.

Blöndal S. 1987. Afforestation and reforestation in Iceland. Arctic and Alpine Research 19 (40): 526-529.

Bruce D. 1944. Correspondence and letter orders from U.S. Department of Defense, Headquarters Alaskan Department, Office of the Commanding General, APO 942, Seattle, Washington. Copies received from D. Bruce. May 11, 1983.

__________. 1993. History of tree planting in the Aleutian Islands. In: Forest Development in Cold Climates. Alden J, Mastrantonio JL, Ødum S, eds. Proceedings of a NATO Advanced Research Workshop, June 18-23, 1991, Laugarvatn, Iceland. Plenum Press, New York: 393-426.

Frost OW. 1988. Journal of a voyage with Bering, 1741-1742. Translated by Enge MA and Frost OW. Stanford, CA: Stanford University Press. 252 p.

Fernow BE. 1902. The forests of Alaska. Forestry and Irrigation 8: 66-70.

Golder FA. 1968. Bering's Voyages. Vol. II: Steller's Journal of the Sea Voyage from Kamchatka to America and Return on the Second Expedition 1741-1742. Joerg WLG, ed. Reprinted by Octagon Books, Inc. New York. 291 p.

Hewson EW, Wade JC, Baker RW. 1977. Vegetation as an indicator of high wind velocity. Phase I. Final Report. Solar Energy, Department of Energy. RLO/2227-T24-77/2. Dept. of Atmospheric Sciences, Oregon State University, Corvallis, OR 97331. 32 p.

Ledgard NJ. 1993. Forestry in New Zealand's Southern High Country. In: Forest Development in Cold Climates. Alden J, Mastrantonio JL, Ødum S, eds. Proceedings of a NATO Advanced Research Workshop, June 18-23, 1991, Laugarvatn, Iceland. Plenum Press, New York: 529-548.

Lines R, Howell RS. 1963. The use of flags to estimate the relative exposure of trial plantations. Forest Record No. 51. Forestry Commission, H.M.S.O., London. Appendix, Maps, Photographs. 31 p.

Low AJ. 1986. Tree planting in the Falkland Islands. Forestry 59: 59-84.

______________. 1987. Tree planting prospects in Shetland and Orkney. Scottish Forestry 41 (4): 282-296.

National Weather Service. 1988. Climatological Data Alaska, Monthly summaries to Vol. 75. National Climatic Data Center, Federal Building, Asheville, NC 28801.

Stewart PJ. 1982. Trees for the Falkland Islands. Commonwealth Forestry Review 61 (3): 219-225.

Veniaminov I. 1840. Notes on the Islands of the Unalaska District. Pierce RA, ed. 1984. Alaska History, No. 27. Limestone Press, Kingston, Ontario, Canada. 511 p.

Wardle P. 1993. Causes of alpine timberline: A review of the hypotheses. In: Forest Development in Cold Climates. Alden J, Mastrantonio JL, Ødum S, eds. Proceedings of a NATO Advanced Research Workshop, June 18-23, 1991, Laugarvatn, Iceland. Plenum Press, New York: 89-103.

Williams CN, Jr. 1989. Summary of climate data for Adak Naval Air Station 1949-1988. Naval Oceanography Command Detachment. National Climatic Data Center, Asheville, NC 28801.

Windell K. 1996. Tree shelter update. Timber Tech Tips. USDA, Forest Service. Missoula Technology and Equipment Development Center, Missoula, Montana. 6 p.

Climate change and the growth of white spruce near Anchorage, Alaska

Glenn Patrick Juday

Forests are one of the major renewable resources of Alaska. Alaska's forests provide habitat for wildlife (including many species important for subsistence), forest products production and opportunities to expand forest products production, and the scenic backdrop for much of Alaska's tourism industry. The boreal forest is also an important component of the Earth's climate system. Boreal forests make up about 17% of the earth's land surface area (Bonan 1992) and the stored pools of carbon in boreal forest soils and trees represent a significant share of the total storehouse of carbon on land. So the effect of changing climate on the growth (uptake of carbon dioxide), death, and decay (release of carbon dioxide) of boreal forests is an important component of the global warming issue (Malmstrom and others 1997).

In the late 1970s Alaska experienced a very sudden and major change from one climate regime to a new and distinctly warmer one. This change is now often referred to as the "regime shift". Nearly the entire spectrum of renewable natural resource systems have been affected by the regime shift of the 1970s, and the effects on forests are particularly notable (Juday and others 1998). This article is a study of the growth history of older forests of Fort Richardson Army Base, Alaska in relation to climate. Sampling was carried out in 1995 as part of a graduate thesis and the environmental assessment of the resources of the base (Marler 1997).

Study area

Fort Richardson covers about 24,000 ha (59,000 acres) in south-central Alaska at the head of Cook Inlet. The base borders Anchorage on the

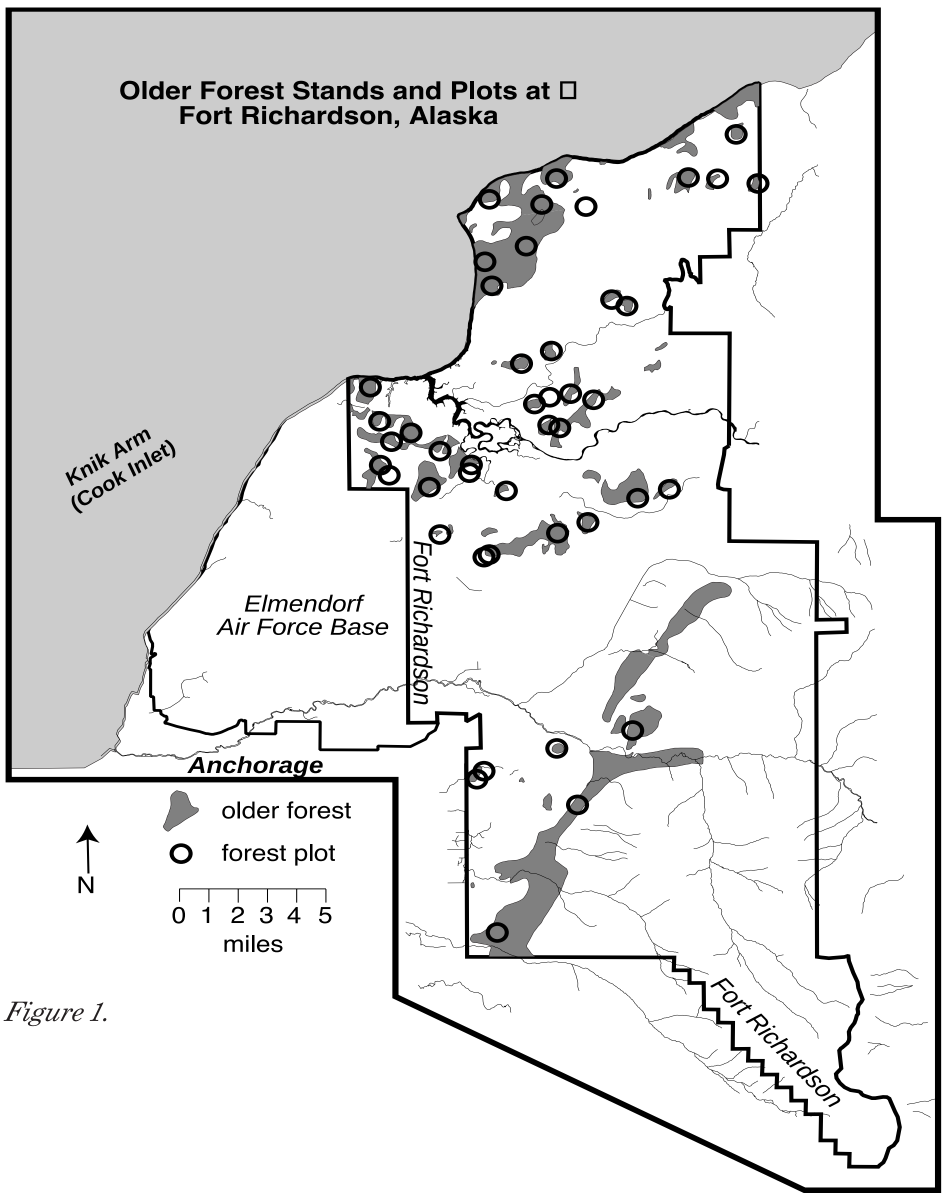


Figure 1.

northeast. Old-growth forests at Fort Richardson and adjacent Elmendorf Air Force Base (Fig. 1) are even-aged, mixed-species stands of *Betula papyrifera* (birch) and *Picea glauca* (white spruce), with *Alnus tenuifolia* (alder) and *Echinopanax horridum* (devil's club) in the understory or in gaps. The white spruce on the base probably contain some genes of Sitka spruce (*Picea sitchensis*), especially trees near the shore of Cook Inlet. *Calamagrostis canadensis* (bluejoint grass) dominates the understory in recently formed gaps (Tande 1983). Stands of old-growth originating in the period 1750–1790 (Fig. 1) are present on Fort Richardson (Bennett 1983, Tande 1983). Fires associated with the Alaska Railroad and early 20th century homesteads have affected the vegetation of Fort Richardson in the last century (Bennett 1983, Henley and others 1955). However, natural fire has not been a major, ongoing disturbance factor in the Anchorage landscape (Tande 1983), and the incidence of lightning fires in the entire Cook Inlet–Susitna Lowland Physiographic Province has been extremely low (Gabriel and Tande 1983).

Methods

Tree cores were collected from 197 white spruce in 39 older forest stands and six younger forests for comparison (Fig. 1). Stands occurred on glacial landforms composed of ground moraine, terminal moraine, and outwash plain. Trees were cored using an increment borer as close to the ground as possible. At the Tree-ring Laboratory at the University of Alaska Fairbanks rings were measured to a precision of hundredths of millimeters. Measurements from the 50 oldest trees were then processed to remove growth trend effects, and normalized into ring-width index values (Cook and Kairiukstis 1990).

The normalization process using the division method transforms raw values into a new variable scaled in standard deviations units, with a mean of exactly 1.0 and a standard deviation of 1.0. Below-average growth will have a ring-width index value less than 1.0, and above-average growth will have a ring-width index value greater than 1.0.

I calculated yearly ring-width index values of the 50 oldest trees for the 20th century, and then calculated the correlation between ring-width index and climate for both annual values and for smoothed (5-year running mean) values that dampen some of the year-to-year variability and emphasize medium-term trends. To show longer-term trends I also calculated the yearly ring-width index of the 14 oldest trees that contributed ring-widths continuously from 1800.

I combined climate data for the Anchorage International Airport station with the earliest Anchorage records which begin in 1917. Missing Anchorage data in the 1930s were estimated using a prediction from the closest representative station based on long-term relationships between the stations, using the methods of Juday (1984). Fort Richardson white spruce trees produced their largest ring-width in years with warm summer (April through September) temperatures and high annual precipitation. So I transformed mean April through September Anchorage temperature and annual precipitation into normalized values using the subtraction method (mean of 0, standard deviation of 1.0). I then added together the normalized temperature and precipitation values into a climate favorability index for white spruce, and re-normalized the index. Climate index values that match the long-term average have a mean of 0.0, above-average climate favorability will have values greater than 0.0, and years of below-average climate favorability will have negative climate index values. I calculated climate index values for the period since 1935 when the record is not interrupted by predicted data and is generally of higher quality.

Results and discussion

The climate at Anchorage is distinctly different after the regime shift compared to before. Summer temperatures in Anchorage since 1977 are at the highest sustained level of the 20th century, and recent cooler years are not extreme (Fig. 2A). Annual precipitation at Anchorage consistently has been above average since the regime shift (Fig. 2B). Warmth and precipitation have a tendency to increase or decrease together in Anchorage as either warm and moist air masses move up from the ocean to the south, or cool and dry air masses from the interior of Alaska move down from the north.

Annual values of the 50-tree ring-width index are significantly correlated with white spruce climate favorability index at Anchorage. Warm and wet intervals, especially those lasting at least 2 or 3 years, are periods of high radial growth. Cold, dry intervals in the 1950s and in the early 1970s are periods of major growth slowdown in Fort Richardson white spruce. Smoothed values of climate index and ring-width index are even more strongly correlated. Both climate index values and tree growth appear to be at their highest levels during the 20th century in the 1980s and 1990s.

Because of the excellent relationship between climate and tree growth, it is natural enough to use the one to infer what is happening when the other is unavailable. Tree-rings can be used for mathematical reconstruction of past climates (Cook and Kairiukstis 1990) but several issues beyond the scope of this paper must be addressed in developing the reconstructions. The general pattern of climate change in Alaska before weather measurements previously has been reconstructed from tree-rings (Jacoby and Cook 1989, Jacoby and D'Arrigo 1989, Wyles and others 1996), so it's possible to make a general comparison between trends indicated by Fort Richardson tree growth and past climate.

