CHAPTER 11

ALASKA'S RANGELANDS

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PREFACE

Rangeland is a very extensive resource in Alaska. It has attracted attention for many years, and occasionally the calculated potential for animal production has stimulated proponents to describe these ranges less cautiously than prudence would dictate. For example, Grosvenor (55) clearly overstated the range potentials for reindeer when he wrote in 1903:

> The reindeer enterprise is no longer an experiment, although still in its infancy. There are 400,000 square miles of barren tundra in Alaska where no horse, cow, sheep, or goat can find pasture; but everywhere on this vast expanse of frozen land the reindeer can find the long, fibrous, white moss which is his food. There is plenty of room for 10,000,000 of these hardy animals. The time is coming when Alaska will have great ranches like the great cattle ranches of the Southwest, and they will be no less profitable.

I believe such errors arise from being misinformed rather than from an intent to misrepresent facts. Resource specialists who have enthusiasm for Alaska are obliged to convey as many facts as available in order to accurately represent those resources. To understand rangelands and their use and management requires knowledge of soil/plant/animal relationships that include ecological, nutritional, and physiological processes. Glib treatments might be acceptable in favorable climates where margin for error is relatively wide; but in extreme environments, such as in Alaska, the demands for accuracy increase. Consequently, I feel compelled to present in this chapter as much as possible of available information pertinent to Alaska's rangelands, because potential ranchers will come from the ranks of those unfamiliar with the ranges, those unfamiliar with range livestock operations, or both. Historical and technical information have been presented and/or referenced to give a perspective that will help society with political decisions and help individuals match their resourcefulness to the task of producing livestock for Alaska's growing population. Where biological constraints were found or had been suggested, I have recognized them. Social and economic constraints have been mentioned but not detailed, because those should be properly addressed elsewhere.

Reading this chapter in its entirety is unnecessary, if one is interested in only certain portions of the state and specific animal species. Headings are given, and topics within each range region are addressed in a parallel fashion. Students and technical specialists are urged to examine original sources for greater depth of understanding than is possible with this treatment. Areas that need further research should also be apparent. Perhaps this report will help in ranking topics of study so that future efforts can be systematically addressed, although the pathway to discovery needs to wander a bit to allow for really significant findings.

Finally, readers ought to note that the favorable aspects of Alaska's rangelands include good supplies of water, rapid and lush growth of forage plants, and plant communities that are most often in their ecological prime. Undoubtedly, the biological components for producing range livestock and the need for those animals exists in Alaska. Putting those pieces together into economically and biologically acceptable systems is certainly a worthwhile goal.

ALASKA'S RANGELANDS

Rangelands are probably the most common land resource in the world. Williams *et al.* (163) estimated that they constituted 47 percent of the earth's land area. Many of the U.S. ranges are the leftover lands that were unsuited to forest production, cropland agriculture, or some more highly valued use. Cropland and industrial developments have not relegated much of Alaska's rangeland to leftover status. There are administrative, regulatory, and ownership categorizations which may preclude grazing on some Alaska lands, but the biological potentials for grazing have not been destroyed.

The range livestock industry is important to our society because it converts plant materials that are largely unsuited for human consumption into animal products that are very important to human health and well-being. In many instances, these range plant materials in Alaska go unused each year, even by wildlife. The real worth of the industry lies in its ability to perform this conversion at minimal economic and technological costs to society.

Rangelands, by definition, include those natural plant communities which are used by domestic livestock as well as wildlife (123). Consequently, all of Alaska except areas barren of vegetation are technically rangeland. However, as with many natural resources, ranges vary in quality from place to place; furthermore, human values change over time, making rangeland more or less important depending upon the immediate conditions.

When addressing Alaska's rangeland resources, the effects of cold temperatures on soil/plant/animal systems have utmost importance because they govern the rates of the various energy and nutrient exchanges and cycles. Those processes profoundly affect the efficiency of the range livestock industry. Long winters of varying degrees in harshness must be considered by those contemplating range livestock operations. However, some rangelands in Alaska are suitable for yearlong grazing by domestic cattle and sheep. There are also rangelands that can be grazed yearlong by bison, yak, musk ox, reindeer, etc., but that are often seasonally inappropriate for grazing ordinary livestock. Understanding those facts is necessary to more fully appreciate the scope of Alaska's rangeland resources. To hastily dismiss either domestic animal and short-season grazing or exotic livestock and yearlong ranges would be seriously short-sighted. Ungulate wildlife, migratory waterfowl, and predator species, which may be uncommon on other U.S. rangelands, are very important aspects of Alaska's ranges. Their mention here is to note competition and conflicts between them and range livestock, which should not be interpreted as a lack of appreciation for those species.

The belief that knowledge of Alaska's rangelands is relatively scarce is accurate in comparison with the amount of information that is often available for other areas of North America. It is also true that a great amount of information has been derived for Alaska's rangelands and their use, but it is largely unavailable to the public and scattered among a variety of sources. This review is aimed at bringing those topics together with a

This scene by John Webber, member of one of Captain James Cook's voyages, depicts a late 1770s view of "Bolcheretzkoi in Kamtschatka." Cattle clearly had a prominent place in the life style of this settlement. Subsequently, Siberians brought cattle from Kamchatka to Kodiak.
Anchorage Historical and Fine Arts Museum.

focus on common domestic grazing animals and semidomestic creatures such as reindeer, musk ox, and undomesticated bison, which have been commercially managed elsewhere. Moose have been captured and used for beasts of burden in Alaska, and they represent a ruminant that can convert shrub forage into red meat. This discussion will not address moose, however.

ALASKA'S RANGE LIVESTOCK

Cattle

Cattle were introduced to Alaska from Petropavlovsk-Kamchatskiy, Siberia by the Russian-American Fur Company in 1794, when two cows and a bull were brought to Kodiak (45). Cattle have been kept continuously on that island for nearly 200 years. Apparently, the Russians had a strong desire for beef, milk, and dairy products, which caused them to import at least one pair of cattle to each of their Alaska posts. Elliott (42) described these cattle as small, about the size of Shetland ponies. The livestock were ranged during the summer and sheltered in winter. During the grazing season, the cattle were rounded up each night to guard against persistent predation by brown bear.

Villages along Cook Inlet, including Linda, also known as Laida (near Anchor Point); Ninilchik; Kasilof; Chernila (across the river from Kenai); Kenai; Kustatni (now Kustatan); Tyonek; and Knik proved to be the best agricultural sites for the Russians. Cattle, poultry, and swine were kept by these Siberians in part or all of the villages. Originally, these people were the aged and infirmed employees of the Russian American Fur Company who had spent their lives in service away from their homeland. Because they had married Natives or half-breed women, their family ties were strongest in America. Therefore, by "Supreme Command" (45), on April 2, 1835, the fur company gave them land, tools, seed, and livestock to allow them a dignified retirement. The Crown required that all their produce be purchased. Elliott (42) described these farmers and their descendants as being "very very" poor in the 1880s. Nevertheless, it was their livestock as well as some recent U.S. introductions which were found in Alaska when the U.S. Department of Agriculture (USDA) first investigated the agricultural potential of Alaska in 1897-98 (61, 62).

Sheep

There was a rather short but significant attempt to develop a strain of sheep better suited to Alaska's range conditions than what was ordinarily available. The USDA Biological Survey Experiment Station in Fairbanks commenced the work in 1929 using wild sheep from McKinley (Denali) National Park. The original purpose was to "seek domestication of the mountain sheep as a grazing and farm animal, for production of an admittedly superior meat and to experiment in crossing with the domestic sheep for a hardy Alaska strain" (109).