From the perspective of the last 200 years, the Fort Richardson tree-ring record indicates that the late 20th century is highly unusual (Figure 3). Ring-width index in the 1980s and 1990s is at the highest level of the last two centuries. Ring-width index of the 14 oldest trees may understate climate favorability prior to 1950 to some degree. But even allowing for that, the record seems to indicate that the early 1800s were just below the long-term average growing conditions. The second half of the 1800s were distinctly unfavorable, probably because of colder and drier weather than at any other period except for brief intervals in the 1950s and early 1970s. The occurrence of highly favorable tree growth conditions in Anchorage

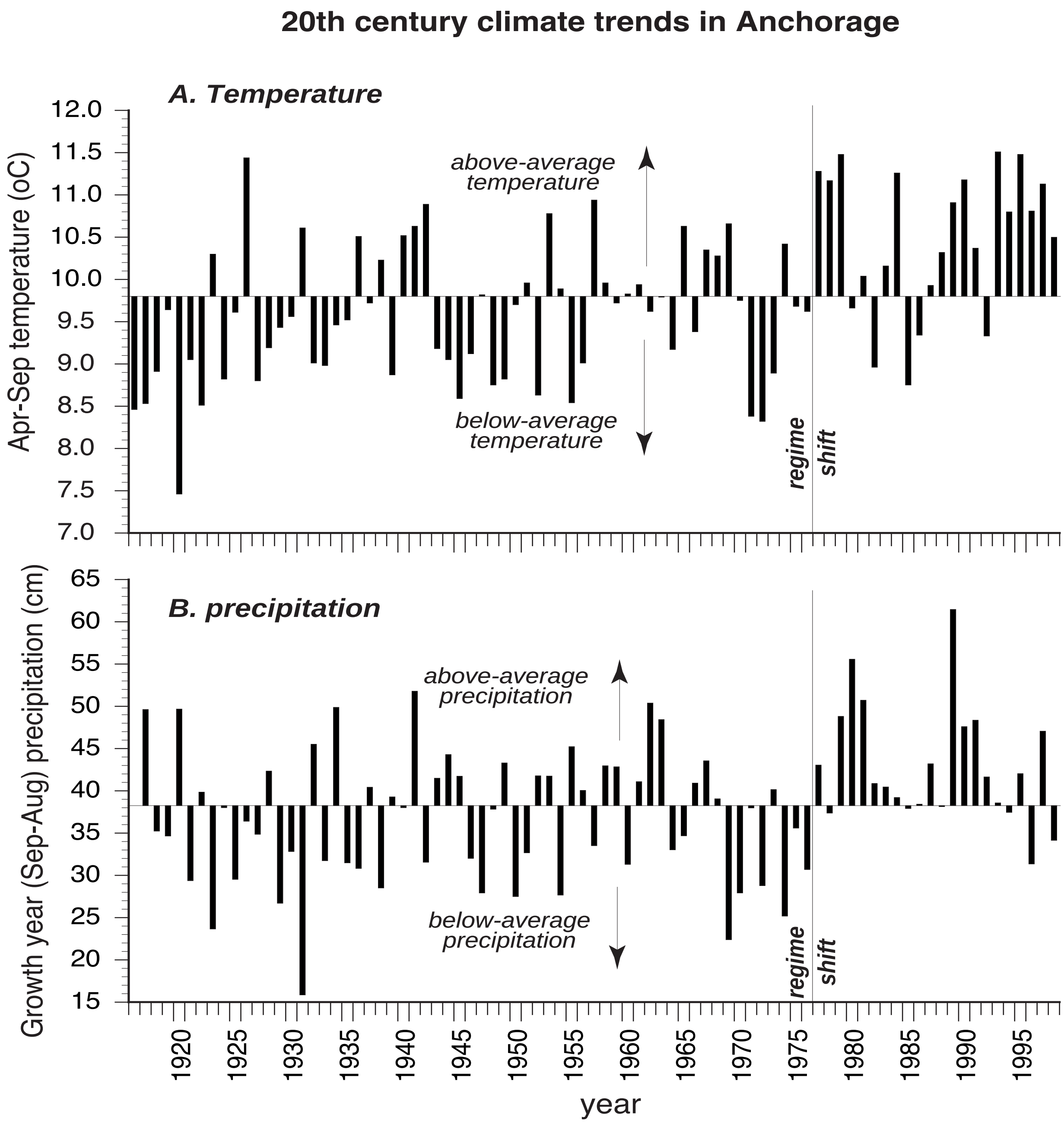


Figure 2.

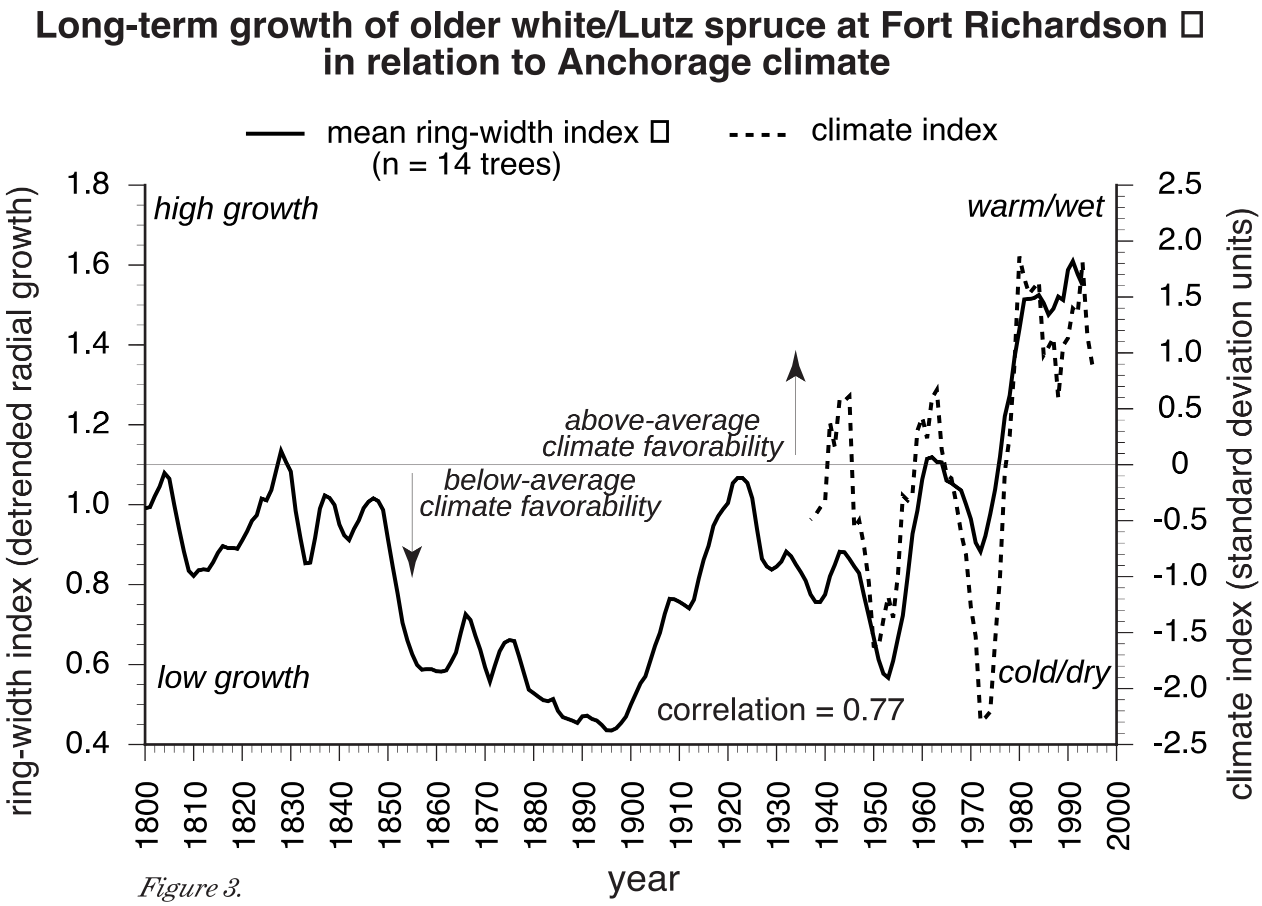


Figure 3.

since the regime shift is exactly the opposite of recent climate change in interior Alaska. White spruce at both dry low elevation sites (Juday and others 1999) and productive sites (Juday and others 1998) have experienced reduced climate favorability as the result of warming. It appears that climate warming has produced a variety of changes in the growth of white spruce, some favorable and some unfavorable, depending on the region and the factors that limit tree growth in that region. The effects probably vary by tree species as well. As a result, the appropriate question to ask is not what is the *effect* of climate warming in Alaska on tree growth, but what are the *effects*?

Lessons

Foresters and other natural resource managers often must think in terms of very long periods of time. A stand of trees may contain the influences of 100, 200, or more years of events in its development. As we can see from the Fort Richardson tree-ring and Anchorage climate records, the environment today may not be similar to the environment at the time an older forest first started growing. Environment and growing conditions in Alaska and other parts of the far north apparently are quite changeable, not stable or steady-state. So systems of natural resource management in these environments, if they are to be successful, will have to be adaptable and able to respond to large changes. The ideal of even, steady-state growth, and resource harvest doesn't appear to match the actual environment well.

But perhaps the most timely lesson for today's resource users and managers in Alaska is that we are now forming our impressions of what is "normal" in an unusual time, at least from the perspective of the last several centuries. The climate is at a sustained level of warmth that has not been experienced in Alaska in quite some time. So, is this evidence of global warming? The easy answer is that all observations are evidence either for or against any hypothesized change. To that degree, the Anchorage climate record and Fort Richardson tree growth are consistent with hypothesized global warming. What will happen next? It must be admitted that the climate *could* enter another cool phase, or it *could* continue the recent strong warming trend. But given a reasonable period of time and based on the past record, we can be confident that the climate will *change*.

References

Bennett A. 1983. Forest Fire History of Fort Richardson. Memorandum for record, Fort Richardson, Alaska.

Bonan GB. 1992. A simulation analysis of environmental factors and ecological processes in North American boreal forests. Chapter 15 p. 404-427. In: Shugart HH, Leemans R, Bonan GB, eds. A systems analysis of the global boreal forest. NY: Cambridge University Press. 565 p.

Cook ER, Kairiukstis LA. 1990. Methods of Dendrochronology: applications in the environmental sciences. Kluwer, Dordrecht.

Gabriel HW, Tande GF. 1983. A Regional Approach to Fire History in Alaska. U.S. Department of the Interior, Bureau of Land Management Technical Report 9, Alaska.

Grove J. 1988. The Little Ice Age. Methuen. London. 498 p.

Henley KD, Pruss DE, Reichle RE. 1955. Woodland Management Supplement to Land Management Plan for Fort Richardson, Alaska. Corps of Engineers, 106 p.

Hughes MK, Diaz HF. 1994. Was there a 'Medieval Warm Period' and if so, where and when? Climatic Change 26: 109-142.

Jacoby and Cook. 1981. Past temperature variations inferred from a 400-year tree-ring chronology from Yukon Territory, Canada. Arctic and Alpine Research 13(4): 409-418.

Jacoby GC, D'Arrigo RD. 1989. Reconstructed northern hemisphere annual temperature since 1671 based on high-latitude tree-ring data from North America. Climatic Change 14: 39-59.

Juday GP, Barber V, Berg E, Valentine D. 1999. Recent dynamics of white spruce treeline forests across Alaska in relation to climate. p. 165-187. In: Kankaanpaa S, Tasanen T, Sutinen M-L, eds. Sustainable development in northern timberline forests. Proceedings of the Timberline Workshop, May 10-11, 1998 in Whitehorse, Canada. Finnish Forest Research Institute. Research Papers 734. Ministry of the Environment. Finland. 188 p.

Juday GP, Ott RA, Valentine DW, Barber VA. 1998. Forests, climate stress, insects, and fire. Chapter 3, p. 23-49. In: Weller G, Anderson P, eds. Implications of global change in Alaska and the Bering Sea region. Proceedings of a workshop at the University of Alaska Fairbanks, 3-6 June 1997. Published by Center for Global Change and Arctic System Research, University of Alaska Fairbanks.

Juday GP. 1984. Temperature Trends in the Alaska Climate Record. Proceedings of the Conference on the Potential Effects of Carbon Dioxide-Induced Climatic Changes in Alaska. Ag. Exp. Sta. Misc. Publication 83-1. Univ. of Alaska Fairbanks. p. 76-88.

Malmstrom CM, Thompson MV, Juday GP, Los SO, Randerson JT, Field CB. 1997. Interannual Variation in Global-Scale Net Primary Production: Testing Model Estimates. Global Biogeochemical Cycles 11(3): 367-392.

Marler SC. 1997. Old-growth forests of Fort Richardson, AK: composition, structure, and development. M.S. Thesis, Miami University of Ohio. Oxford, OH. 59 p.

Tande GF. 1983. Vegetation. In: Rothe TC, Lanigan SH, Martin PA, Tande GF. Natural Resource Inventory of Elmendorf Air Force Base, AK: Part I. Anchorage, AK: U.S. Dept. of the Interior, Fish and Wildlife Service, Region 7, Special Studies: 14-85.

Wiles GC, D'Arrigo RD, Jacoby GC. 1996. Temperature changes along the Gulf of Alaska and Pacific Northwest coast modeled from coastal tree rings. Canadian Journal of Forest Research 26: 474-481.

Northern Tansy Mustard Fills a Niche

Jay McKendrick

According to my old college dictionary, the word versatility means: *"Quality or state of being versatile; ability along many lines of effort, many sidelines".* For those involved in resource development, versatility has become a survival trait. Since the 1970s, environmental compliance issues have changed mining, timber harvest, livestock grazing, and oil and gas production on private and public lands. Longstanding practices had to be abandoned or changed to comply with new regulations, with the cost borne by the consumer in the form of increased prices, increased taxes or both. Though largely unnoticed by the general public, this change continues on Alaska's North Slope today. Keeping abreast requires both reliance on prior experience and the ability to change one's approach to suit new challenges. Sometimes an unexpected discovery can result.

Background

In July 1996, while I was involved with other projects in the Prudhoe Bay Oil Field, I was asked to assist in establishing plant cover on buried reserve pits at two exploration wellsites. A company (no longer in Alaska) had drilled two exploratory wells and was obligated to fulfill permit requirements; however, plant recolonization progress at these wellsites was not meeting permit timelines. BP Exploration (Alaska), Inc. (BPX) had since acquired this company's assets on the North Slope and needed to rectify the situation.

Both wells had been drilled in winter from ice pads, and drilling wastes were buried on site. The surface areas of these burials were about 7,700 and 16,400 ft^2, respectively, or slightly more than half an acre in total. (For perspective, the total area of the National Petroleum Reserve-Alaska is 22,758,400 acres, and the entire North Slope of Alaska is about 50,432,000 acres.)

One wellsite (Badami No. 1) was drilled in the winter of 1989-90 near the seacoast east of Prudhoe Bay. Local weather conditions are often damp and foggy in summer. The bare soil contained areas of salinity, suggesting the overburden had been obtained from an area affected by seawater. The cap of overburden was approximately 4 ft above the surrounding terrain. A small pool of water had formed around the well marker, indicating thawing as a result of drilling. Plants typical of saline soils along the seacoast had invaded portions of the site, but total cover was much less than 5% in 1996, six growing seasons after site abandonment.

The other wellsite (Sequoia No. 1) was drilled during January and February 1992. It is located in the Kuparuk drainage, approximately 26 miles southwest of the Prudhoe Bay Oil Field. Weather conditions are much warmer than at Badami No. 1, because there is less fog during summer months when the sea ice has melted. Overburden used to cover this burial site was hauled from a gravel minesite in the Kuparuk River in the Prudhoe Oil Field. The overburden cap is approximately 15 ft above the surrounding terrain. A much smaller pool of water developed around the well marker at this location than at Badami. However, shallow pools of water developed next to the burial site at Sequoia No. 1. Four growing seasons after abandonment, vegetation cover was less than 5%.

Grasses often recommended for seeding these kinds of sites were abandoned in favor of developing a natural species complex on the mounds. These grasses were omitted from seed applications at the Badami site and included at the Sequoia site. The strategy of seeding grasses and overusing fertilizer has gained a reputation for impeding natural plant succession in the Alaska tundra. Relying only on natural succession, however, presents a problem with the time factor. Natural tundra succession on such sites requires approximately 25-30 years to develop a complete plant cover. Seeding grasses can provide complete cover within 3-5 years. Seeding and fertilizing in combination can impede natural plant recolonization for an unknown period, if the seeded grasses establish successfully. Fertilizing alone can redirect plant succession toward a grass-dominated community. This redirection is known to persist at least 30 years and is a greater problem on mesic and dry habitats than on wet sites. The agencies and industry need to close out permits soon after work is completed; waiting for a quarter to half a century for plant performance is impractical. Therefore, some type of intercession is needed that will provide assurance to the permitting agency and the industry that compliance stipulations have been met, and that further remediation is unnecessary.