Lincoln-Cotswold and Rambouillt stock were crossed with the wild Dall sheep. Three hybrid lambs were produced in 1933 and four in 1934. The project was showing promising results in 1934: hybrids were immune to insect problems that affected domestic breeds; body size was considered good; hair-wool coats seemed adequate; and the animals were hardy and easy to handle. No explanations were offered for why the project suddenly terminated. It is possible that this experiment, like others at the time, was lost because of funding restrictions. It is certain that the biological potentials were promising and merited further study in order to develop an improved range sheep breed for Alaska.

Gasser (49) reviewed Alaska's livestock history and reported several introductions of sheep into the territory. According to his account, the sheep introductions began in 1853 when 500 head were released at Dutch Harbor. That and subsequent introductions were from non-Russian sources. Apparently, sheep were not a part of the early Russian agriculture in Alaska. Generally, sheep have been raised most successfully on southwestern marine grasslands where forage is available almost yearlong, large predators are absent, and winters are relatively mild. These biologically favorable conditions resulted in good meat production and premium quality wool.

Some sheep raising has occurred in the Matanuska Valley and near Fairbanks, but those operations have been small, as have those on the Kenai Peninsula. Sheep were brought to Fairbanks and the Matanuska Valley with the development of gold mining during the early 1900s. Ranges on the mountain slopes of the Matanuska Valley provided abundant summer forage. Tidal flats on upper Cook Inlet were used for hay production and late season grazing.

Relative to horses and cattle, sheep require a higher level of nutrition and satisfy those needs by selectively grazing plant species and plant parts. Mid-grasses and grass-forb and some alpine communities are probably more desirable for sheep than are tall-grass ranges, which may contain little variety of plants and grow rapidly beyond the sheep's reach. However, sheep have been grazed on tall-grass ranges on the Kenai Peninsula, and when ranges were stocked heavily enough, sheep were able to keep the forage grazed.

Range sheep production in Alaska is not a questionable use of native forage. Biologically, the animals can be produced on Alaska's marine grassland ranges and other ranges. Factors other than range and biology have limited sheep ranching in Alaska.

Horses

Horses are not an ordinary source of red meat in western cultures. They were used in Alaska extensively for transportation and construction work during the early part of this century. Currently, pleasure horses dominate the Alaska horse scene. Icelandic ponies were recommended for reindeer herding by Porsild [117] more than 50 years ago and were recently introduced to the Kotzebue area to serve the reindeer herders' needs for transportation. These animals have survived on tundra ranges for at least one winter (W.B. Collins, personal communication). It is likely that these animals will require some mineral, energy, and protein supplementation during lean seasons of the year. The amounts of supplementation will vary with degrees of weather and work related stresses placed on the animals.

Horse raising for meat has been practiced in northern Russia [12]. Apparently, the horse is capable of surviving year-around on ranges that prove inhospitable during winter for cattle and sheep. Bailey [12] recognized a potential for horse production on boreal ranges in Canada. The biological potential exists in Alaska, too, but sociological constraints may currently preclude the practice.

Reindeer

Reindeer were introduced into Alaska from Siberia as a humanitarian gesture designed to alleviate suffering of the Eskimo whose marine and terrestrial food and clothing sources had been reduced. Heavy sea mammal predation from outside commercial interests had depleted the marine mammals [48].

Two theories explaining declines in caribou numbers have been debated. One is that populations were reduced because firearms were introduced and hunting skills increased. Another suggests natural cycling of populations independent of human activity. There are evidences supporting both. The important point is, if natural cycling occurs in caribou, the same factors may also affect reindeer and need to be accounted for in current management plans. Caribou predation and range deterioration from fire and overgrazing are factors usually assigned to such declines. Lent [81] and Leopold and Darling [82] noticed the declines coincided with the coming of European influences to the region. The caribou depopulation that occurred in the late 1800s persisted in northwestern Alaska until the early 1940s. During that period, 1,280 reindeer were introduced, and their numbers increased to more than 600,000 and subsequently declined to less than 25,000. Much of the reindeer industry was concentrated along the western and northwestern portions of the mainland.

Alaska's reindeer history merits special treatment. No other animal production activity has been as extensive in land use as reindeer herding, and no local range livestock enterprise has yielded for Alaskans as much red meat. Each reindeer enterprise has been entirely based on the forage resources of the ranges without support from either stored forages or grains. The reindeer is naturally adapted to tundra and certain boreal zone ranges. On the mainland, reindeer require prime condition lichen ranges during winter. The species also lives very well on marine grassland ranges of the Aleutian Islands, requiring no lichens for winter grazing where little snow cover occurs to limit access to other suitable forage plants. Thus, the reindeer, as a species, is capable of effectively converting rangeland forages into animal products without man's intervention. Continuously realizing benefits from that process requires not only human ingenuity, but knowledge and management of the animals and their ranges. Without judicious management and concern for both reindeer and their rangelands, the plant/animal system could, at best, support the hunter-gatherer culture of an earlier time.

Musk ox

Musk ox were returned to Alaska in 1930, following their extinction with the coming of white men and firearms to the territory. The original intent was twofold: (1) To conserve a species threatened by extinction, and (2) to investigate possibilities of domestication and breeding musk oxen to make greater economic use of Alaska's vast forage resource [113]. Several factors intervened, and it was almost 50 years before musk ox range work began. A venture at musk ox farming as a means of converting tundra range forage into animal products with captive musk ox commenced seriously in 1976 when the musk ox herd, which had been maintained near Fairbanks for several years, was moved to Unalakleet. Extreme overstocking of the musk ox farm ranges at 0.3 to 0.5 ha/musk ox substantially deteriorated the forage supply and produced serious internal parasite and other animal health problems in the winter of 1982-83. This grazing rate was 14 to 28 times that for the best reported native ranges for musk ox in Canada [143]. Forage for winter feed was imported annually to the Unalakleet farm to sustain the herd during winter, a practice antithetical to the farm's apparent goal of a self-sustaining livestock operation based on natural range resources.

Musk ox are known to coexist with caribou on tundra and tundra-boreal transition ranges in Canada. This coexistence of wild populations does not normally involve competition, according to Vincent and Gunn [151]. As indigenous inhabitants of these ranges, the species is well-adapted to yearlong grazing and reproduction in the absence of human intervention. Winter feeding ought not to be a major consideration, as it is

A musk ox tramps across tussock cottongrass range on the musk ox farm near Unalakleet, Sept. 20, 1978.

with cattle and sheep in the boreal zone. Musk ox cannot tolerate deep winter snows, however.

Musk ox farming in Alaska has shown that the species can be maintained on fenced pastures and ranges, and that under current systems it must be managed for harvest of its qiviut crop. Even though musk ox farming appears biologically sound, costs of fencing ranges relative to their carrying capacities may prove unfeasibly high. Hence, the effectiveness of open ranging musk ox and devising some form of either supplemental feeding or herding to periodically capture animals for harvest needs investigation.

Bison

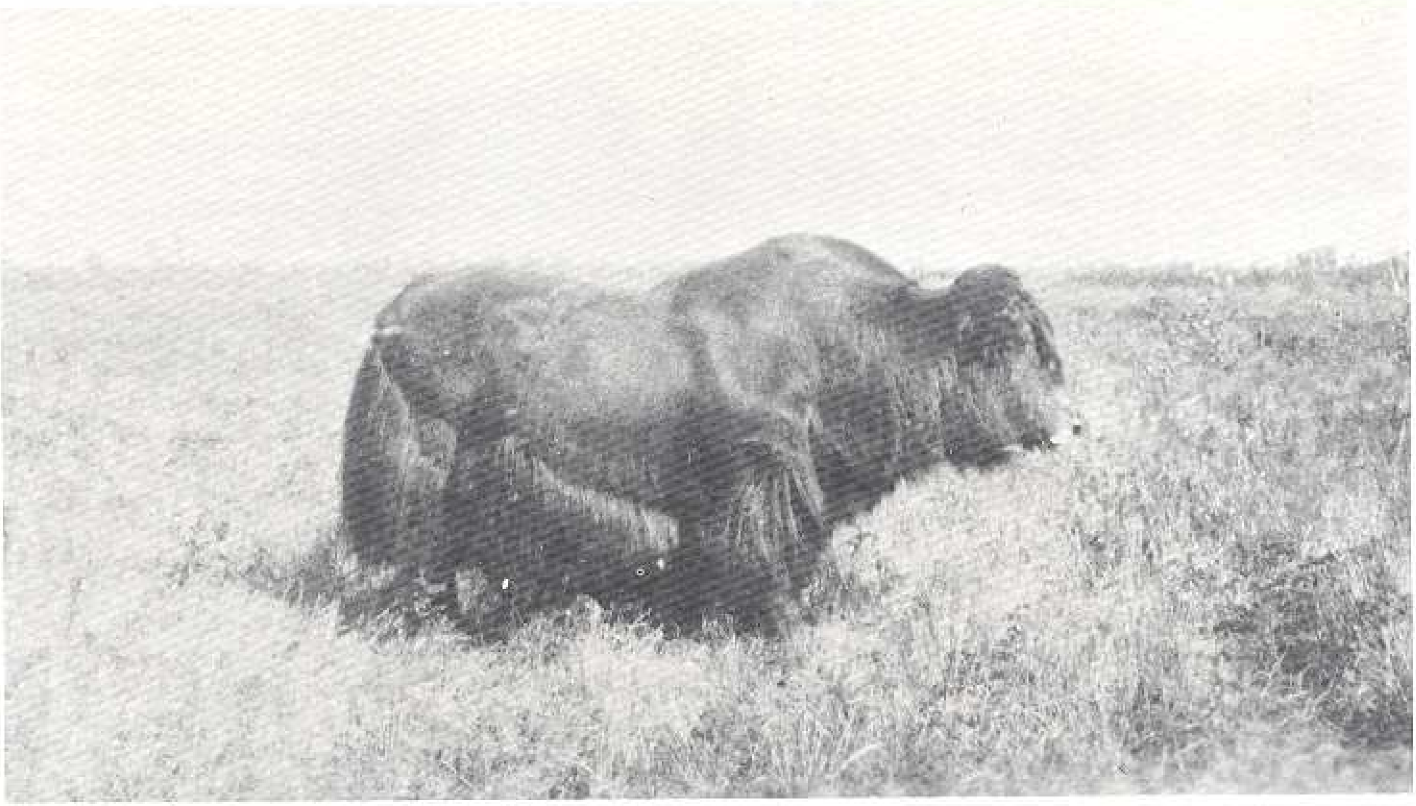
Bison were introduced to Alaska by the USDA Bureau of Biological Survey in 1928. Herds have since roamed freely. Only limited attempts to capture and cultivate animals from these herds have occurred, as with the musk ox. There have been bison conflicts with cropland agriculture in the Delta Junction area, and those conflicts centered on range needs by the wild herd (89).

In addition to providing the state with an interesting big game animal, the introduction and subsequent persistence of bison for 55 years on native ranges have amply demonstrated that this class of animal, in addition to reindeer and musk ox, can survive year-around and reproduce well on certain of Alaska's rangelands. Therefore, bison represent a range animal capable of converting local range forages into useful animal products with minimal, if any, demand on hay and grain for winter provisions. Ecological disturbances that prevent climax tree and shrub dominance and favor subclimax herbaceous forages are central to maintaining sizable bison populations in Alaska's boreal zone. Stream erosion and flooding and wildfires are the most common natural disturbances now favoring Alaska's bison herds (89, 27). Cultural developments, including road and pipeline construction and agricultural and military clearings, are prominent factors currently generating range conditions that are beneficial for Alaska bison.

Evidence from comparisons among cattle, sheep, and bison on short-grass ranges indicated bison are able to extract more nutrients from poor quality feed than cattle (114). Thus, bison are probably more capable of utilizing Alaska's range forages during seasons when feeds are low in quality than are domestic cattle.

Yak

Alaska may be the only state in the United States that ever experimented with the yak as a range animal. The species is apparently well-adapted to high elevation



This adult yak on the Alaska Agricultural Experiment Station farm near Fairbanks was photographed between 1919 and 1930. Alaska Railroad Collection, Anchorage Historical and Fine Arts Museum.

ranges of Asia and tolerates harsh weather. Early agricultural specialists in Alaska became interested in testing the yak's ability to harvest Alaska's range forages. The history of these experiments is rather short and promising, even though it terminated abruptly.

Animals were donated by the Canadian National Park Service in 1919 (51) to develop a hardy hybrid tolerant of Alaska's interior weather. Obtaining offspring was difficult due to sterility until 1924. More breeding stock was introduced in 1923. By 1928, there were nine yak-Galloway hybrids at the Fairbanks station. By 1930, 17 yak-Galloway hybrids had been born, although not all survived to adulthood. In August 1930, seven full-blooded yaks and seven hybrids were placed on open range near Healy, Alaska. Animal condition was noticeably improved after 60 days on that range (7). The published account unexplainably ends after indicating the herd of six yaks and seven hybrids wintered west of the Nenana River on the north slope of the Alaska Range. One animal died from poisonous plants, according to the account.

The Great Depression was occurring at that time; and the Federal government turned the Alaska experiment stations over to the University of Alaska on June 30, 1932. It is most likely that economic conditions curtailed the yak grazing trials.

The animals were apparently easy to handle and yielded palatable meat. If they were able to range yearlong among *Calamagrostis* (bluejoint reedgrass); *Eriophorum* (Cottongrass); and the *Festuca* (fescue) types, as stated in the experiment station's annual reports, that would indicate the species and hybrids might fill the same niche as bison. Hybrids were observed to feed in the open year-around, and accepted browse more readily than cattle (4). In terms of management, the yak may be more easily handled than bison. Sufficient evidence indicates that yak might be a suitable range animal for Alaska. Male sterility of hybrids and the death of one animal due to poisonous plants were the only negative aspects revealed in the literature.

RANGE VERSUS PASTURE

It is important to distinguish rangelands from pasture lands. Rangelands are maintained mainly by governing use to take advantage of natural environmental factors, thereby minimizing cultural manipulations. Pasture lands are agricultural croplands used for livestock grazing. They are often part of crop rotation systems and receive fertilization, weed control, tillage, seeding, and /or other cultural manipulations. There are an array of examples between these two extremes in grazing resources, but the fine distinctions are left to other treatments of the subject.

FOUR RANGE ZONES OF ALASKA

Alaska's rangelands occur in four major zones: (1) coastal forests; (2) boreal forests; (3) arctic tundra; and (4) maritime grasslands. To some degree, livestock have been grazed in all four zones. Historical accounts of some of those ventures are quite interesting; they reveal the determination of fur companies, miners, and pioneering farmers as they conquered obstacles of terrain and climate to convert forage into useful animal products. Readers interested in such accounts are referred to several sources: Porsild (117); Miller (95); Elliott (41); Luick (84); Stern *et al.* (138); Scotter (132).