Approach

Clearly these sites needed to show more progress than they had to that time. Heavy applications of grass seed and fertilizer would have been the usual approach, but experience with long-term monitoring indicated that would be unacceptable for agency objectives. Applications of indigenous plant seed was the only alternative. Acquiring native plant seed in the arctic is unpredictable at best, and impossible early in the growing season when these requests were received. The only choice was to use seed remaining from another experiment (McKendrick and others 1992). Mixtures of seed from our limited inventory were prepared and applied to the two locations in July and September 1996 (Table 1). Twelve species were originally applied to both sites, with the Sequoia site receiving four commercially available grasses. In 1998, a recently acquired grass, *Puccinellia arctica*, was applied to Badami No. 1 (Table 1). The sites were to be monitored for three growing seasons and then evaluated with respect to agency stipulations. Last growing season (1999) was the year to meet performance criteria.

Results

Plant establishment at the coastal site was not promising by the end of the 1997 growing season. Part of the problem was related to the amount of seed applied, as the original information used to develop seed applications was incorrect. The size of the area was actually nearly twice that projected. Consequently, the application designed to deliver a very light application was only half as much as targeted. We applied additional seed of *Puccinellia arctica* in July 1998 to give the developing community some added plant cover. By the end of the second growing season, the canopy cover was only 6% toward the target of 20–30% by the end of the third growing season.

At the end of the 1999 (third) growing season, canopy cover on the two sites were 32% and 81%, respectively, for the coastal and inland locations (Table 2). At the coastal location, the significant plant species were:

Cochlearia officinalis 10%
Puccinellia arctica 7.6 %
Descurainia sophioides 4.8%
Puccinellia langeana 4%

Table 1. Indigenous seeds applied to Badami No. 1 (6 July 1996) and Sequoia No. 1 (1 September 1996) and average seeds per gram for each of the 16 species. *Artemisia arctica* and *A. borealis* seed were may have been mixed in some collections. *Puccinellia arctica* was added to the Badami No. 1 location in 1998 because site recovery was not meeting rehabilitation objective timelines.

Plant Species	**Badami No. 1 Near Coastal Site (seed/ft^2)**	**Sequoia No. 1 Inland Site (seed/ft^2)**	**Seeds/gram**
Alopecurus alpinus	0.07	1.0	1,150
Arctagrostis latifolia	—	20.0	2,000
Armeria maritima	0.02	0.2	890
Artemisia arctica/borealis	0.44	5.3	2,000
Astragalus aboriginum	0.02	0.4	550
Astragalus alpinus	0.04	0.4	530
Deschampsia beringensis	—	26.4	3,000
Descurainia sophioides	0.21	14.2	11,300
Festuca rubra	—	37.3	1,400
Oxytropis alpinus	0.07	0.5	800
Oxytropis borealis	0.11	0.5	800
Oxytropis campestris	0.07	—	700
Pedicularis capitata	0.04	1.0	2,500
Poa glauca	—	90.0	4,500
Puccinellia arctica (applied 7/15/98)	100.00	—	7,080
Puccinellia langeana	(not coated) 0.45	(coated) 107	(not coated) 4,600 (coated) 2,300
Trisetum spicatum	0.13	3.1	3,800

Table 2. Canopy cover percentages by plant species on the Badami No. 1 (1 September 1999) and Sequoia No. 1 (3 September 1999) buried reserve pits.

Plant species	Badami No. 1 Near Coastal Site	Sequoia No. 1 Inland Site
Arctagrostis latifolia	0.4	7.6
Artemisia borealis	0.4	0.8
Carex lugens	—	1.2
Cochlearia officinalis	10.0	—
Deschampsia beringensis	—	2.0
Descurainia sophioides	4.8	35.0
Epilobium latifolium	—	1.6
Festuca rubra	—	6.8
Phippsia algida	0.8	—
Poa arctica	0.8	—
Poa glauca	—	2.0
Puccinellia arctica	7.6	—
Puccinellia langeana	4.0	—
Puccinellia phryganodes	0.4	—
Stellaria spp.	0.8	—
Standing Dead	2.0	24.0
Totals	32.0	81.0

Cochlearia and *Puccinellia langeana* were colonizing before we applied any seed. It is not possible to distinguish between seeded plants and volunteers of *P. langeana*. We are certain that *Descurainia sophioides* (northern tansy mustard) and *Puccinellia arctica* resulted from seed applications. The light application of fertilizer during seeding enhanced growth of both the seeded and volunteer species on the reserve pit mound. Had we not monitored the location and applied the *Puccinellia arctica* seed in 1998, the site would likely not have met compliance requirements.

We were asked not to inspect the inland site in 1998 in order to save the cost of helicopter access. However, we were passing by that area on an assignment from the Bureau of Land Management in 1998 and were able to see the site, which was most phenomenal in appearance. The entire mound was covered with a tall dense stand of *Descurainia sophioides* plants. Having seen these plants in their juvenile state the previous year and anticipating a strong performance in 1998, we were not disappointed. The cover was 4 to 5.5 ft in height and too dense for grazers that had been keeping canopy cover to a minimum on the site. The understory plants were able to develop to their fullest extent in 1998, giving the community a significant boost. These tansy mustard plants developed a standing dead comprising 24% of the canopy in 1999 and produced seed that germinated and formed a mat of basal rosettes which will mature in the year 2000. The canopy cover was 81% by the end of the 1999 growing season (Table 2). We also noticed that cottongrass seeds were caught in the canopy of the tansy mustard plants. Apparently, wind carried these seeds across the terrain, and they became entrapped on the finely dissected canopy of stem branches and seed pods.

Species of greatest importance at the inland site were:

Descurainia sophioides 35%
Arctagrostis latifolia 7.6%
Festuca rubra 6.8%

Descurainia sophioides was entirely the result of our seed applications. We are certain that two ecotypes of *Arctagrostis latifolia* were present (one seeded, the other a volunteer). *Festuca rubra* may have also resulted from seeding and volunteers. Clearly, the plant that contributed the most change to the site was *Descurainia sophioides*.

Descurainia sophioides is a member of the mustard (*Cruciferae*) family. Cabbage, broccoli, radish, rape, and cauliflower are common crops in that family. *Alyssum* is a flowering mustard often used in Alaska flowerbeds. The family consists of about 350 genera and 2,500 species, according to Hitchcock and others (1964). Flowers have four

Badami Production Facility

between 8 and 13 thousand per gram. Germination ranged between about 87% and 99%, indicating high quality seed had been acquired.

Discussion

Inserting *Descurainia sophioides* into the recolonization process succeeded in meeting timelines for performance without hindering natural recolonization. While it dominates a site, it provides habitat useful to wildlife and enhances conditions favoring establishment of other plant species. In so doing, it induces conditions for its own demise. The species only exists on disturbed soils. Once effects of the disturbance have diminished and other plants invade, northern tansy mustard cannot compete and fades from the community. This makes it an ideal plant for artificial tundra revegetation, satisfying immediate needs for agencies and industry without compromising the natural return of the tundra vegetation complex. There are other plant species that function in a similar manner. One is *Puccinellia arctica*; however, we did not have seed of that grass in 1996. The serendipitous discovery of northern tansy mustard's value came about because an immediate need coincided with the good fortune of having some 7-year-old native plant seeds in the freezer. In 1990, we included seed of *Descurainia sophioides* in our test plantings at Prudhoe Bay and were impressed with its

First year basal rosette of Descurainia sophoides

petals and four sepals. *Cruciferae* seeds are borne in long narrow pods (siliques) or broader than long silicles. *Descurainia* produces siliques and is a genus largely from temperate regions of North and South America. It was named for a French apothecary and botanist (Hitchcock and others 1964). The common name of tansy mustard is attributed to the 'tansylike' leaves (U.S. Forest Service 1937). It has also been known as 'flixweed'. The genus is noted for occupying disturbed and overgrazed areas. In the western U.S., it was often associated with bedground for sheep and believed to have been spread as seeds were caught in the sheep wool (U.S. Forest Service). According to Hultén (1968), the species occurs in Alaska on gravel bars and disturbed soils. In the arctic it can be found around animal burrows. It often appears along roadsides in Alaska, but is not evident every year. Around villages, it is believed to have hybridized with the introduced species *Descurainia sophia*.

My involvement with the species in Alaska began August 17, 1989, at milepost 398.7 of the Dalton Highway, just south of Deadhorse, Alaska. We were searching for plant species to use in revegetation tests on the BP Put River No. 1 drilling pad (McKendrick and others 1992), when I happened upon a stand of plants on the Trans-Alaska Pipeline right-of-way. I was fascinated by the height of these plants, because they were clearly out of character for the arctic coastal plain. Specimens were well over 4 ft in height, standing four to five times that of nearby undisturbed tundra plants. Close examination revealed a dense stand of *Descurainia sophioides,* an indigenous biennial in its second and final year of growth. Seeds were ripe, so we gathered approximately 180 grams by hand stripping the plants. This collection amounted to between 1.4 and 2 million seed, based on subsequent laboratory determinations. *Descurainia* seed are small, as is common for the mustard family. There are second-year growth. Some of these giant forbs of the tundra grew to 1.25 meters in height in their last season of life. Arctic ground squirrels were attracted to the seed pods (those they could reach), and were observed stripping seed and taking it to their dens. Some of the standing dead stalks have persisted for eight years, capturing snow and sheltering the plots. Our plants grew best where we had placed silt loam about 4 in deep on the gravel fill. In pure gravel, the plants were short and less productive in canopy development. Gradually, the species has faded from its initial prominence and is now rarely found in the test plots.

Sequoia site, view east across top of mound, 1 September 1996

Conclusions

Some of the pluses for *Descurainia sophioides* were:

1) it protected young perennials from excessive grazing,
2) developed live and standing dead cover that captured snow and reduced wind erosion risk,
3) provided shelter for small mammals and ptarmigan,
4) produced seed for birds and small mammal diets, and
5) trapped seeds of cottongrass blowing across the tundra.

Although the vegetation problem at these two wellsites was significantly remedied by northern tansy mustard, seed producers in Alaska should not rush out and plant fields of this species in hopes of selling it for revegetation of oil field disturbances. Exploratory drilling techniques change rapidly. Although these wells were drilled in the early 1990s and required revegetation, the practice of burying drilling wastes on site has been discontinued. Exploratory wells now are drilled from ice pads, and all waste material is either injected on site or hauled to another location and injected. Once the drilling operations have concluded, and the ice pad melted, the only evidence remaining is a crushing of standing dead, causing the area to appear greener than the surrounding tundra for a few growing seasons. At the point where the well was drilled a small pond of water usually develops

Sequoia site, view east across top of mound, 3 September 1999

Ptarmigan nesting under standing dead of Descurainia sophioides

in response to the thawing of permafrost during drilling. Often the well casing is cut off below ground and nothing projects above the surface. Hence, revegetation is no longer needed on exploratory drilling sites. There is probably a small market for *Puccinellia arctica* to seed overburden at gravel mine sites, where production facilities are developed. The grass may also be useful outside the arctic to vegetate mine spoils consisting of mineral soil. It is unsuited to either gravel or sand that is subjected to wind erosion.

Acknowledgements

Financial and logistical support for this work came from BP Exploration (Alaska), Inc. and Conoco, Inc. The U.S. Department of Agriculture and the state of Alaska sponsored a portion of the indigenous seed harvesting and processing. Christopher J. Herlugson, Michelle Gilders, Jennifer Parnell, and Leslie Griffith of BP Exploration (Alaska), Inc. provided oversight to the two revegetation projects. Joe Serra and Neil Hermon, Jr. and the Badami Central Processing Facility arranged logistics and field support for the Badami No. 1 wellsite monitoring. Hunter Irvin assisted with Badami field logistics. Tess Carr and Erica Herlugson arranged travel, and Tess assisted with applying seed and fertilizer at Sequoia No. 1. Linda Perry Dwight, contractor to BP Exploration (Alaska), Inc., assisted with project coordination during the 1998 field season. Pete Scorup and Dan McKendrick assisted with data collection and applications of seed and fertilizer at Badami No. 1 in 1998. Bill Baker and Dan Cooley helped apply *Puccinellia arctica* seed and fertilizer at Badami No. 1. Peg Banks assisted with preparing this article and with photography at Sequoia No. 1. Steve McKendrick assisted with evaluating Badami No. 1 in 1999. Conce Rock and Dave Trudgen, contractors to BP Exploration (Alaska), Inc. assisted with project coordination during the 1999 field season. Don Meares, BLM, Fairbanks arranged helicopter support to NPR-A in 1998, which took us by Sequoia No. 1 when the site was first dominated with *Descurainia sophioides* in 1998.

References

Hultén E. 1968. Flora of Alaska and neighboring territories. Stanford, California: Stanford University Press. 1008 p.

Hitchcock CL, Cronquest A, Owenbey M, Thompson JW. 1964. Vascular plants of the Pacific Northwest Part 2: *Salicaceae* to *Saxifragaceae*. Seattle: University of Washington Press. 597 p.

McKendrick JD, Scorup PC, Fiscus WE, Turner G-L. 1992. Gravel Vegetation Experiments—Alaska North Slope. University of Alaska Fairbanks, Agricultural and Forestry Research Station. Agroborealis 24(1): 25-32.

U.S. Forest Service. 1937. Range Plant Handbook.. U.S. Government Printing Office, Washington, D.C. W285.

Silvicultural Systems for Alaska's Northern Forest

Edmond C. Packee

Alaska is at the threshold of developing the Northern Forest timber resource. The Alaska Constitution commits the state to sustained yield and multiple-use—the resource must be managed in a sustainable manner. Similar commitments exist for federal lands. Good business and forest practice guidelines encourage sustained yield on private lands. Sustained yield of the forest requires planning that addresses regeneration, tending, and harvest (Nyland 1996).

This paper provides an initial effort to develop a systems approach for managing Northern Forest ecosystems. A silvicultural system is "a planned series of treatments for tending, harvesting, and re-establishing a stand" of trees (Helms 1998). The silvicultural system is named after the regeneration method. Emphasis here is on the regeneration method. As new data become available, revision and tending prescriptions are expected.

The Northern Forest

Forests in Alaska consist of two major formations: Coastal Forest and Northern Forest (Fig. 1). Sitka spruce (*Picea sitchensis*), western hemlock (*Tsuga heterophylla*), and mountain hemlock (*Tsuga mertensiana*) dominate the Coastal Forest. White spruce (*Picea glauca*), black spruce (*Picea mariana*), quaking aspen (*Populus tremuloides*), and birch (*Betula kenaica* and *B. neoalaskana*) dominate the Northern Forest. The two formations share one hardwood, balsam poplar (*Populus balsamifera*); the coastal variant is referred to as western black cottonwood (*P. balsamifera* ssp. *trichocarpa*). Because of gross climatic, geologic, and biologic differences, silvicultural systems developed for one are not suitable for the other.