COASTAL FOREST ZONE

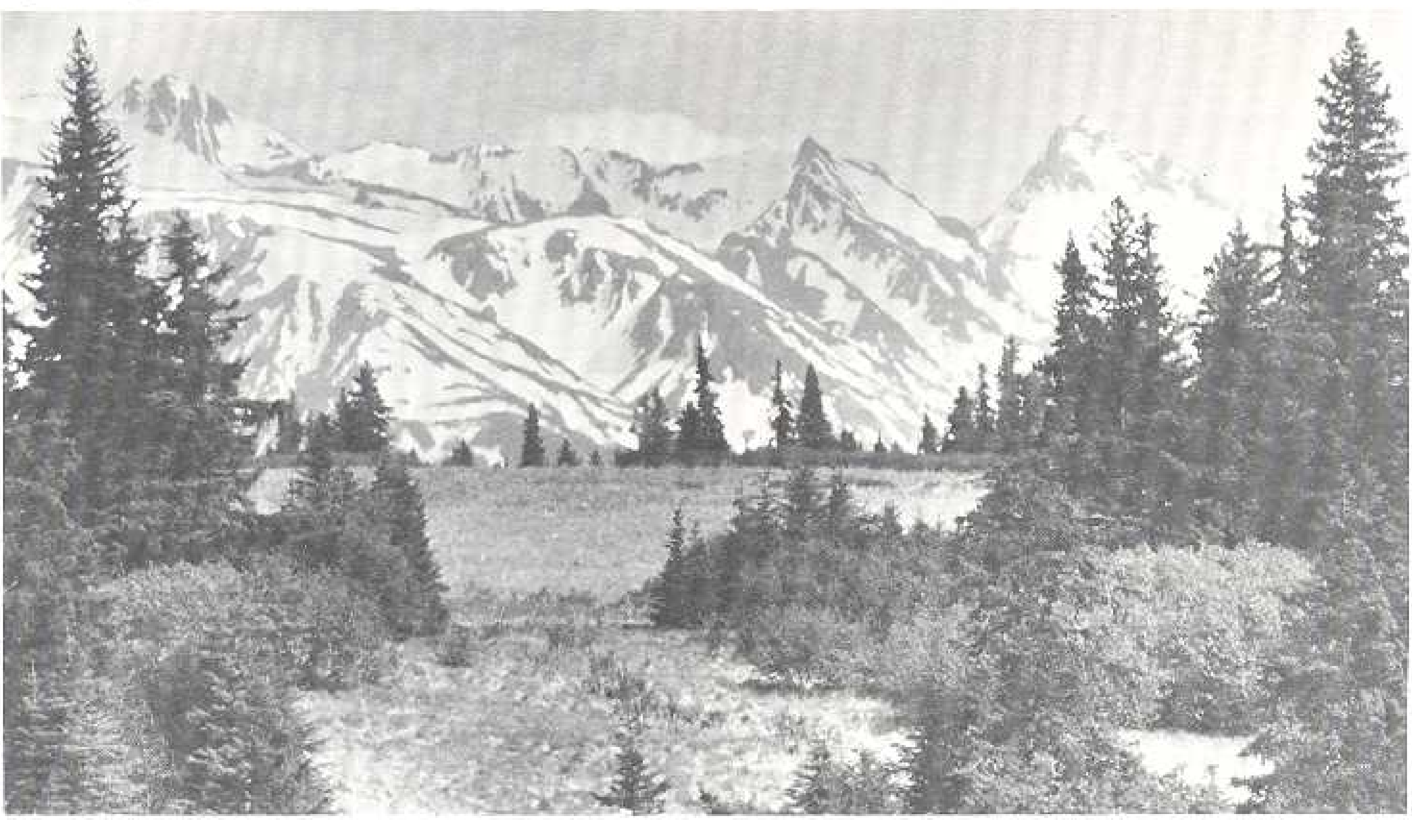
Geographical Extent

This zone extends from the southeastern panhandle region along the coast to include the lower and eastern Kenai Peninsula, the west side of Cook Inlet from west of Tyonek to Afognak Island, and much of Kodiak Island. It is usually characterized by heavy forest growth. The dominant vegetation type is needleleaf forest. Occurrences of several open range types (i.e., *Elymus*, fresh sedge marsh, fresh grass marsh, halophytic sedge marsh, bluejoint herb, bluejoint meadow, and bluejoint mixed herb) (150), give the region a justifiable reputation for capacity to produce grass.

Topography, Climate, and Soils

Topography is rugged owing to numerous mountains and valleys that extend landward from the ocean. Valleys are glacial in origin, and the presence of glaciers contributes significantly to barrenness, as do the rocky mountaintops. As this zone merges with the boreal and marine grassland zones, the rugged topography is sometimes modified, and timber stands thin, which results in formation of some of Alaska's prime cattle and sheep ranges on the Kenai Peninsula and Kodiak Island.

Soils are acidic, often contain high levels of organic matter, and are capped with thick mulch. Those of the northern portion are heavily influenced by volcanism; those of the southeastern are often shallow, rocky, and indurated and formed on glacial debris. Low temperatures limit nutrient cycling. Phosphorus absorbing, fixing, and releasing capacities of the volcanic ash affected soils have been noted (96, 97), and may be an important



This lower Kenai Peninsula scene shows openings in the coastal forest that produce abundant summer forage.

factor to consider when either continuously grazing or harvesting forage stands in this portion of the coastal forest ranges.

Climate is moist and cool. Temperature extremes are modified by the Japanese current, which is the overpowering environmental factor that favors this northernmost extension of the Pacific Northwest's coastal forests.

Vegetation

Dominant vegetation trees include *Picea sitchensis* (Sitka spruce); *Tsuga heterophylla* and *T. mertensiana* (Western and mountain hemlock); *Chamaecyparis nookatensis* (Alaska-cedar); and *Thuja plicata* (Western redcedar), which is confined to lower panhandle forests. Timber in this zone exceeds all other Alaska forests in rate of growth and lumber quality. Wildfire is not a common feature affecting vegetation in this zone. Open alpine vegetation occurs above timberline and provides range for Sitka blacktail deer and mountain goats. At the heads of bays and mouths of streams where forest growth is absent, coastal grass and sedge meadows occur. Several of these communities, their associated soils, and plant successional relationships have been described. Some have been noted for their value for cattle and horse grazing (58), primarily because they are available late in the season. The dominant native herbivore in the southeastern regions is Sitka blacktailed deer. Moose occur in the northern portions and in large valleys that reach inland. However, deep snows limit herbivores in this panhandle region. No native herbivore population had a significant grazing impact on the herbaceous vegetation in open meadows and grasslands before livestock were introduced.

Grazing Uses

In the early part of this century, several dairy farming ventures were established using coastal meadows for both summer grazing and winter forage production in southeastern Alaska. By 1929, these ranges fed the cattle that dominated Alaska's first dairying industry (6). Important range forage plants include: *Elymus mollis* (dunegrass); *Carex lyngbyei* (Lyngby sedge); *Deschampsia caespitose* (hairgrass); and *Calamagrostis canadensis*.

Old growth forest ranges, which are prime deer habitat (153), are largely unsuited to domestic livestock in this zone due to relatively low understory production of palatable plants. Tree removal can, for a few years, result in impressive herbaceous and shrubby vegetation of sufficient quantity and quality for domestic livestock grazing. However, such disturbances were insignificant prior to commencement of logging which followed acquisition of Alaska by the United States. Landslides and stream and marine erosion were perhaps the only disturbances that discouraged forest dominance.

Grazing Seasons

Distinct seasonal availabilities of forage resource are

Mature coastal forests of the southeastern Alaska panhandle region have an understory of shrubs and forbs that provide forage for the indigenous deer population.

major limitations to any livestock enterprise in this zone (Fig. 1). Tall grasses and forbs that dominate the meadows do not cure on the stem. Hence, following senescence, the nutritional quality of the tall-grass range's forage plants is too poor to sustain ruminant animals. Moist weather usually prevents hay curing when forage is in its prime for harvest; thus, either ensiling or importing feed to carry animals through winter months remain the rancher's choices in many locations.

In 1898, when the Alaska Agricultural Experiment Station was established, accounts from stock owners in the panhandle indicated that grazing was possible from May 1 to November 1 (62). This was the first grazing season data reported for Alaska, although Russian colonists recognized the situation much earlier. Recent studies further north on the lower Kenai Peninsula at Homer indicated a grazing season from mid-June to mid-September (64) for upper benches and, perhaps, one to several months more than that for coastal elevations. In some years lack of snow cover allows longer grazing on the ranges. Subsequent data from the Homer study (unpublished) indicated that cattle failed to gain weight after the tall-grass began turning brown during late August to mid-September.

Second growth forests of southeastern Alaska develop dense canopies that prevent forage production on the forest floor for many years.

Mid-grass stands of *Alopecuris alpinus* (mountain foxtail); *Poa* spp. (blue-grasses); *Phleum alpinum* (alpine timothy); and *Festuca altaica* (fescue) seemed to be preferred by cattle late in the season, suggesting that those grasses might retain their nutritive quality longer than the tall-grass bluejoint ranges. That was also noted in observations of sheep grazing on Kodiak (135). Data for the tall-grass, bluejoint reedgrass, show this species has low digestibility and copper contents in leaves on regrowth late in the season. Perhaps that is why stock fail to grow on it and prefer other forages as the growing season wanes.

Early reports for Kodiak Island indicated that a long grazing season existed, and undoubtedly the presence of lush grass stands and mild winters suggested that year-around grazing was possible. Depending on that proved unwise for the Alaska Agricultural Experiment Station. After 10 years experience with livestock in Alaska, C.C. Georgeson (50) warned would-be stockmen on Kodiak: "Some winters are so mild that stock can browse a large part of the time, but this is not to be counted on and provisions must be made for enough winter feed to carry the herd from November to the middle of May." Death losses due to impaction have occurred in cattle that fed on dead tall-grass ranges during early spring months (136). The forage yields so little energy in such a state that the animals' rumens are unable to function.

In 1929, W.T. White surveyed grazing regions of Kodiak Island and presented a map showing areas suited to summer and summer-winter range use. Acreages were only generally estimated, and no carrying capacities or stocking rates were given (6). White was particularly cognizant of the need for winter feed and protection for livestock. He reported locations of tree stands that would give stock shelter in winter and Lyngby sedge and dunegrass stands that were then known to be the best available sources of ensilage among all native plant communities for this zone.

Range Carrying Capacities

Range carrying capacities were later estimated for types occurring on the northeastern portion of Kodiak Island (68, 125). These are apparently the only estimates available for this coastal forest zone. Reported capacities ranged between 0.4 and 18.1 acres per AUM. (AUM = animal unit month and is equivalent to the feed requirement of a mature cow nursing a calf, approximately 800 pounds of dry forage.) According to these two reports,

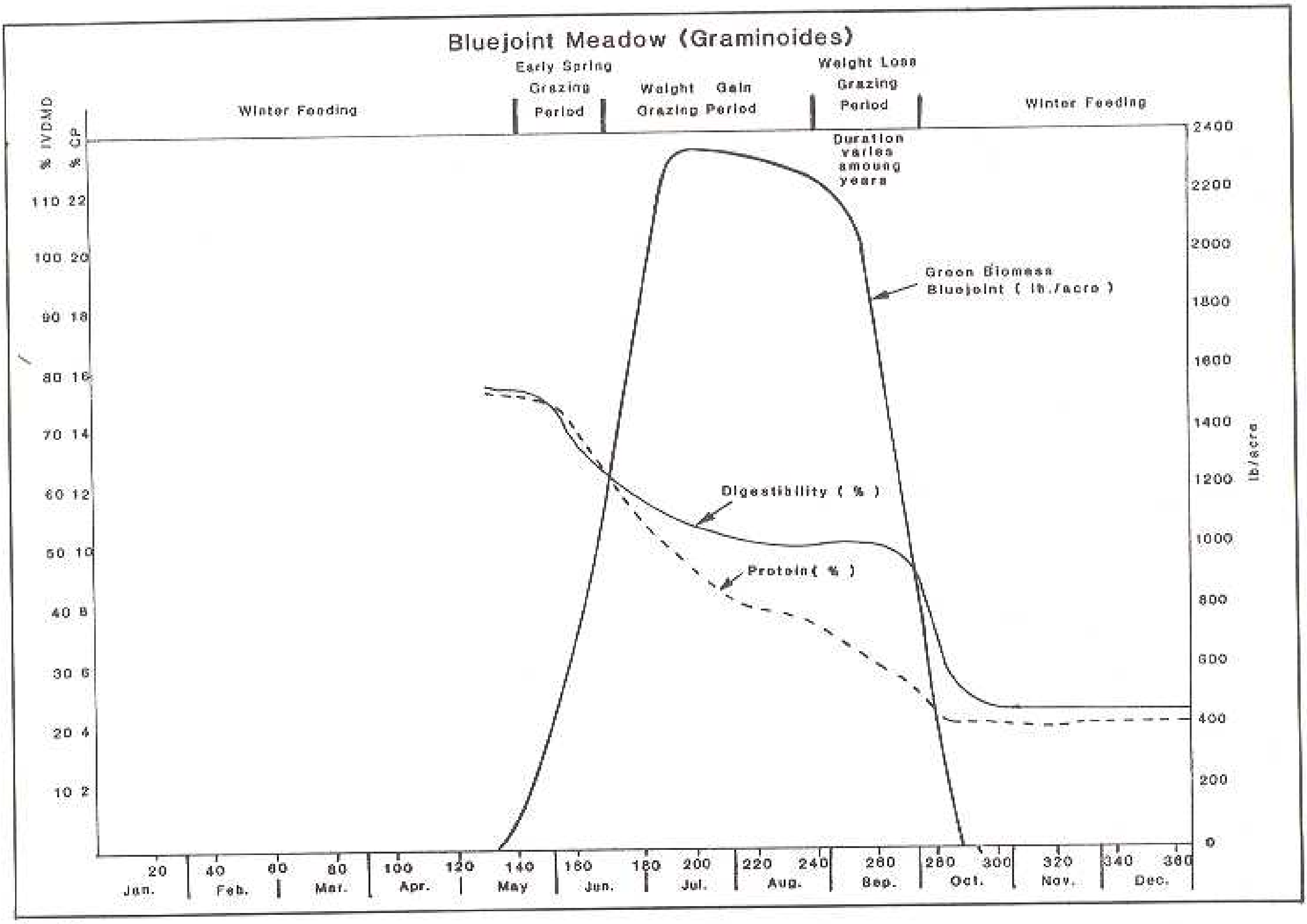


Figure 1
This graph shows the rapid annual growth and senescence of bluejoint reedgrass on Alaska's boreal and coastal forest rangelands. Crude protein and digestibility levels depict the brief seasonality of forage quality. Cattle gain weight on these ranges for about one quarter of the year. During the remaining three quarters, stockmen must provide supplements and/or other feed sources to maintain their animals.