The Northern Forest occupies discrete biogeoclimatic units (Hartman and Johnson 1984, Alden 1991, Zasada and Packee 1995) (Fig. 1):

- Kenai Peninsula-Alaska Peninsula—where white spruce and Sitka spruce naturally hybridize; balsam poplar and western black cottonwood intergrade; and mountain hemlock commonly dominates a subalpine forest.
- Susitna-Matanuska valleys—where Sitka spruce and mountain hemlock are absent and white or black spruce dominate, balsam poplar and western black cottonwood intergrade, and understory vegetation consists of a mixture of boreal and coastal elements.
- Copper River Basin—similar to the Susitna-Matanuska valleys but with lesser amounts of hardwoods, climatically more continental with considerable continuous permafrost, and lacustrine (proglacial lake) deposits.
- Interior Alaska—north of the Alaska Range where coastal understory species are lacking, tamarack (*Larix laricina*) occurs locally, permafrost is discontinuous, and boreal forest elements are well developed.
- Western Alaska—west of the Kokrines Hills including the Koyukuk, lower Yukon, and Kuskokwim drainages where soils are permafrost-rich soils; sparse lichen forests dominate on uplands and closed forests dominate on valley bottoms and southerly aspects.

In each unit, ecological factors differ and cause differences in stand development and structure. Pleistocene and Quaternary history, soils, natural fire frequency and intensity, insect outbreaks, and wildlife populations vary as well. A need exists for a biological or ecological platform upon which to refine silvicultural systems for each cover type and ultimately each stand. Existing classifications based on dominant tree species with little regard for ecological changes (succession) over time limits development of silvicultural systems to addressing regeneration. Further refinement must address social pressures that vary dramatically within and among the geographic units and the real financial constraints.

Forest stands and cover types of the Northern Forest are commonly single cohort, reflecting a past catastrophic disturbance, particularly fire, fluvial processes of erosion and deposition, and possibly insects. Forest tree cover currently dominating the stand (Society of American Foresters cover types, followed by type numbers) (Eyre 1980) includes: White Spruce (201), Black Spruce (204), Tamarack (38), Paper Birch (252),

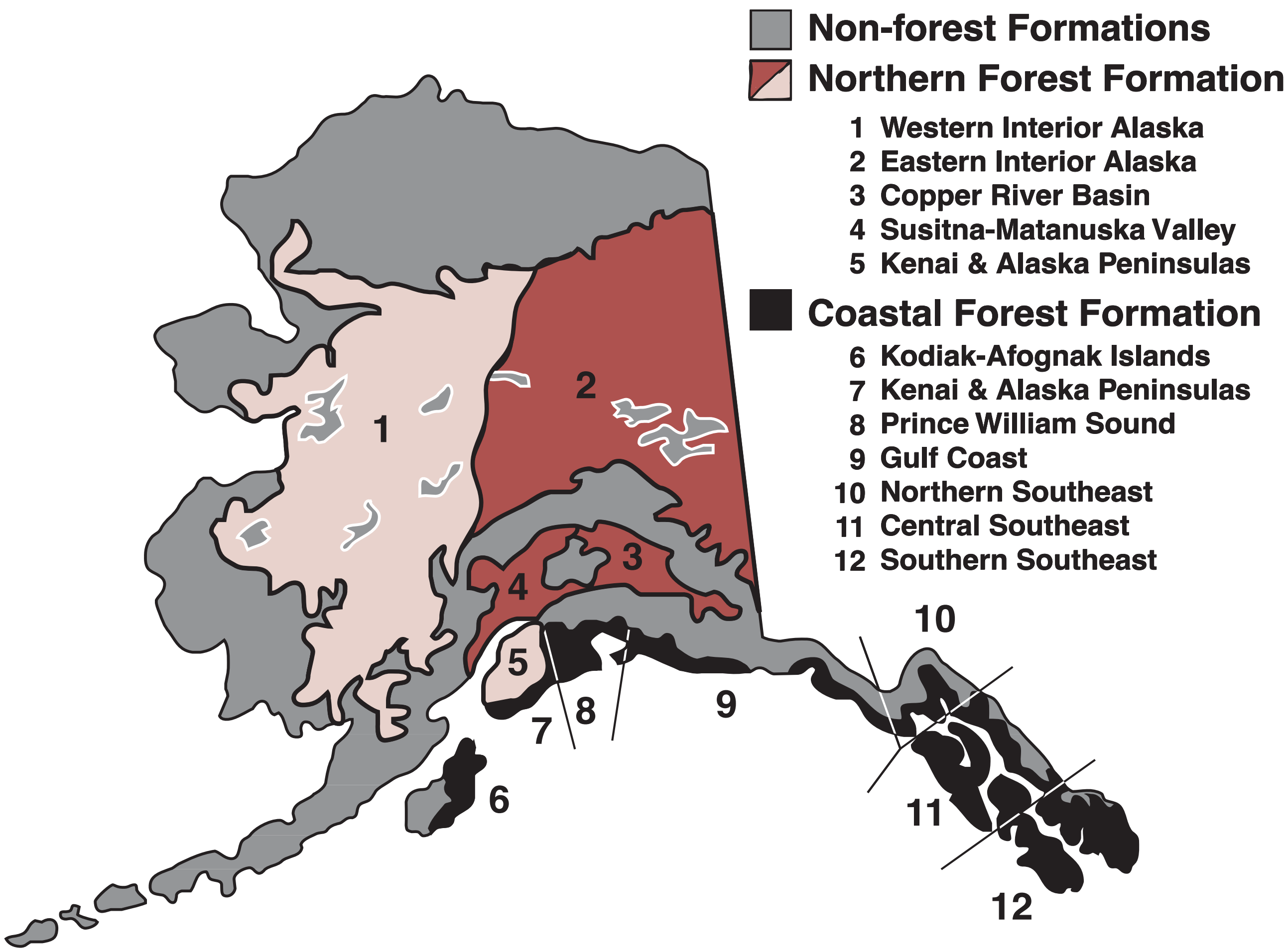


Figure 1. Biogeographic units of Alaska with emphasis on the Northern Forest.

Aspen (16), Balsam Poplar (includes western black cottonwood) (203), White Spruce-Black Spruce (253), Black Spruce-Tamarack (14), Paper Birch-White Spruce (202), Paper Birch-Black Spruce (254), Aspen-White Spruce (251), Balsam Poplar-White Spruce (203), and Paper Birch-Aspen-White Spruce (252, 202, 251). Environmental factors and disturbances (natural and man-caused) have created a mosaic of stands and age groups across the landscape that are the essence of Northern Forest biodiversity.

Hardwoods and tamarack are relatively shade intolerant; they are seral, that is, capable of being replaced on most sites by more shade tolerant tree species. This replacement of one community vegetation by another is referred to as succession. Hardwoods can dominate the overstory until the stand breaks up and is replaced by either hardwoods or the more shade tolerant spruces. Unless disturbance, from small gaps to large acreages, occurs, the likelihood of stands being dominated by or even retaining a significant component of shade-intolerant species is low.

Based on tree diameters, many stands look like they consist of trees of many ages. However, diameter and age are poorly related. In reality, Northern Forest stands are commonly “even-aged”; with one, two, or occasionally three age classes being present. “All-aged” stands are infrequent. Oliver and Larson (1990) refer to stands originating after major disturbance as cohorts; such stands often do not meet the rigid definition of “even-age”. Stands originating after a single major disturbance are single-cohort stands; stands developing as a result of two or more disturbances (the latter of lesser significance) are multi-cohort stands (Oliver and Larson 1990).

Many pure and mixed Northern Forest stands have a stratified appearance. Smith (1992) described a Massachusetts’ forest: “...the main continuous canopy of leafless hardwoods separated a solid lower stratum of evergreen hemlocks (*Tsuga canadensis*) from evergreen emergents soaring above the hardwoods."

In Alaska, the hardwoods are aspen or birch, the evergreen hemlock is white spruce, and the soaring emergents are either veteran white spruce or poplars. The stratified appearance of Alaskan stands is due to species composition or the possible presence of more than one cohort. Youngblood (1992) investigated the structure of stratified mixed stands in the Tanana Valley and found single-cohort stands. Similar stands are abundant in the Susitna Valley. Weston-York (1999) identified single and multi-cohort stands on the lowlands of the western Kenai Peninsula.

Developing silvicultural systems for Northern Forest stands requires an understanding of stand development patterns including: nature of the mosaic pattern and stratified mixtures, cohort initiation and development, and limiting and compensating ecological factors. A working knowledge of the ecology of the species (crop and competitors) is essential. Silvicultural systems must be adapted to fit stand development patterns and not, simply, what is expedient. Hawley and Smith (1954) refer to the tendency "to limit [one's] silvicultural outlook to partial cuttings aimed primarily at indefinite extension of the lives of existing stands. While this policy has advantages as a temporary expedient, it must ultimately collapse because it evades rather than solves the basic problem of renewing existing stands..."

Silvicultural Systems

"Silviculture is normally directed at the creation and maintenance of the kind of forest that will best fulfill the objectives of the owner" (Smith 1986). Objectives can include commodity production, wildlife-habitat, recreation, and aesthetics. Regardless of the objectives, the production or maintenance of a stand requires regeneration. Actions taken to secure regeneration impact future harvests and social and financial rewards. In Alaska, regeneration is both an investment and a cost of doing business. The state constitution mandates sustained yield; federal and state laws and regulations require adequate regeneration; many private owners expect "reforestation" to be part of the harvest package. Although silviculture can be costly, based on harvested volume, its costs are relatively insignificant compared to harvest costs (Baskerville 1992).

Successful silviculture for wood products, wildlife habitat, recreation, and aesthetics requires that the specific objectives of the owner be clearly defined so that silviculture is not "an end in itself but...a means of ensuring that it [the forest] will be a permanently productive source of goods and benefits" (Smith 1986).

New forests will be managed to produce desired stand structures of tree fiber to provide various products and services including, but not limited to: commodities such as quality sawlogs, chips, or mixtures; wildlife habitat for food, perching, and nesting including cavity trees; and aesthetically pleasing settings. Creation or replacement of old forests with new forests requires space for the young trees. Space can be created by harvesting trees. There are two harvest methods available for harvesting trees: clearcutting and partial cutting. These two harvest methods are tools to achieve a certain result; they are not regeneration methods or silvicultural systems.

Commercial tree harvest can recoup the regeneration cost. Except for the Pacific Northwest Coastal Forest, future average conifer sawlog tree diameters are 12 inches and under and conifer and hardwood yields per acre for the year 2040 for various regions of the contiguous United States (Bradley 1991) are realistic for Alaska. Cost-effective regeneration of preferred species demands, however, the correct silvicultural system. This is true whether the objective is commercial fiber or production of wildlife habitat. Utilization of normal succession patterns is a prerequisite to cost-effective regeneration; equally important, such an approach also addresses biodiversity concerns (Avery and Leslie 1990, Hunter 1990, Petty and Avery 1990, Smith 1992). Hence, the silvicultural system should emulate ecological processes.

Matthews (1989) defined silvicultural system "as the process by which crops constituting a forest are tended, removed, and replaced by new crops, resulting in the production of stands of distinctive form." He notes three major aspects: 1) method of regeneration, 2) form of the crop produced, and 3) orderly arrangement of stands across the forest (including silviculture, protection, and efficient harvesting considerations). Smith (1986) reminds foresters that a silvicultural system covers the entire rotation and is based on a working or evolving hypothesis. By design, silvicultural systems are to be altered as new information becomes available and hypotheses change. Emphasis, in this paper, is on removal and replacement of existing forest trees with a new crop that meets regeneration standards at the free-to-grow stage; this is the reproduction effort. Crop tree free-to-grow stage occurs when trees are commonly 125–150% of the height of competing vegetation (Silviculture Branch 1990) or large enough to escape browsing damage to the terminal leader. Care must be taken to avoid mixing the concepts of silvicultural system with harvest system; they are not synonymous.

Silvicultural systems are of two basic types:

- HIGH FOREST—stands originate from seed or cuttings and are suited to conifers, paper birch, and poplar.
- COPPICE FOREST—stands originate from vegetative regeneration (sprouts and suckers); and are suited to aspen, poplar and to a lesser degree, paper birch.

For hardwoods, a mix of high forest and coppice forest may be employed; approaches for the conifers are limited to high forest. High forest silvicultural systems include: clearcut, seed tree, shelterwood (uniform, group, irregular, and strip), selection, and group selection. Coppice forest systems include coppice and coppice-with-standards.

Regeneration Methods

The Clearcut Method entails removal of the entire stand in one cut; it is the simplest way to replace mature stands. It can be done with any forest cover type (Table 1). It creates a pure or mixed, single-cohort stand. Regeneration may be natural or artificial. Natural regeneration depends on advance regeneration, which in most cases will be the shade tolerant spruces, or a nearby seed source of any species. For hardwoods, sprouting is an additional regeneration source and is dealt with under coppice systems. Exposure of understory vegetation to maximum light encourages rapid growth of competing species. Throughout the Northern Forest, bluejoint (*Calamagrostis canadensis*) is an intense competitor and responds vigorously to increased light. It can develop into dense stands that commonly range from three to five feet tall. Hardwoods and shrubs also respond to increased light and can effectively compete with conifer seedlings. Grass or shrubs can cause regeneration failures. If skillfully manipulated, stands with adequate conifer and hardwood reproduction develop into highly productive stratified mixtures providing excellent structure for wildlife.

The Seed Tree Method entails removal of the mature stand in one cut but leaves behind a small number of seed trees, either singly or in small patches, as the seed source for the new stand. Seed trees should be the best trees in the stand and be well distributed across the landscape. Diameter limit cuts using a minimum diameter in single cohort stands usually select against the better genetic material. Seed trees may be harvested once regeneration is adequate. This method is suited to windfirm conifers and birch and poplar stands (Table 1). It is unsuited to aspen or stands subject to wind or heavy snow that cause breakage. Generally, it is not recommended for single-cohort white or black spruce. The object is to establish a single-cohort, single- or mixed-species stand. Where shade intolerant hardwoods are left as seed trees, white spruce can be planted to create a stratified mixture. Response of bluejoint or shrub species to increased light and nutrients often causes regeneration failures.

The Shelterwood Method removes the mature stand in a series of cuts near the end of the rotation in order to secure advance, high quality regeneration of the desired species. Resulting stands can be single- or multi-cohort. Shelterwood is not to be confused with thinning; the latter is designed to provide more growing space for individual crop trees. Carefully planned and executed thinnings can lead naturally into shelterwood cuts. A modified form of shelterwood could involve planting of spruce under hardwoods. Several approaches or systems are feasible for the Northern Forest.

The Uniform Shelterwood System "implies a uniform opening of the canopy for regeneration purposes, as well as an even age and regular condition of the young crop reproduced" (Ford-Robertson 1971). It is applicable to pure stands of white or black spruce, mixed stands of white spruce-black spruce, and mixed stands of hardwoods and spruce where the objective is conversion to spruce (Zasada 1990; Youngblood and Zasada 1991); it is possible to use it with paper birch, but a major constraint is competing vegetation, particularly bluejoint and, south of the Alaska Range, devil's club (*Oplopanax horridus*) and false-azalea (*Menziesia ferruginea*) (Table 1). The goal of the Uniform Shelterwood System is a usually a single-cohort forest.