In this May 7 photograph of Kodiak Island rangeland near Narrow Cape, spring forage is not yet available, but residue of the past year's grass growth evidences the area's productivity.

the leased Kodiak ranges on the northeastern section of the island produced 45,000-49,000 AUMs. At that time, the Bureau of Land Management (BLM) was responsible for all leasing under provisions of the Alaska Grazing Act of March 4, 1927. The agency used 60 percent of the estimated grazing capacity to calculate stocking levels for the leases and considered available winter forage rather than summer grazing resources as the leasing base (68). According to a five-year BLM range plan prepared for Alaska in 1961-62, the best range types varied from 0.6 to 10 acres per AUM, and there was a major need to research range carrying capacities, range conditions, and trends and competition between wildlife and livestock, because extrapolating data from elsewhere was considered inappropriate.

Limitations

Determining carrying capacities and stocking rates is yet a critical need for proper use and management of tall-grass ranges in Alaska. Dickson (38) observed that extreme overgrazing on parts of Kodiak Island and in the Juneau vicinity resulted in removal of tall grasses and forbs, and invasion by low-growing *Poa annua* (annual bluegrass) and *Hordeum jubatum* (wild barley) occurred. *Poa* is a palatable forage plant, but *Hordeum* is unpalatable and considered to be a weed on ranges. Moderate overgrazing resulted in tall grasses being replaced by *Elymus* (ryegrass); coarse bunches of *Poa* (bluegrass); and *Agrostis* (red top). Use factors (139) for bluejoint stands are difficult to apply because of spot grazing.

Spot grazing results when animals repeatedly graze the same plants in a range unit and avoid all others. Tall grasses tend to grow rapidly and fail in quality at maturity and are especially prone to this problem. Grazing patterns become fixed on these tall grass types, and heavy overuse of the grazed patches results unless something is done to alter those patterns. Two management methods that may overcome the problems are either fencing to confine animals to a small enough area, which forces uniform use before stock are permitted to move to new ground, or herding to prevent continued reuse of favored areas. The effects of those practices on livestock gains are untested.

Another technique with merit from a biological viewpoint is to burn the ungrazed, standing dead grass in early spring just before the new growth emerges. That will cause the previously ungrazed patches to become palatable to livestock and invite their use during the subsequent growing season. Burning tall-grass ranges is a common practice in the True Prairie vegetation type of the Great Plains. It was practiced on Kodiak Island to reduce death losses from impaction when the Agricultural Experiment Station had a field station at Kalsin Bay

Cattle grazing patterns persist on a moderately stocked pasture (one yearling per 1.9 acres of grassland type range). In one fenced range unit, the five levels of use depicted in the following sequence of photographs were evident at the end of the fifth grazing season. The remaining forage in each site (first through fifth photograph, respectively), was 0-50, 500-800, 1,000-1,500, 1,800-2,200 and 2,500-3,800 pounds per acre. (The boy's height is 53 inches.)

[136]. Later experiments modeled after those in Kansas indicated that burning increased the grass stand [6].

Nutritional deficiencies in the forages of the coastal forest zone include seasonal and plant specific shortages of protein, digestible energy, and some minerals. Vrooman *et al.* [152] suggested that the occasional birth of blind calves indicated vitamins A and D, calcium, and phosphorus deficiencies. Excessive bleeding of dehorned and castrated animals is a common occurrence on the lower Kenai Peninsula, which indicates possible dietary mineral deficiencies.

Seasonal examinations of bluejoint show that the crude protein and calculated metabolizable energy levels in uncut forage declines sharply with plant development [4, 92]. Hays cut from native stands on the lower Kenai Peninsula in 1977 were limited more often in digestible energy than in crude protein [87]. Unpublished data for various range plants in this region show that grasses and sedges are usually poor sources of calcium and phosphorus.

On upland ranges near Homer, the dominant forage plant is bluejoint reedgrass. Often associated with, but subordinate to that species is *Equisetum arvense* [meadow horsetail], which contains as much as 10 times the calcium concentration and twice the phosphorus concentration of the grass. Another common forb in this area that contains appreciable phosphorus and calcium levels is *Sanguisorba stipulata* [Sitka burnet]. These forbs are often selectively grazed by cattle, and probably contribute greatly to balancing the dietary requirements for calcium, phosphorus, and others minerals as well as protein for livestock.

Low and marginal copper contents in native forages have been noted in data from this region, especially on the lower Kenai National Moose Range (47). It is worth noting that molybdenum aggravates copper deficiencies; hence, high levels of molybdenum that occur in some portions of the state, notably the southern panhandle and the upper Kenai Peninsula (33), are suspect areas for copper deficiency problems.

Hanson (58) indicated that hazards of the coastal marshes restricted their use by livestock. Problems of cattle becoming bogged down in holes, periodic flooding and marooning of livestock, and heavy mosquito populations during some months were specifically noted. Although not mentioned, the presence of arrow grass and potential poisonings of animals in these areas should be noted.

Livestock poisoning occurs occasionally on upland ranges. Sheep deaths on Kodiak due to poisoning occurred in 1920 (51). Eleven of the poisonous range plants listed for Alaska occur in this zone (Table 1). *Lupinus nootkatensis* (Nootka Lupine) is a problem for livestock and has been associated with calf deformities on Kodiak. *Equisetum fluviatile* (swamp horsetail) is a serious threat to horses, mainly during winter months (73), and *Cicuta douglasii* (poison hemlock) is a danger to all livestock and unwary humans. Unfortunately, poison hemlock can be confused with *Angelica lucida* (angelica). Angelica is a very nutritious range plant that is highly digestible and selectively eaten by livestock on these ranges. *Veratrum viride* (false hellebore) is a common poisonous range plant of these ranges. It is very digestible and rich in protein, potassium, and phosphorus. Cattle have been observed eating this plant with no apparent ill effects (35).

Several cattle have died on the Homer Research Center's lower bench pastures since the station was opened in the mid-1970s. Postmortem examinations indicated typical bracken fern poisoning; however, western bracken fern *(Pteridium aquilinum)* occurs in Alaska only in the southernmost portion of the panhandle; therefore, some other species must have caused those deaths at Homer. The plant responsible needs to be identified because it poses a serious problem to grazing on the wet meadows of the lower Kenai Peninsula.

Reports of death losses from other poisonous plants on these ranges are unknown. Usually, animal deaths from these problems result when livestock are short of feed and forced to eat normally undesirable forages. Since most of these ranges are currently understocked, the risk of feed shortages would be of most consequence either early in the growing season or when feed was seasonally limited.

The most common shrub limiting range use is probably alder. All four species of alder *(Alnus* sp.) that occur in Alaska are found in portions of the coastal forest zone (149). *Alnus crispa* (American green alder) is present in the coastal forest ranges of the upper Kenai Peninsula. *Alnus sinuata* (Sitka alder) is found throughout the coastal forest ranges. *Alnus rubra* (red alder) is confined to the panhandle region; and *Alnus*

Table 1
Listing of Poisonous Range Plants (71) and Their Zones of Occurrence and Habitats (63) of Alaska.

Scientific Name	Common Name	Zones of Occurrence[1] CF	B	AT	MG	Habitat
Aconitum delphinifolium	monkshood	X	X	X	X	Meadows to rocky slopes
Andromeda polifolia (36)	bog rosemary	X	X	X		Bogs, swamps, meadows
Cicuta douglasii	poison hemlock	X	X			Marshes
Cicuta mackenzieana	poison hemlock	X	X	X	X	Marshes
Delphinum brachycentrum	larkspur		X	X		Meadows to rocky slopes
Delphinium glaucum	larkspur	X	X		X	Wet meadows
Equisetum fluviatile	swamp horsetail	X	X	X	X	Marshes
Lupinus arcticus	arctic lupine		X	X		Dry and damp slopes
Lupinus nootkatensis	nootka lupine	X	X		X	Dry slopes and stream sides
Pteridium aquilinum	bracken fern	X				Dry open and woods
Triglochin maritima	arrow grass	X	X	X	X	Meadows and brackish marshes
Triglochin palustris	arrow grass	X	X	X	X	Wet sites and brackish marshes
Veratrum viride	false hellebore	X	X		X	Meadows and wet places
Zigadenus elegans	death camas		X	X		Open woods and grassy slopes

[1]CF = coastal forest; B = boreal forest; AT = arctic tundra; MG = marine grassland.

tenuifolia [thinleaf alder] occurs on the Kenai Peninsula, the west side of Cook Inlet, and the northern panhandle region.

These species are nitrogen-fixing shrubs that invade disturbed areas and develop thickets which impede human and livestock travel as well as reduce forage production through competition. These thickets also provide good cover for bear, which prey on livestock. Generally, exposed mineral soils are most susceptible to alder invasion as evidenced by stand formation along roadcuts, on landslides, and other places where mineral soil and gravel debris have been uncovered. The role of alder in formation and fertility enhancement of soils is undoubtedly important to this ecosystem. The extent to which those effects positively affect range forage has not been quantified.

BOREAL FOREST ZONE

Geographical Extent

This zone extends north and west from the coastal forests and is the most extensive of Alaska's forests. It is the northernmost forest in Alaska and was considered by Griggs (54) as a Hudsonian forest. Viereck and Little (149) distinguish between the coastal forests, those characterized by *Picea sitchensis* (Sitka spruce) and interior forests, those characterized by *Picea glauca* (white spruce).

Topography, Climate, and Soils

Topography is varied from rugged mountains in the Alaska Range to broad, flat valleys that are, in places, often poorly drained. Glaciation, volcanism, and stream erosion have all contributed to the varied landscape.

Climate grades from a near coastal maritime zone that is modified by the Japanese current and Bering Sea to an extreme continental zone of the interior. Boreal zone precipitation is less than that of the coastal forests. Maximum high and low temperatures for the state are recorded in this zone. Because it receives sufficient moisture to produce a sizable woody biomass and experiences seasonally dry periods that are broken by thunder storms, this is a naturally fire-prone ecosystem.

Soils are typically cold and contain permafrost over most of this zone. Organic litter accumulation insulates these soils, which aggravates the permafrost condition. Mosses often dominate the understory, producing a spongy mass that decomposes slowly and retains water. These conditions often create wetlands, even on steeply sloping sites. Much of the interior region is poorly drained bogs or muskegs. This preponderance of wetness provides abundant breeding sites for mosquitoes, makes cross-country travel difficult when unfrozen, and reduces forage and timber growth. Prevalence of these conditions means that mesic and well-drained sites, which have utility for wildlife and livestock grazing, commercial agriculture, and construction, are of prime value.

Vegetation

In this zone, the vegetation types are quite varied, ranging from closed needleleaf types through mix forests, deciduous forests, and scrub types. In some locations, timber production is sufficient for harvests, but yields are not comparable to those of the coastal zone.

In Canada, the boreal zone was distinguished from the boreal forest-tundra transition and labeled forest barren (12). Original use of the word "taiga" (meaning land of little sticks) was for the transition zone between tundra and boreal forest (23). Unfortunately, the word is now applied generally to the boreal zone forests. I have chosen to simply include the transition within the boreal zone; thus, wherever spruce trees occur, it is part of the boreal zone.

The boreal forests occupy an array of environmental settings varying from those permafrost-free areas of southcentral and southwestern Alaska that merge with the coastal forest and marine tundra zones to the woodlands and savannah-like taiga to the north that are underlain by permafrost.

Throughout this zone, the largest tree specimens denote high site productivity and occur along stream edges (103). A.E. Porsild (117) noted similar conditions for spruce forests near the Dease Arm of the Great Bear Lake of Canada. This heavy growth can be seen along the Susitna and Little Susitna Rivers north of Cook Inlet. There, large cottonwood and spruce along streams overtop the adjacent forests, which suggests benefits from improved drainage. In drier climates, such patterns in vegetation result from favorable moisture along streams. In Alaska, Neiland and Viereck (103) credited frequent flooding and associated nutrient additions, as well as disturbances from floods that prevented moss and mulch layer developments, as factors responsible for high productivity along streams. In the interior, the streamside prominence of trees is readily apparent when viewed from above. Often, white spruce columns line the edges of streams, while black spruce and/or scrub occupy the swampy areas between streams.

Van Cleve, Viereck, and Schlentner (148) reported annual above-ground biomass production in streamside alder to range between 2,580 pounds/acre and 3,800 pounds/acre. The implications of these productivities are important to this discussion because they indicate

This view of boreal forest types includes mixed forest, shrub, and wetlands. Range forage production varies among the types, most of which are dominated by woody species. Following fires, forage yields may increase, while tree and shrub competition is lessened.

potentials for range forage yields, in the event that woody plants are excluded. In the case of alder, the production levels are partially attributed to its nitrogen fixing capabilities.

To the western and northern extremes of this zone, the vegetation pattern that is associated with streams is further expressed with white spruce along drainages and either shrub or herbaceous vegetation occurring between streams. In the adjacent arctic tundra zone, willow and alder shrubs line the streams, and lower-growing types occupy inter-channel lands. This pattern suggests differential productivity relative to drainage, soil temperature, and winter snow cover.

Well-drained areas between streams are also more productive for tree and forage plants than adjacent poorly drained areas. Effects of fire on these communities have superimposed another set of vegetation patterns comprised of an array of seral types of varying species compositions, which were determined by severity and age of the burn and availability of tree seeds during recovery.

Boreal zone climax forests do not produce as much shrub and herbaceous range forage as do certain seral stands. In terms of caribou and reindeer range, it is the climax forest in the transition between the boreal and tundra zones that yields the important winter lichen ranges (82, 83). Dense, even-aged seral stands of trees resulting from fires eventually produce a closed canopy and exclude understory forbs and grasses. Lutz (86) described several typical tree communities as they developed following disturbances. Those descriptions were written with emphasis on the tree components, but they contain information on understory plants of importance to range use. Descriptions of soil, plant, and animal responses to fires illustrate the dominance of woody plants in this zone and also show how forage production can occur as a subordinant component of the boreal ecosystem.

It is possible to find disclimax (100) communities of herbaceous vegetation in this zone that resulted from repeated and frequent burning, which eliminates seed production of trees for sufficient time to almost preclude their reinvasion. Lutz (86) estimated that 100 to 200 years might pass before forests could reinvade such bluejoint reedgrass stands. That estimate has not been validated, but those grass stands develop heavy mulch and vigorous growth, which definitely retard tree seedling establishment until some factor reduces competition and provides a mineral soil seedbed.

Subalpine meadows of the boreal forest zone yield abundant forb-grass forage that, in many locations, remains ungrazed due to the absence of grazers. Mid slopes in the distance are being grazed by a few cattle in this 1975 view of the Little Susitna Valley.

Vegetation types that are most useful for livestock range include various bluejoint and other species of reedgrasses as they occur alone or mixed with forbs; fescue types, including *Festuca altaica* and *F. rubra* (red fescue); and wheatgrass and ryegrass (*Agropyron* and *Elymus*) stands. These herbaceous types are usually most productive either on disturbed areas or above timberline. Below timberline, fires induce the larger and extensive displays of grasses, while erosion creates linear stretches along the various stream courses.