Group Shelterwood takes initial advantage of advanced regeneration found in natural gaps in the forest canopy. As regeneration requires release, gaps are expanded outwards by felling trees around the edges. Additional gaps are created if natural gaps are insufficient. Regenerated gaps are expanded outwardly until the last seed bearing trees separating gaps are removed. This may initially result in a multi-cohort stand, but Matthews (1989) states that resulting stands "are of an even-aged type by the time the pole stage is reached."

Irregular Shelterwood consists of successive regeneration cuts "with a long and indefinite regeneration period, producing young crops of somewhat uneven-aged type" (Matthews 1989). An

Table 1. Silvicultural systems and reproduction methods for forest cover types of the Northern Forest of Alaska, a first approximation.

Forest Cover Type	Desired Species	Silvicultural System/Regeneration Method: Clearcut	Seed Tree	Shelterwood: Uniform	Shelterwood: Group	Shelterwood: Irregular	Shelterwood: Strip	Selection: Uniform	Selection: Group	Coppice: Simple	Coppice: w/Stand.
White Spruce (201)	Sw	Y	(Y)	Y	Y	Y	Y	(Y)	Y	N	N
Black Spruce (204)	Sw	Y	N	N	N	N	N	N	N	N	N
	Sb	Y	N	Y	Y	Y	Y	Y	Y	N	N
Tamarack (38)	T	Y	N	N	N	N	N	N	N	N	N
	Sw	Y	N	N	N	N	N	N	N	N	N
Paper Birch (252)	B	Y	Y	(Y)	N	N	(Y)	N	N	(Y)	N
	Sw	Y	Y	Y	N	N	N	N	N	N	N
	B/Sw	Y	Y	Y	Y	Y	Y	N	N	(Y)	Y
Aspen (16)	A	(Y)	N	N	N	N	N	N	N	Y	N
	A/Sw	(Y)	N	N	N	N	N	N	N	Y	Y
Balsam Poplar (203)	P	Y	(Y)	N	N	N	N	N	N	Y	Y
	Sw	Y	N	N	N	N	N	N	N	N	N
	P/Sw	Y	Y	N	N	N	N	N	N	Y	Y
White Spruce-Black Spruce (253)	Sw	Y	N	N	N	N	N	N	N	N	N
Black Spruce-Tamarack (14)	T	Y	N	N	N	N	N	N	N	N	N
	Sb	Y	N	Y	Y	Y	Y	Y	Y	N	N
Paper Birch-White Spruce (202)	B	Y	Y	(Y)	N	N	N	N	N	(Y)	N
	Sw	Y	N	N	N	N	N	N	N	N	N
	B/Sw	Y	Y	Y	Y	Y	Y	N	N	(Y)	Y
Paper Birch-Black Spruce (254)	B	Y	Y	N	N	N	N	N	N	(Y)	N
Aspen-White Spruce (251)	A	(Y)	N	N	N	N	N	N	N	Y	N
	A/Sw	Y	(Y)	N	N	N	N	N	N	Y	Y
Balsam Poplar-White Spruce (203)	P	Y	Y	(Y)	N	N	(Y)	N	N	(Y)	N
	Sw	Y	N	N	N	N	N	N	N	N	N
	P/Sw	Y	Y	N	N	N	N	N	N	Y	Y
Paper Birch-Aspen-White Spruce (252, 202, 251 variants)	B/A/Sw	Y	(Y)	N	N	N	N	N	N	(Y)	Y

Sw = white spruce
Sb = black spruce
T = tamarack
B = paper birch
A = aspen
P = balsam
poplar-black cottonwood

important feature of this approach is the continual improvement in the growing stock by selection through all tending and harvesting activities. The effort must select for the best future crop trees, not the removal of the best trees (high-grading). Resulting stands are multi-cohort (uneven-aged and may approach all-aged). The irregular shelterwood system may be used to favor white spruce where it is socially desirable to convert the stand from a natural, single-cohort condition to an uneven-aged stand (Table 1); such an effort ignores the usual natural disturbance regime. To avoid abuse such as high-grading, the objective must be clearly defined.

Strip Shelterwood entails harvesting a series of narrow bands, often less than one-half the height of the trees in width, to obtain the necessary regeneration (Matthew's 1989). Preparation and final harvest cuts progress into the stand, often into the prevailing wind. The result is a multi-cohort stand with each cohort appearing as a band. The approach can be used with pure stands and stratified mixtures, shade tolerant and intolerant species (Table 1). Where moose habitat is a concern, it creates an excellent combination of browse and cover; hence, it is not recommended for hardwoods where fiber production is the primary goal.

The Selection Method utilizes repeated entries at relatively short intervals to remove mature and immature trees, usually the oldest or largest, either singly or in small groups. The object is to create and maintain an uneven-aged stand.

Reproduction is encouraged on a continuous basis. "When properly applied, the system is aesthetically pleasing, but is difficult to apply in most forest types" (USDA Forest Service 1973). The method is not recommended for shade intolerant hardwoods or tamarack.

Zasada (1973) states that the selection method might be suitable for white spruce, provided seedbed conditions permit or adequate disturbance of the ground vegetation and organic layer occurs (Table 1). Westveld (1939) also suggests that the selection system with soil scarification might work for uneven-aged stands of white spruce-balsam fir (*Abies balsamea*).

Smith (1992) referring to past selection cutting schemes admonishes the forest manager, "Once the even-aged condition exists, it is very difficult to change it." This warning cannot be taken lightly because of the stratified nature of Alaskan stands; single- and multi-cohort stands developed in relation to environmental agents are natural and contribute to biodiversity (Avery and Leslie 1990, Hunter 1990, Petty and Avery 1990, Smith 1992). To ignore such characteristics is to ignore natural succession and biodiversity at both the species and landscape levels. Caution is needed since the selection method can easily degenerate into high-grading.

Group Selection involves removal of trees in small patches; patch size normally should not exceed more than one-half an acre with a maximum no larger than one acre. The object is to create or maintain an uneven-aged stand. It may closely emulate natural patch disturbances and related succession patterns that occasionally occur locally in some drainages. Thus widespread application is not warranted. It may be used where the desire is to maintain or encourage white spruce (Table 1). On appropriate sites, it may even be possible to encourage limited amounts of hardwood regeneration. This approach can also degenerate into high-grading.

The Coppice Method involves harvests for which regeneration depends mainly on vegetative reproduction such as sprouting from stumps or root systems (Table 1). Birch sprouts from stumps; aspen produces root suckers; and poplar sprouts from stumps and produces root suckers. The object is a single-cohort stand. Occasionally, a mixed hardwood stand can be developed. To obtain vigorous root suckering of aspen, clearcutting is essential.

Coppice-With-Standards involves production of coppice and high forest on the same area with trees (the standards) of seedling origin being carried through much longer rotations than those of coppice origin. Standards may or may not be the same species as the coppice. The object is to produce a single- or two-cohort stand, not an all-aged stand. The goal is a stand that resembles the stratified mixtures that naturally occur throughout the Northern Forest. Typically, the coppice would be hardwoods with the standards being white spruce (Table 1). The white spruce could be natural or more likely be planted.

Table 1 provides a summary of silvicultural options by Forest Cover Type to produce stands of specific species. The suggested options are based on personal observations and the literature. Table 1 attempts to incorporate natural processes including species requirements and succession.

The silviculture systems, especially the regeneration methods were brought to North America from Europe. Some scientists and lay persons suggest that they are not satisfactory under American conditions and are poorly adapted to American forests and society's expectations. Baker (1934) addressed this concern,

> "The viewpoint is obviously unsound, for European systems really include every possible variant of silvicultural management; and so if we say that no European silvicultural system will work in America, it is tantamount to saying that no silviculture of any kind is possible. We have the systems confused with rigidity; actually they are just as flexible as … conditions require. To apply them flexibly requires a minimum of rules and a maximum of silvicultural art. …failure to make the systems work is more due to the lack of silviculturist artists than fundamental unsuitability of European systems."

The matrix of options provided in Table 1 need to be scrutinized or verified for Alaska. Table 1 also provides a framework to begin development of more specific prescription details, e.g. type of regeneration, type of planting stock, and site preparation treatments.

References

Alden JN. 1991. Provisional tree seed zones and transfer guidelines for Alaska. USDA Forest Service General Technical Report PNW-GTR-270.

Avery M, Leslie R. 1990. Birds and forestry. London, England: T & AD Poyser Ltd.

Baker FS. 1934. Theory and practice of silviculture. New York: McGraw-Hill Book Company, Inc.

Baskerville GL. 1992. Forest analysis: Linking the stand and forest level. In: Kelty MJ, Larson BC, Oliver CD, eds. The ecology and silviculture of mixed-species forests, p. 257-277. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Bradley DP. 1991. 'Ignorance' of logging costs harms long-term forestry. Forest Industries 118(6): 29-31.

Eyre FH, ed. 1980. Forest cover types of the United States and Canada. Washington, DC: Society of American. Foresters.

Ford-Robertson FC. 1971. Terminology of forest science, technology, practice and products. Washington, DC: Society of American Foresters.

Hartman CW, Johnson PR. 1984. Environmental atlas of Alaska. Fairbanks, AK: Institute of Water Resources/Engineering Experiment Station, University of Alaska Fairbanks.

Hawley RC, Smith DM. 1954. The practice of silviculture. New York: John Wiley & Sons, Inc.

Helms JA, ed. 1998. The dictionary of forestry. Bethesda, MD: Society of American Foresters.

Hunter ML, Jr. 1990. Wildlife, forests, and forestry. Principles of managing forests for biodiversity. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Nyland RD. 1996. Silviculture: Concepts and applications. New York: McGraw-Hill Companies, Inc.

Oliver CD, Larson BC. 1990. Forest stand dynamics. New York: McGraw-Hill, Inc.

Petty SJ, Avery MI. 1990. Forest bird communities. Edinburgh, Scotland: Forestry Commission Occasional Paper 26.

Silviculture Branch. 1990. First approximation of correlated guidelines for free growing stocking standards for the ecosystems of British Columbia. Victoria, BC: British Columbia Ministry of Forests.

Smith DM. 1986. The practice of silviculture. New York: John Wiley & Sons, Inc.

Smith DM. 1992. Ideas about mixed stands. In: Kelty MJ, Larson BC, Oliver CD, eds. The ecology and silviculture of mixed-species forests. Dordrecht, The Netherlands: Kluwer Academic Publishers. p. 281-287.

Smith KW. 1992. Bird populations: Effects of tree species mixtures. In: Cannell VGR, Malcolm DC, Robertson PA, eds. The ecology of mixed-species stands of trees. Oxford, England: Blackwell Scientific Publications. p. 233-242.

USDA Forest Service. 1973. Silvicultural systems for the major forest types of the United States. USDA Agriculture Handbook 445.

Westveld M. 1939. Applied silviculture in the United States. New York: John Wiley & Sons, Inc.

Youngblood AJ. 1992. Structure and dynamics in mixed forest stands of interior Alaska. Unpublished Ph.D. dissertation. Fairbanks, AK: University of Alaska Fairbanks.

Youngblood A, Zasada J. 1991. White spruce regeneration options on river floodplains in interior Alaska. Can. J. For. Res. 21: 423-433.

Zasada JC. 1973. Interior Alaska white spruce. In: USDA For. Serv. Silvicultural systems for the major forest types of the United States, p. 20-21, USDA Agr. Hdbk. 445.

Zasada JC. 1990. Developing silvicultural alternatives for the Boreal Forest: An Alaskan perspective on regeneration of white spruce. Univ. Alberta Faculty Agr. For., Forest Industry Lecture No. 25, Edmonton, Alberta.

Wavelength-selective mulches and tomato production in Fairbanks, Alaska

Grant E.M. Matheke and Patricia S. Holloway

The selective reflecting mulch, SRM-Red™, has been shown to increase yield of first quality early market tomatoes when compared to tomatoes grown through black plastic mulch (Fortnum and others 1997, Csizinszky and others 1995, Heacox 1995). SRM-Red™ increases yield by reflecting far-red wavelengths of light into the plant canopy which promotes shoot growth, and flower and fruit development (Kasperbauer and Hunt 1998). This product has engendered interest in Alaska where field cultivation of high quality tomatoes is difficult, and yields may be quite low.

In the Interior, many people grow tomatoes through clear plastic or infra-red transparent (such as IRT-100™) mulch in order to warm cold soils. Clear mulches are the most effective at warming the soil, but IRT mulches eliminate weed growth beneath the mulch by blocking the radiation used for photosynthesis. During most seasons, yield of temperature-sensitive crops such as sweet corn are comparable when grown through clear or infra-red transparent (IRT) mulches (Matheke and others 1991). The purpose of this project was to evaluate the effects of SRM-Red™ on yield of field-grown tomatoes in Fairbanks, Alaska and to compare yield with the standard IRT-100™ mulch.

Methods

'Sub Arctic 25' tomatoes were seeded in the greenhouse during the third week of April and transplanted into the field at 30–inch (76cm) spacing in rows five feet (1.5 m) apart on June 3. Plots were fertilized with 3 lb per 100 ft^2 (1307 lb/A) 10–20–20s (s = sulfate of potash) and tilled prior to transplanting. Rows were oriented in an east/west direction. Roberts Ro-drip trickle irrigation tape was laid adjacent to the planting row, then the row was covered with a three-foot (91 cm) width of either SRM-Red™ and IRT-100™ mulch. Plots were arranged in a randomized complete block design with four replicates and three plants per replicate. Tomatoes were harvested at the pink to red ripe stage. Weather data were compiled from a U.S. Weather Service station, elevation 475 ft (145 m), located approximately 350 ft (107 m) west of the garden. The experiment was repeated for two seasons, 1998 and 1999.

Results

There was no significant difference (P<0.05) in the average yield per plant, individual fruit weight or the number of fruit per plant between SRM-Red™ and IRT-100™ mulch in both years of the study (Table 1). There was a significant difference in the yield between 1998 and 1999.

Table 1. Yield and fruit weight of tomatoes grown through IRT-100™ and SRM-Red™ polyethylene mulches in 1998 and 1999.

Year and Treatment.	Number of fruit per plant	Fruit yield per plant (kg)	Individual fruit weight (g)
1998[*]			
IRT-100	11.6 + 5.4	0.4 + 0.2	40.8 + 5.2
SRM-Red	12.2 + 1.8	0.4 + 0.1	36.3 + 6.3
1999			
IRT-100	105.8 + 0.2	3.6 + 0.4	34.3 + 1.2
SRM-Red	101.7 + 0.1	3.4 + 0.4	33.4 + 3.1

[*]Data within columns and between treatments in each year do not differ significantly at P=.05; data between years differ significantly for yield and number of fruit per plant, P=.05.

In 1998, the weather was unseasonably cool and wet after a warmer than average May (Table 2). In 1999, the weather was appreciably warmer than 1998 with above average temperatures from June through September. Although the frost free period was similar each year, much of the frost free period in 1998 was early in the season before the tomatoes had been set out. In 1999, more of the frost free period extended into the fall resulting in an extra 14 days of harvest.

Conclusions

The difference in tomato yields between 1998 and 1999 is striking. In 1998, we harvested an average 0.93 lb (0.4 kg) per plant, whereas in 1999 yield was nearly 8 lb (3.6 kg) per plant. The large difference in yield between 1998 and 1999 can be

Table 2. Weather records for 1998 and 1999 growing season.

	May	June	July	August	September
Average daily max. F					
1998	62	68	73	61	61
1999	58	73	72	69	56
30 year 49–94	60	71	73	66	54
Monthly high temp					
1998	80	85	87	80	67
1999	70	91	85	87	68
Average daily min. F					
1998	36	48	51	44	39
1999	34	49	50	46	34
30 year 49–94	38	49	52	47	35
Monthly low temp					
1998	28	38	44	31	2
1999	28	35	41	33	16
Rainfall (inches)					
1998	0.63	1.30	3.38	2.68	1.40
1999	0.32	2.12	2.06	1.89	2.27

	1998	1999
Last Spring frost	18 May	29 May
First Fall Frost	28 Aug	11 Sept
Frost Free days	102	105
Thaw degree days	2626*	3383**

*Until 1st fall frost, 28 Aug 1998

**Until 1st fall frost, 11 Sept 1999

attributed to cooler and wetter weather in 1998 and the longer harvest period in 1999. Even under the vastly different growing conditions of these two seasons, there was no difference in the yield (in numbers of fruit or weight), or in the average weight of the fruit between the two mulch treatments. In both warm and cool seasons, the mulches produced the same results. Although we did not measure soil temperatures beneath the mulches, tomatoes grew as well on the red mulch as the IRT mulch treatments indicating that it did not cool soils sufficiently to cause yield reductions. For tomatoes as well as other warm season crops, we continue to recommend the use of clear polyethylene mulch for maximum soil warming to promote both earliness and higher yields. But either SRM-Red™ or IRT-100™ mulches are a good alternative where weed control beneath the mulches is necessary.

References

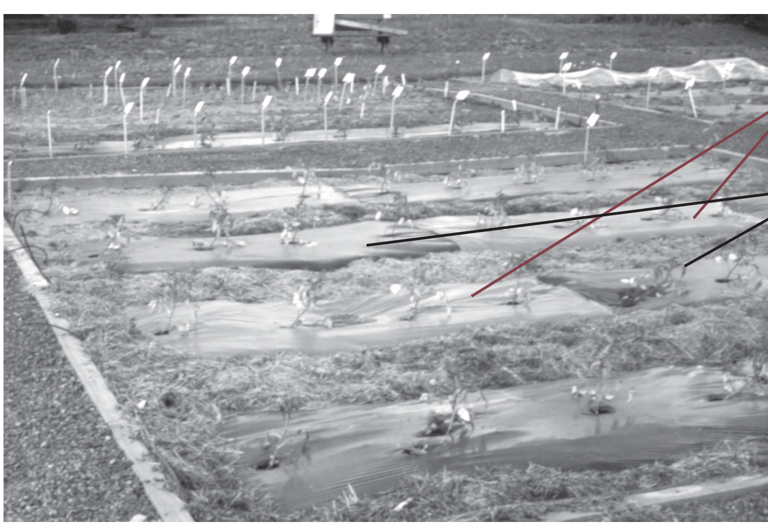
Csizinszky AA, Schuster DJ, Kring JB. 1995. Color mulches influence yield and insect pest populations in tomatoes. Jour. Amer. Soc. Hort. Sci. 120(5): 778–784.

Fortnum BA, Decoteau RR, Kasperbauer MJ. 1997. Colored mulches affect yield of fresh-market tomato infected with Meloidogyne incognita. Journal of Nematology. 29(4): 538–546.

Heacox L. 1995. The colors of designer fields. American Vegetable Grower. 43(2): 12, 16, 56.

Kasperbauer MJ, Hunt PG. 1998. Far-red light affects photosynthate allocation and yield of tomato over red mulch. Crop Science. 38(5): 1414. Abstr.

Matheke GEM, Holloway PS, Wagner PJ. 1991. IRT-76 polyethylene mulch film and growth of sweet corn in Fairbanks, Alaska. AFES Research Progress Report No. 25.



Plots were established using SRM-Red™ and IRT-100™ mulch with grass clippings in walkways. GBG file photo

Musk ox: An historical industry looks toward the future

Carol E. Lewis

John Teal had a dream—raising musk oxen and collecting their underwool (qiviut, pronounced ki'-vee-ut) to support a cottage industry in rural Alaska. Today one commercial musk ox herd and one research herd provides qiviut to maintain that dream.

Despite increasing demand for knitted products from qiviut and an emerging market for meat products, the musk ox industry in Alaska is not growing. The Alaska Science and Technology Foundation (ASTF) has provided funding for investigations of new feed rations to enhance the health and productivity of farmed musk oxen. A component of the study is to prepare a plan for revitalizing the industry. The Agricultural and Forestry Experiment Station is cooperating with the Institute of Arctic Biology, University of Alaska Fairbanks and individuals from the private sector to develop a footprint for industry growth.

Introduction

Musk oxen (*Ovibus moschatus*) are survivors from the late Pleistocene and the last glacial epoch. Fossil records indicate they have been in the arctic and subarctic for over 10,000 years ago. The Barren Ground musk ox (*Ovibus moschatus moschatus*) was most likely the subspecies found in Alaska.

photos by Perry Barboza

The musk ox population in Alaska was extirpated in the 1800s. Although the ultimate cause of this local extinction is not clear, hunting pressure may have contributed to their decline. In 1930, the U.S. Congress provided funds to ship 34 animals from Greenland to Nunivak Island off the coast of southwestern Alaska. From this first herd, 71 animals were moved north to the Seward Peninsula during 1970 and 1981. Subsequent translocations populated areas of Cape Thompson and the Arctic National Wildlife Refuge in the northern coast of Alaska. Musk oxen have since migrated further east into the northern Yukon Territories, Canada.

The Industry

An industry cannot survive without infrastructure. The animals, of course, form the backbone for the musk ox industry in Alaska. Research is a critical element particularly with a breed as little understood as the musk ox. Finally, product diversity, product processing and an aggressive marketing strategy are necessary if the industry is to succeed and grow.

The First Domestic Herd

John Teal successfully raised and bred musk oxen on his farm in Vermont. The original animals were captured in Canada in 1954 and 1955. After 10 years of work, Teal obtained funding from the W. K. Kellogg Foundation to start the Musk Ox Project.

Teal established the first herd of domestic musk oxen in Alaska. In 1964, musk oxen were captured from Nunivak Island and moved to Fairbanks. The herd was transported to Unalakleet in western Alaska in 1975. Finally, in 1986, the animals were brought to their current home in Palmer located in southcentral Alaska. There are currently 60 animals in the herd.

The Musk Ox Development Corporation (MODC) grew out of the original Musk Ox Project. It was formed in 1982 as a non-profit organization to assure the success and survival of domestic musk oxen.

Research Support

The Large Animal Research Station (LARS) was created in 1979 in Fairbanks to establish a research herd of musk oxen for the study of nutrition, physiology and animal behavior. The first 16 animals were brought to the station in 1980. The herd now numbers 70 head.

LARS is administered by the Institute of Arctic Biology at the University of Alaska Fairbanks. Research projects involve graduate and undergraduate students, research associates and faculty, and visiting scientists. It serves an educational role through its programs for K-12 students and visits by Elderhostel as a part of course on Alaska natural history. LARS also provides outreach assistance to MODC and others interested in musk ox and their products.

Products of the Industry

Qiviut Fibers and Finished Products

The historical product from musk oxen has been qiviut, the extremely fine under-hair prized for its warmth and the soft feel of garments knitted from the processed fiber. Musk oxen naturally shed their coats once a year in the spring. During this period, they are combed by hand. A mature animal will yield five to seven pounds of raw wool. Combing is only the first step in a value-added fiber industry leading to the finished product. The raw wool must be cleaned, de-haired of the coarse guard hairs, and spun into yarn. This process can take up to one year. With current technology, 500 pounds of raw material is required to begin processing.

There are no qiviut processors in Alaska. There are, however, two major companies in the state that knit only qiviut. Each serves a very different market. Oomingmak, the Musk Ox Producers' Cooperative, was formed in 1969. It is a successful craft cooperative with more than 200 Eskimo members who are knitters that work at home. Each village has a signature pattern used in the garments they create from naturally colored qiviut fibers. Qiveut Creations has been working with qiviut fiber since 1986. Both hand knitters and machine knitters apply their craft to original designs by the owner. Unlike Oomingmak, Qiveut Creations uses a multitude of colored fibers and blends wool or silk/wool with the qiviut for some of its creations.

Exotic Animal Products

There is an increasing demand for exotic meats in upscale restaurants and markets. Musk ox is no exception. One meat processor in Alaska manufactures a full line of musk ox products including jerky, a structured steak, medallions and a kippered product.

There is more than meat to a musk ox. There has been a small market for the skulls and the tanned hides. In addition, there may be a pharmaceutical market for such by-products as the blood. There is also a potential for marketing the musk ox milk as a whole product or as a manufactured product such as cheese.

The Animals

There is a demand for musk ox, and supplies are limited. Governments and breeders outside Alaska sell animals. Animals can also be obtained from zoos. Both LARS and MODC use their animals as exhibits. Visitors are allowed to tour the facilities, view the animals, and at times participate in activities involving the animals. There is increasing interest in the tourism aspect of owning a musk ox herd in Alaska, however, exhibition of animals requires licensing under the Animal Welfare Act.

The Industry Plan

Through support from the Alaska Science and Technology Foundation, a Musk Ox Task Force was formed in late December 1999. Members of the task force were selected because of their broad knowledge and experience with exotic breeds and their specific interest in musk oxen. They represent expertise in feed production and marketing; exotic animal breeding and sales;

production of exotic breeds; qiviut production, fibers, knitting, and product marketing; and meat processing and sales.

The challenge to the task force is to prepare a plan for expansion of the industry. A conservative preliminary model prepared for the ASTF shows that the industry could reasonably expand to 200 animals and realize a positive return over a period of approximately 20 years considering only fiber and qiviut garments on the revenue side.

A Musk Ox Task Force and Resource Panel Workshop was held on February 11 and 12, 2000 in Fairbanks. The theme was: "The Private Industry Must Take Control of the Industry If It is to Succeed". Resource Panel members lent their specific expertise in animal physiology, reproductive physiology, animal husbandry, veterinary medicine, feeds and nutrition, hay production, qiviut, fiber quality, and marketing.

Highlights of the discussions at the workshop were:

- Animals are not available in large numbers and there are limited sources of supply.
- Producers must understand the commitment and management responsibility necessary to succeed in any animal production enterprise.
- The demand for qiviut outstrips the supply and Alaska knitters and others are buying from Canada.
- There is a backlog of fiber processing and there is virtually no new technology being developed to handle small quantities of raw qiviut.
- There is an established market for musk ox meat, the Canadians have established market channels, and in the near future supply will not meet demand.
- It is essential that there is a support group and information network for new entrants to the musk ox industry and for those who are currently involved if the industry is to sustain and grow.

The Musk Ox Task Force prepared an outline for a plan for the industry's future and action items to promote the industry.

1. Status of the industry
   a. product demand
   b. industry interest
   c. feasibility of production
   d. limitations
   e. solutions
   f. time frame for development
2. Producers' action plan
   a. reality based awareness of the business
   b. reasonable expectations of returns
   c. realistic size of operation
   d. sufficient capital and a business plan
3. Industry advocates' action plan
   a. provide an information base
   b. anticipate questions and be prepared to answer
   c. facilitate workshops for interested persons
   d. provide opportunities to form a musk ox association for producer support (at all levels from the animal to the end product) and lobbying efforts

The first workshop will be offered during the 2000 Alaska Agricultural Symposium in November in Anchorage, Alaska. There are also plans to hold a trade show in conjunction with the workshop.

More Information about Musk ox

Websites:

Bering Land Bridge National Preserve: Musk ox on the Seward Peninsula.

http://www.nps.gov/bela/htmlmoremusk.htm

The Qiviut Homepage with links to specific companies. http://www.qiviut.com

Qiviut. http://www.higharctic.bc.ca/Fibre.html

Text:

Groves, Pamela. 1992. Musk Ox Husbandry. Inst. of Arctic Biology. Spec. Rpt. No. 5.

Acknowledgments

Thanks are due to Perry Barboza, Assistant Professor, and John Blake, Associate Professor, Institute of Arctic Biology for their support and technical help. Thanks also to Deb Segla, Administrative Assistant, and Sam Strom, undergraduate B.S. major, UAF School of Agriculture and Land Resources Management for their help during the workshop.

“Hey, I thought I saw Rudolph in the hallway!”

Maria Berger

Students were surprised to find a large, furry hoofed mammal in their midst at several Fairbanks area schools last year. Not Rudolph, but Elsa, one of 17 reindeer from UAF’s Reindeer Research Program (RRP), paid visits to several schools during 1998 and 1999. Researchers from the RRP were there with her, to present information and a slide show on reindeer biology and history.

Among the myths dispelled was that Elsa, with her well-developed antlers, is a male. Reindeer and their close relatives caribou are the only members of the deer family in which females, as well as males, have antlers. Another misconception is that reindeer use their antlers as shovels. Though the part of the antler overhanging the nose is often called the “shovel”, it is actually the front hooves, with their sharp edges and concave undersurfaces, that are used to dig through snow to obtain winter forage.

Students learned that reindeer and caribou are the northernmost members of the deer family. They discussed many adaptations of these mammals to snow and cold and how these unique features have benefitted not only the reindeer but also the humans who tend them. For example, reindeer guard hairs are made up of air-filled cells which provide tremendous insulation, allowing reindeer to remain within their “thermoneutral zone” down to temperatures as cold as –30° F. Native herders used reindeer hides to make warm and beautiful parkas to help them survive arctic and subarctic cold.

Researchers also took the slide show to the village of White Mountain, on the Seward Peninsula, and visited grades from kindergarten through twelve. Many students in Seward Peninsula communities have attended reindeer corrallings and could contribute their knowledge and experiences to discussions afterward.

Reindeer were introduced to Alaska from Siberia in the early 1890s. Alaska Eskimos had already been trading across Bering Strait, obtaining the brightly colored reindeer hides (which often have more contrasting light and dark patches than caribou) so that they could sew ornamental designs into their parkas. Whalers, and later miners had depleted many of the marine mammals and caribou herds used by Native Alaskans.

An early superintendent of schools, Reverend Sheldon Jackson, thought that introducing Inupiat Eskimos to reindeer herding would provide them with a reliable source of food and clothing, as well as transportation and employment. By the mid 1890s, Lapp herders from northern Norway were recruited to the Seward Peninsula as teachers, and herding quickly became part of the Inupiat culture.

Greg Finstad (top) and Elsa (left) have been visiting schools in the Fairbanks area.

Unique features of reindeer and caribou

- northernmost members of the deer family (*Cervidae*)
- both females and males have antlers
- even young calves have spike antlers their first summer
- thrive on a winter diet of predominately lichens, unlike any other mammal
- gregarious and nomadic, undertaking long distance migrations seasonally in large groups
- their hooves include two smaller dewclaws which act as snowshoes, helping to spread out their weight on soft ground
- superbly adapted to move about in a snowy environment

Herders put a reindeer into the chute so it can be weighed, inoculated, and released back into the herd.

Currently, there are 20,000 reindeer in Alaska, with the majority on the Seward Peninsula.

The RRP has been involved in developing and promoting the reindeer industry in Alaska since 1981. Researchers have worked closely with Native herders on many projects, including maintaining a record-keeping system for research and management, developing vaccines, improving husbandry techniques and conducting ecological research on reindeer ranges. The slide show and talk is an educational outreach program, in which researchers take science into the community, to integrate research results with Native Alaskan traditional knowledge.

With the assistance of the Reindeer Herders Association, the RRP will use feedback from these presentations to develop a curriculum unit to be taught in schools. It will include material on reindeer biology, adaptations to northern ecosystems, the history of the reindeer industry in Alaska and how it has been incorporated into the culture of Native Alaskans.

Greg Finstad and Natalie take Elsa around to meet elementary school children and teach about the unique animal called reindeer. All photos on this page are RRP file photos.

And though Elsa isn't Rudolph, she may yet have an opportunity to fly! The RRP plans to transport Elsa by aircraft from Fairbanks to Nome, so that she can be featured in this year's presentations in Nome area schools.

What next? Agenda for Alaska agriculture in the twenty-first century

William R. Wood, UA President 1960–73

Is there a future for agriculture in Alaska? Yes. Will farming in the North Country follow the historic pattern that made the prairie states of the Midwest the breadbasket of the world? No. No. No!

The population of the earth is now six billion, not one. Transportation is by air routes and highway systems not in existence before the 20th century. Water routes are time-conscious. The sail is gone. Navigation aids abound. Freight carrying capacity is enormous, yet problems for the small-scale shipper escalate.

In terms of communication the global market is one. Every place is connected almost instantly with everywhere else. Access to the global marketplace is rapidly approaching the cost effective from anyplace, even the remote, the far-flung, the isolated.

From knowing what is right and what is wrong; from knowing what works well for the common good, the best interest of the many for the long haul, and what does not — we now accept the notion of relativity. Anything is "okay" in a particular situation — if you can get away with it. This philosophical aberration must be dealt with by the Alaska farmer of the 21st century. The future of Alaska agriculture hinges upon everyday honesty, integrity, and fairness to all, by every grower, processor, and marketer who is a player in the Alaska agriculture game.

To participate effectively in global competition, Alaska agriculture must, as a whole, develop an image of highest quality in every product and service offered— the "top of the best from the top of the world". This is the opportunity available. Think about this. Take the long view—in depth.

Remember Tennyson's lines from *Lacksley Hall*, written at the end of the 19th century as mankind faced the 20th:

> "Men, my brothers, men the workers, ever reaping something new:
> That which they have done but earnest for the things that they shall do:
> For I dipt into the future, far as human eye could see,
> Saw the vision of the world, and all the wonder that would be;
> Saw the heavens fill with commerce, argosies of magic sails,
> Pilots of the purple twilight, dropping down with costly bales;
> Heard the heavens fill with shouting, and there rained a ghastly dew
> From the nations' airy navies grappling in the central blue;
> Far along the world-wide whisper of the south wind rushing warm,
> With the standards of the peoples plunging through the thunderstorm;
> Till the war drum throbbed no longer, and the battle flags were furled
> In the Parliament of Man, the Federation of the World."

William R. Wood speaks at the 1999 Ag Symposium held in Anchorage each fall.

Many of the wonders prophesied by Tennyson and many, many more have emerged and are now in place in the 20th century, the most astounding century for human achievement in world history. Yet the battle flags have not been furled, nor wars disappeared, nor do we have a Parliament of Man, a Federation of the World. We do have the United Nations, NATO, the Organization of American States, a European union of sorts, and other alliances attempting to bring peace and harmony among the diverse peoples of the world. There are notable failures at times, yet gains on some issues such as human rights and recognition of the needs of others. The issues of division, even in Alaska, are many and ancient—the gulfs to be spanned wide and deep.

But humankind, the people, all six billion of them, requires food to stay alive. Alaska's renewable resources will be a part of the solution. On the basis of the old-time family homestead, Alaska could likely sustain a resident population of one million. In the 21st century, Alaska agriculture could be called upon to meet basic food needs of five, even ten or more millions.

To do this, two principles are involved that appear antithetical: the ideal of "small is beautiful" and the practicality of "economy of scale". Witness the trend toward bigger and bigger mergers that tend to drive the family farmer and the small town merchant out of existence. Yet witness, too, the resurgent urge, fostered by the Internet and other wizardry of our communication age, to escape the congestion and frustrations of city existence by setting up the personal computer workplace in one's cabin or chateau by the lake or on a mountain side, at least in some suburban setting where the daily traffic to and from the workplace is not a hazard to be outwitted.

In Alaska, the future agriculturist may be able to participate actively in both scenarios—the "small is beautiful" and the "economy of scale". The latter likely hinges upon processing, upon human value added to the quality products grown here.

Don't overlook a fundamental fact for the future —the Alaska image bottom line for both scenarios is Quality of Product—"only in Alaska can be provided the top of the best from the top of the world"—virus free, disease resistant to the n^{th} degree, pesticide free to the highest extent possible, quality control system extraordinary. "From Alaska—THE BEST, unpolluted, uncontaminated—the freshness that lasts".

How to achieve this image is the challenge of the 21st century. It involves very strong support for advanced research and practical demonstrations at the university level. Also a no-nonsense apolitical department of state governance responsible for certified seed and plant matters including seed banks, forest nurseries, native plant preservation, plant materials laboratories, experimentation plots and demonstration plots should be created. Lastly, inspection services essential to building and preserving the NEW FRONTIER image of Alaska agriculture must be provided.

Even with top quality crops, it will be difficult to compete globally on a quantity basis. The next giant step for Alaska agriculture will likely focus on processing and packaging. The trend in human consumption is not toward the home-cooked meal straight from the garden but toward the pre-packaged meal. Think through what this implies for all Alaska farmers.

Is Alaska preparing for the change in how people are fed worldwide? The entrepreneurship in processing and packaging is quite different from that required in growing, yet the two must dovetail. Since modern day processing and packaging for global distribution requires huge quantities, in Alaska where tradition of independence of the individual grower is strong, there now looms the problem of coming together —toward some sort of consolidation or merger or cooperative conglomerate— if we are to cope with the needs of the processor/packager. The *immediate* market is the processor/packager rather than the ultimate consumer.

A breakthrough opportunity is now emerging in Anchorage, a new International Gourmet Fish Dinner project, some two hundred thousand square feet of state-of-the-art equipped processing and packaging plant space, primarily financed from overseas sources. Are Alaska growers getting ready to supply this major processing plant with the highest quality potatoes, carrots, and peas for these projected multi-million gourmet fish dinners?

The "small is beautiful" scenario has merit for some. Originality, creativity, and dedication to exceptional quality are essential. The field is open and perhaps uncharted for Alaska grown and processed food items. The talent to perform is here in abundance, yet is there the required drive toward entrepreneurship—the creative, original, even exotic, one-of-a-kind, dedicated, persistent inner effort? Is there a Silicon Valley spirit among us? To quote from Tennyson, the last line of "Ulysses",

"Are we strong in will—To strive, to seek, to find, and not to yield?"

I came from a Midwest prairie farm nearly a century ago. I have lived through the influenza epidemic of the late teens, rationing during World War I, the Great Depression, World War II as a Navy veteran, the Korean conflict, and the Vietnam debacle. I have had a minuscule part in the extraordinary challenges and changes of the 20th century, the most astonishing era of world history. Sometimes I reflect upon that farm experience:

"How small the place
Where I grew up
That once was more than big,
A vast and endless
Spread of space.

Had I stayed put
In this lone place
Would I have shrunk
As much?

Perhaps I have,
For then I seemed to me
As big as big could be,
And growing,
Ever growing.

But now the far horizon
Looms so near at hand
It compact me,
And I am small

As small as small can be—
Or somewhat smaller."

Our roots are deep in the past. The fruit we bear is our legacy for those who come after. May the harvest be a good one for them, both for the few and the many.

The youth we need for leadership, for building the newest and best, for being good neighbors, for doing whatever has to be done for the common good, will emerge among the farm boys and farm girls of Alaska. Their Alaska is not the Last Frontier, but the New Frontier. Believe in them.

Agriculture in Alaska, the New Frontier, has a great and exciting future; the potential and the promise are strong. The twenty-first century will mark the success of growing, harvesting and marketing of renewable resources in the great North Country. This I believe and actively advocate. We must dream and dare and do. Together, with God's quiet help, we can do whatever needs to be done. We are Alaskans!

Dr. Wood looks back to his mother to whom he wrote a bit of verse in tribute a quarter century ago. The then Secretary of Agriculture, when visiting the University of Alaska campus, saw it and had a framed copy displayed in his office.

PRAIRIE MOTHER: ELIZABETH RANSOM WOOD

by William Ransom Wood

She was old, my Mother –
One hundred three,
Seven months and nine days.
Quite old. And quite delightful.

Prairie Mother,
Strong and vibrant
As the undulating wheat
Deep rooted, shoulder high
Dancing with the wind,
Kissed by the sun,
Laughing with the white-puffed clouds
Drifting idly across the endless blue,
In love with work and life —
Elizabeth Ransom Wood.

"Go ahead, son,
You can do it.
You can do it better.
When farm boys are no more,
Who will build the cities?
Who will make the laws?
Who will teach the fools and wise ones?
Who will grow the crops?"

"In your sinews,
The iron strength of
Native soil.
Honor your heritage;
The way and the light will change,
Or seem to change. Hold fast."

"When the task ahead
Is really tough to handle,
Don't look to others
To tote the load;
Look to yourself.
You can do it,
Now!"

The drab, the ugly, nor the dull
She did not see;
Only the joy of doing,
Only the beauty
Yet to be.

An historical perspective of the Delta Ag Project

Jay Hammond, Governor of Alaska 1974-82
a summary of his 1999 Ag Symposium speech

I appreciate the opportunity to discuss agricultural issues and how they related to the past, present and future of Alaska. When I was in office, I tried to make a distinction between healthy growth and malignant growth. Healthy growth is environmentally sound and pays its own way.

I resisted any sort of subsidization of enterprise in the state but I felt that if we are going to subsidize anything I would prefer it to be in the renewable resource realm. The prime issues there were timber, fish and agriculture. As a consequence we embarked on a program which, over the years, people have suggested was the biggest blunder of the Hammond administration, the Delta Agriculture Project. I accepted that until I learned a few facts regarding that particular issue.

About 95 percent of the food stuffs are imported into the state of Alaska. We were not at all agriculturally self sufficient. It seemed to me that some sort of program to enhance and advance agriculture was appropriate. As a result the Agriculture Action Committee was formed. They came to the conclusion that the Delta area had the potential to produce a massive amount of grain, particularly barley, and that with a foreign market this might lead to a renewable industry and more products here in Alaska.

The Agriculture Action Committee proposed several components, like links in a chain. Each link must be in place before there was any potential. Those links individually were such things as having 50,000 acres to produce the barley, people to farm the lands, transportation to get the grain to market, a holding facility to store it, and the Asian market with people willing to buy it. All of these things were slowly put into place.

The main problem was we failed to complete it during my administration. Another $3 million was needed for the grain storage facility in Seward. The Agriculture Action Committee felt it was only viable to use the railroad but the new administration did not complete the grain terminal. The City of Valdez offered to build the terminal at no cost to the state so the legislature was persuaded that this would save the state money and they put a halt to the project.

Meanwhile we had obtained commitments from the marketplace for virtually every bushel of grain that could be grown. When you put all these things together it gives a different picture than that provided in the media. I remember going to Delta one time to meet with people from the prairie provinces of Canada. They were astonished by the potential production per acre. They said they would have given anything to promote an agriculture project such as this. The more I looked into it the more enthusiastic I became. At least it was worth a gamble.

One of the things that causes me to think this was not the "Biggest Blunder" occurred when I went to Edmonton awhile ago. There was a group of meteorologists who met to talk about global warming. Their conclusions were that the average temperature in the U.S. would rise about five degrees over the next 50 years. That would increase temperatures in the northern climates by 15 degrees. They said that whole ecosystems would move north and that what were the current grain belts would shift northward. They had maps showing the belt buckle of the future grain belt virtually over Delta. Unfortunately curve balls came out of the woodwork such as grasshoppers, bison, drought, and other problems that made Delta look less viable.

One of the criteria I gave the Agriculture Action Committee was that they had to demonstrate that it would be capable of sustaining itself and paying itself off. I certainly wish we had forged every link in the chain. Then if it had fallen under its own weight I would be willing to accept that it was perhaps not the most prudent thing to do. Unfortunately, a number of projects went down in a domino effect. The Point McKenzie Dairy Project was supposed to have the grain via the railroad to supply the animals. All that came crashing down simply because the state didn't spend that additional 3 million dollars to erect the grain terminal. The materials were already purchased so it could easily have been completed.

I have talked to University people who said it could have been successful. I am heartened by those whose farming efforts have allowed them to succeed and I applaud you for your tenacity and efforts. I think you have helped to lift the perception of the Big Blunder on the part of my administration. Five years ago I encountered a group of Russians and USDA folks. They had just been out to Delta and were impressed by it. They could not understand why we had not completed it. When Governor Cowper went to the Far East to sell coal, he found out that they were only interested in the Delta grain. The Koreans even offered to take over the whole area and do it themselves.

Where do we go from here? Certainly we will never be able to put together the kind of project that requires huge amounts of expenditures, loans, and commitments from the state. As you well know agriculture has an intimate relationship with the University. As the university flourishes the potential for agriculture does as well. So funding is an issue.

The people told the legislature to keep their cotton picking fingers off our dividend. If there was some way to distinguish between earnings of the permanent fund not required for dividends and not used to meet the formula that has been in place since the inception, that might be used. Approximately 500 million dollars could have been used this year. The advocates of the Yes vote wanted $800 million—$300 million directly out of dividends—but the public expressed loudly and clearly that they didn't want any change in the way it is calculated. That doesn't mean there aren't earnings in the permanent fund that could still be used to fund state programs. If they had mentioned that in the ballot proposition and put a percentage on the amount, I certainly would not have opposed it. One of my main objections to the ballot proposition was that it imposed that $300 million dividend tax on Alaskans. Everyone paid exactly the same — the welfare mothers, the babies, the kids, the millionaire.

Somehow the next effort has to be how to pay for programs, and certainly we have to get the university programs that relate to agriculture on a sounder financial track. To balance budgets you must do one of two things—increase your means or cut your expenses. The legislature has been caught in a vise in recent years feeling they have no recourse but to reduce the budget. They can only cut— cut until the pain threshold is such that the public says enough and they are willing to consider revenue enhancing. The legislature has a message before it now, "Don't use a nickel of the dividend earnings." In my view that is not what the public meant. They were concerned about dividend dollars, not those dollars required to fully fund dividends as has been done in the past. This has to be made clear to the public because of promises made by the Governor and some legislators. We must be allowed to cast a more informed vote.

We also have to broaden our revenue base to foster what I call "uneconomic development." Unfortunately, the mandate over the years has been that we have to do the things to create more jobs for Alaskans. Those jobs are not paying the state sufficiently to offset the cost of the people that come seeking these jobs. We're going backward. It is the best formula for going broke there is.

Now we have roughly a $500 million fiscal gap. So to get on track we must either cut government spending by $500 million or generate more revenue. The most painful way would be to extract it from everyone's dividend. On the other hand, the public has to realize that we have to get an appropriate amount of revenue back through taxes or user fees if we are going to sustain programs. I think agriculture will be one of those that will be adversely affected if we do not mend our ways and bridge the fiscal gap appropriately. There are some relatively painless ways to get there from here.

I come from a commercial fishing area where millions and millions of dollars escape in non-resident pockets, 65 percent of pay goes outside the state and they have paid virtually nothing to the state. Those are the sources of revenue that should be tapped first along with the 27,000 transient workers and thousands of tourists. We may have to reduce dividends but I would much rather have the politicians say, "We're going to have your dividend float ever upward and onward but in order to create new programs, we are going to have to take a buck or two back in the form of user fees or taxes." The people need to perceive that they are paying for it. That is the best thing you can do to prevent runaway government growth. I think it is important for the future that the state get back on sound fiscal ground.

What's A Grower To Do?

Robert Thom, owner Budget Feed and Farm

American society is woven on a multicultural loom. Opportunities are not reserved to any particular race or social group, but are available to anyone who is willing to embrace challenge and work with others toward a common goal.

Perhaps the biggest challenge facing the industry right now, in part because it affects just about everybody's wallet, is retail consolidation. Fewer grocery store chains mean fewer buyers. Those buyers want to deal with big suppliers who can guarantee year-round product, and that means fewer suppliers. While the industry keeps growing in sales volume, the number of independent marketers of produce is shrinking.

Growers will need to get bigger too, not necessarily by expanding their own operations, but by teaming up and forming alliances. You don't have to become huge to sell to the big guys.

Growers also need to keep their eyes open to developing new markets. They're going to have to change and reinvest in new technologies and new ways of doing business. A grower who says "I'm just going to sit back and continue operating in the same way my father did," will find business increasingly tough. Just like in the days of the railroads, adapting to change will shape the winners and losers in our industry.

There are two levels of accountability in life: one without and one within. On the outside all people play by the same rules. We have laws to abide by, taxes to pay, regulations to follow, and a strong government to make sure we comply. But the world within is policed only by our own sense of morality. What is acceptable in the public realm often falls short of what we require of ourselves. For a business owner this discrepancy can impact the bottom line. Why? Because meeting personal standards is often more expensive than settling for what the bare minimum requires. Success in business is important, but not as important as our ideals.

1999 Alaska Women in Agriculture

Ms. Patricia Fellman, her husband Pete, and their seven children have served the agricultural community and the dairy industry with distinction for thirteen years.

Ms. Fellman spent six years clearing land, picking sticks, constructing farm buildings and a home prior to the last seven years of milking cows, feeding calves, and producing feed for their Dairyaire Farm. She has provided her children with home schooling, participated in Cub Scouts and Boy Scouts, church activities and family food production. She has demonstrated true community and farming spirit by assisting neighbors and sharing her experiences and farming knowledge with neighbors in the Delta Junction farm community.

Ms. Fellman has supported and assisted Pete's off-farm jobs and political activities that benefit Alaska's agriculture and all the citizens of the state.

Marsha Melton has served Alaska's agriculture with distinction for 42 years as homesteader, dairy operator, beef producer and supporter of farm activities in the Matanuska Valley.

Ms. Melton and her husband, Len, have operated enterprises in Palmer, the Moose Creek area and Chirikof Island. She has had a strong and clear voice in the Farmers Newsletter, as Co-Chair of the Agricultural Symposium, and as a member of the Board of Advisors for the School of Agriculture and Land Resources Management.

Ms. Melton has served her community as General Manager of the Alaska State Fair for 13 years, served with distinction on the Palmer City Council and the Greater Palmer Chamber of Commerce Board of Directors, and is currently President-Elect of the Palmer Kiwanis.

Dean Fredric Husby, SALRM, presented the 1999 Alaska Women in Agriculture awards to Patricia Fellman, left, and Marsha Melton, above, during the Ag symposium.

Notes

Agriculture Appreciation Day in Palmer

Agriculture Appreciation Day will be August 5, 2000 at the Matanuska Experiment Farm in Palmer. The annual event showcases agriculture in Alaska and is sponsored by the Agricultural and Forestry Experiment Station and the Alaska Cooperative Extension, along with a number of local agriculture-related organizations.

There will be farm tours, displays, games and music, and a free barbecue. Contact (907) 746-9450 for more information.

Despite rainy weather, upwards of a thousand people attended last year's event.

SALRM Turns Twenty-five

The School of Agriculture and Land Resources Management at UAF reached the 25-year mark in 2000. The school was formed in 1975 when the former College of Biological Sciences and Renewable Resources was dissolved. Over the years the focus of the school has consistently been to give students a broad perspective in natural resources management. SALRM includes four departments: forest sciences; geography; plant, animal and soil sciences; and geography, and offers degree programs in natural resources management, and geography.

ARS returns to Alaska to study grasshoppers

The USDA Agricultural Research Service is renewing its presence at UAF with the initiation of a research project investigating the ecology and management of grasshoppers in Alaska. Grasshoppers devastated crops in the Delta Junction region during outbreaks in the late 1980s and early 90s. Although populations have moderated since then, outbreaks are likely in the future given the potentially explosive population dynamics of pest species of grasshoppers.

Welcome, Dennis Fielding, ARS researcher.

Entomologist Dennis Fielding and Biological Technician Linda DeFoliart will be investigating the basic biology and ecology of grasshoppers with the objective of predicting outbreaks and devising environmentally sound methods of preventing and suppressing outbreaks in the subarctic region. Although the pest species of grasshoppers in Alaska occur widely over North America, the short growing season here requires special adaptations on the part of the grasshoppers to successfully complete development.

The subarctic environment provides a unique opportunity to study their life history at the extreme end of their range, which may provide insights into their biology and control throughout North America.

Linda DeFoliart at work in the lab

Current SALRM graduate students and thesis topics

Ph.D. candidates:

XiaoYan Dai– Bioavailability and characterization of soil organic matter in tundra soils
Dorte Dissing– Landscape influence on lightning strike distributions in Interior Alaska
Greg Finstad– Nutritional ecology of reindeer on the Seward Peninsula, Alaska
Dave Maddux– Constructed wetlands in subarctic latitudes
Jason Vogel– Soil carbon dynamics in black spruce ecosystems
Martin Wilmking– The treeline ecotone in Interior Alaska: history, site conditions, and reaction to global change

Masters of Science candidates:

Doug Adkins– Turfgrass management in Alaska
Robin Andrews– A mineral soil survey of interior Alaska in relation to plant and animal nutrition
Judith Chapmin– Administrative law, planning theory and environmental mediation, technical writing and specific policy issues related to RS2477
Karen Clyde– Prediction of early winter distribution and density using landsat thematic mapper in the White River First Nation traditional territory, Yukon, Canada
Vera Elpatyevskaya– Dynamics of organic matter decomposition in broad-leaved/fir forests in the Russian Far East
Julienne Fogde– Combination of landsat & SAR satellite imagery to delineate *Salix alaxensisi* in Interior Alaska
Heather Goldman– Estimating growing season length in Alaska with AVHRR satellite data
Andrea Hansen– Detection of exotic species along RS 2477 rights of way
Jamie Hollingsworth– Early height growth of white spruce in Interior Alaska
Natalie Howard– Forage management for dairy nutrition
Matt MacAnder– Fire scars in boreal forest
Sarah McClellan– Plant nutrient availability from garden soil amendments in Interior Alaska
Nicholas Popovich, Jr.– Vegetative analysis and environmental assessment of control method options in existing GVEA substations, Interior Alaska
Jeff Roach– Hazard perception in outdoor recreation participants
Vaughn Salisbury– *Ips* beetle dispersion from spruce slash piles
John Stinson– Marketing Alaska-grown feed: Market perceptions
Julie Svetlik– Evaluating Creamers' Field education programs
Susan Vogt– Growth and yield characteristics of mixed stands in the Tanana Valley, Alaska
Kerry Walsh– Foraging pattern of the hoary marmot, *Marmota caligata*, in the White Mountains, Alaska
Brenda Wilmore– Duff moisture dynamics in black spruce/feather moss sites in Interior Alaska and their relation to forest fire danger rating system
Aaron Woods– Fire scars in tundra
Harold Zald– Landscape ecology and recruitment history in treeline dynamics

So you want to be a graduate student?

Student recruiter, Barb Pierson says there are some things to keep in mind as you start your journey into graduate school:

- Take your GREs as soon as possible.
- Explore our web pages to make sure the School of Agriculture and Land Resources Management is where you want to be, http://www.lter.alaska.edu/salrm.
- Make contact with a faculty member in the area of research you are interested in. If you are not sure which faculty member to contact, try e-mailing a department head and asking. John Yarie, jyarie@lter.uaf.edu, is department head for Forest Sciences and Steve Sparrow, ffsds@uaf.edu, is department head for the Plant, Animal, and Soil Sciences. Either one can answer questions about Natural Resources Management.
- Contact the Graduate School through their internet pages, http://www.uaf.edu/gradsch. You can also register online.

SALRM Student News

New — Tindall Scholarship

Dick Tindall was employed by the Bureau of Land Management in Idaho, Oregon and Alaska. He retired from the Bureau several years ago and remained active in the Society of American Foresters. The Tindall Scholarship was established by donations from memorial contributions, and Society of American Foresters' contributions that combine to allow an annual $500 scholarship to be awarded. This scholarship is awarded to a full-time undergraduate or graduate student who is registered in natural resources management with a forestry option and at least 60 credits toward a bachelors degree.

The first recipient of the Richard W. Tindall Scholarship was **Joshua Buzby**. Josh graduated from Eielson High School and is a resident of Salcha, Alaska. He graduated this spring with his Bachelors' Degree in Natural Resources Management, Forestry Option. He has a summer job on Fort Wainwright doing Land Condition Trend Analysis and hopes to get a permanent position in some aspect of forest management. Good job, Josh!

Keep an eye out for future new scholarship opportunities for students in the Natural Resources Management — Forestry Option.

Joshua Buzby intends to use his education in Alaska.

Senior Thesis (NRM 405)

Every graduating senior in the School of Agriculture and Land Resources Management must have completed a senior thesis. This is a two semester class. The first semester students formulate their plan, identify a committee, and start their research. The second semester they finish their research, write a paper and do an oral presentation of their results.

In the fall 1999 semester, **Anna Atchison** finished her senior thesis entitled "Analysis of the SALRM/AFES Strategic Planning Survey." This spring there were four students who completed their senior theses. Students and their topics are:

Marcus Bingham– Soil compaction, carbon content and O-horizon thickness along the Stampede Pass Trail,

John Wooters– Germination requirements and optimal transplant age for five Alaska wildflowers,

Amy Davis– Potato yield and quality as influenced by cultivar, harvest date and vine killing, and

Marylou Richard– Fairbanks' stabilized biosludge as a safe and effective growth medium for vegetables.

Marylou found her senior thesis topic led her directly to a job. She started with the Department of Environmental Conservation in May and attributes her successful job search to her senior thesis.

1999 and 2000 Neiland Award recipients

The Neiland Award is given for academic excellence in Natural Resources Management. The student must have a minimum GPA of 3.5. The final decision is then made by a vote from all the faculty in SALRM.

The 1999 recipient of the Neiland Award was **Marylou Richard**. This year the award went to **Jennifer Arseneau**.

Congratulations to both Jennifer and Marylou.

Jennifer Arseneau, overwhelmingly the choice of our faculty in 2000 to receive the Neiland Award.

Senior thesis complete, Marylou Richard is packaging up the samples to send to the Palmer Soils Lab for analysis.

Faculty News

Dr. Glenn Juday has been in the news this past year. His research on tree-rings and climate has been featured in the television program "Earth in the Hot Seat", on A&E Television Network, and in a newspaper article entitled "A Rapid Increase of Temperature in the Arctic" by Yasuyoshi Tanaka of the Tokyo newspaper *Mainichi* (Everyday).

Glenn served as organizer, speaker, session chair, and/or workshop leader of the North American Forest Ecology Workshop, the International Arctic Science Committee Workshop, and the 1999 Society of American Foresters National Convention. He co-authored the keynote address in the Plenary Session for the 50th anniversary meeting of the Arctic Science Conference.

Dr. Jenifer McBeath was presented the UAF Employee Award on College Town Day last year. The citation read " The University of Alaska Fairbanks recognizes Jenifer McBeath for her outstanding contributions to the Fairbanks Community in making our campus and the community a true partnership".

Dr. Elena Sparrow was awarded almost $1 million by the National Science Foundation for a grant to support global environmental change research by Alaska K–12 students and teachers. Teachers will receive training in the Global Learning and Observations to Benefit the Environment (GLOBE) program, current best practices in science education, and the integration of local/traditional knowledge with environmental studies. From students' investigations in the local ecosystems, understanding and learning will be extended to the global environment.

Welcome a new faculty member

Dr. Roseann Leiner has joined the faculty of the School of Agriculture and Land Resources Management at the UAF Palmer Research Center. She is an Assistant Professor of Horticulture/Horticulture Extension Specialist. Roseann will conduct applied research in support of the commercial vegetable crop and potato industry in Alaska.

In 1981, Roseann came to the Matanuska Valley of Alaska after receiving a B.S. in plant science from Cornell University. She worked as a lab technician in horticulture and in 1991, completed a M.S. in natural resources management from UAF. Dr. Leiner continued her schooling at Cornell University where she earned her Ph.D. in plant pathology in 1999.

Dr. Roseann Leiner joins the research faculty in Palmer.

The Forest Soils Laboratory recently purchased a state-of-the-art mass spectrometer from PDZ Europa. The new instrument will be used for ecosystem and global change studies associated with the Long Term Ecological Research program, and will also be available for use by students on a limited basis. The Forest Soils Lab will be able to analyze isotopes of various elements on solid, liquid and gas samples with the mass spectrometer. Processing standards, to establish internal controls on accuracy and precision for the machine, took place this spring. Processing samples for ^{15}N analysis is now underway. Funding for the mass spectrometer was provided in the 1998 federal budget by Senator Ted Stevens' office.

Lola Oliver and Dean Husby stand next to the newly installed mass spec.

UNIVERSITY OF ALASKA
FAIRBANKS