Availability of soil moisture is apparently one factor affecting grass species distribution. Wheatgrasses; *Elymus innovatus* (downy ryegrass); *Elymus mollis*; and *Calamagrostis purpurascens* (purple reedgrass), usually grow in dry sands and gravels. Bluegrasses; fescues; and native brome, *Bromus pumpellianus* (arctic brome), are favored on the mesic sites. Bluejoint; Lapland reedgrass; cottongrass; and various sedges (*Carex* sp.) are common to the wet sites.

Unlike other range areas of the United States, site moistness in this region may change with successional advances of the vegetation. A mesic site in early successional stages may become a wetland as thick organic mats accumulate. These mats hold moisture and insulate the soil, which results in a high permafrost table and poor internal drainage.

Grazing Uses

Native grazing species include Dall sheep and mountain goats in the alpine areas and adjacent subalpine forests; moose in the subalpine and lowlands; and caribou which, like moose, graze in a variety of habitats. Competition between caribou and reindeer for range would be very high because diet and habitat preferences are essentially identical for those two animals. Cattle and sheep grazing above timberline would conflict with Dall sheep. Domestic livestock at the lower elevations may not compete in a dietary sense with moose, except early in the growing season when moose are believed to consume forbs and grasses more frequently than later in the growing season. However, Compton and Brundage (35) estimated that 25 to 30 percent of cattle diets on one of these ranges consisted of browse, some of which could possibly be considered moose forage. In this area and several others, sound information on competition between livestock and wildlife is unavailable and crucially needed. There might be competition for sedges between domestic livestock and caribou during the growing season. Domestic livestock would probably affect caribou winter range mostly through trampling of lichens during summer.

Use of boreal zone ranges in Alaska for agricultural purposes has a shorter history than for the coastal forest ranges. During the Russian occupation, there was little or no agricultural settlement in this zone. Apparently, it was early in the nineteenth century when reindeer grazing occurred at a few boreal zone locations. The early survey of agricultural potentials by USDA in 1897-98 revealed no livestock production in this zone. The early prospectors and miners who used horses and mules were probably the initial users of these ranges.

According to Aamodt and Gasser (1), cattle were first brought to interior Alaska after the 1904 gold discovery near Fairbanks. For several years thereafter, beef animals were brought either from the port at Valdez or down the Yukon River and then driven overland to Fairbanks. These expeditions practiced grazing along the trails to sustain the stock en route to the Fairbanks market. In 1948, there were range livestock ranches in Alaska, but none of these were in the boreal zone (1).

An exception was the cattle grazing lease in the Little Susitna drainage north of Palmer. Cattle grazing, primarily dairy animals, has occurred annually since the lease was filed Dec. 1, 1951. Originally, this lease was issued by the BLM under authority of the 1927 Alaska Grazing Act, and there are indications of cattle use prior to 1951. Sheep used mountainside ranges above timberline in the 1940s (1). Portions of the range are still being used for livestock summer range. Grazing in the Little Susitna Valley occurs above timberline, generally between 1,800 and 2,500 feet elevation. The original vegetation was mostly mesic graminoid herbaceous and mesic forb types with tall shrub and wet graminoid in localized sites. Persistent heavy use in bedding grounds has changed the tall graminoid to annual bluegrass. No organized studies have been conducted to determine effects of grazing on the forage communities.

Grazing Seasons

Because animal grazing periods are related to range-vegetation growing seasons, data on growing season length were examined for dominant trees of the boreal zone. Spruce stems grow for about 50 to 60 days near the Bering Sea (106). Around Fairbanks these same trees grow for about 80 days, an indication of the productive season's duration. Some forage plants on favored sites may grow longer than the trees, but it is clear that a major portion of the annual cycle is allocated to non-growing conditions in this zone. Generally, grazing can occur from June through about mid-September. Bison and yak have survived year-around on some sites north of the Alaska Range, but subjecting cattle and sheep to such conditions would prove unprofitable. Reindeer can graze year-around on some interior ranges. Gasser (49) reported horses grazed year-around in the Goodpaster vicinity of the interior, but that should not be considered as the ordinary condition. Stockmen should be prepared to feed from October through May.

South of the Alaska Range, dairy steers were grazed at the Matanuska Station from June 1 to September 1 on "woods pasture" and were reported to gain 2.38 pounds/day (141). A similar (four month) grazing season was reported for sheep in the southcentral region (1).

Range Carrying Capacities

Carrying capacities of several boreal zone ranges in Canada varied from 4.2 to 5.0 plus acres/AUM (166). Bluejoint meadows and tall grass-forb range sites in the Matanuska Valley have been reported to yield from 2,600 to 4,000 pounds/acre annually (72). Annual mowing would reduce those levels to 1,000 to 1,500 pounds/acre. Assuming a worst-situation example, such ranges could have a carrying capacity of 0.9 to 1.2 acre/AUM, although that has never been verified by controlled grazing experiments.

Mitchell and Evans (100) reported 4,150 pounds/acre total herbaceous production for a disclimax bluejoint-fireweed range in the Matanuska Valley. Grass production comprised 1,500 pounds/acre and fireweed (*Epilobium angustifolium*) amounted to 1,600 pounds/acre. The remaining herbaceous production was 300, 200, and 500 pounds/acre, respectively, for horsetails, ferns, and raspberry (*Rubus idaeus*). From these data it would appear that initially, such a range type could carry 1AUM/0.8 acres, if 60 percent annual biomass of palatable forage is allotted to livestock. Applying similar standards to recently acquired data from five vegetation types in the Matanuska Valley indicated carrying capacities ranged between three and 35 acres per AUM.

The fescue bunch grass ranges near Healy were examined in 1928 by W. T. White (4). Carrying capacity was estimated to be about 3.6 acres/AUM for summer grazing of either cattle or sheep. Bison range carrying capacities near Delta were estimated to be 1.9 to 4.5 acres/AUM (89).

White observed that considerable benefits in grass production accrued from burning these ranges. Presumably, these were positive benefits in carrying capacities due to removal of woody plant competition. Campbell and Hinkes (27) also reported benefits to bison from burning similar ranges. We have observed positive responses to burning on bison ranges on Ft. Greely (89).

Limitations

The major limitation of boreal zone vegetation with respect to ranging livestock is the dominating trend for woody plant succession. The regional climax is forest, shrub, and scrub, varying as to specific location. Herbaceous types are often either transitory exceptions that result from forest or brush removal or understory complements to the forest. Herbaceous stands occur as scattered components in the Woodland-brushland matrix. Accessibility is limited, and distances to suitable winter feed bases may preclude practical use of areas that are biologically suitable for summer livestock production. The transition zone between boreal forests and tundra often contain important winter ranges for wild caribou and reindeer herds.

Surveys of boreal zone ranges of the Goldstream Creek and Tanana and Chatanika Rivers areas in 1929 by W.T. White of the Alaska Agricultural Experiment Station indicated there were considerable acreages of grass and sedges in the region, but the feasibility of use was low due to wetness, lack of suitable winter feed sources, mosquitoes, etc. Thus, even though carrying capacities may have appeared good for summer range, based solely on forage production, other factors were believed to have precluded such use (5).

It appears that disturbances which remove the trees but not the organic soil mat can release the herbaceous and woody understory species without the immediate reinvasion of trees. This can be seen in seismic clearings in the lower Susitna Valley and on the Kenai Peninsula. Any disturbance that exposes mineral soil, however, invites new tree and shrub (alder and willow) seedlings. Often shrubs and trees are among the first that invade such sites, as evidenced along roads throughout the region.

Biological production capacities are limited, but biomass production of even the black spruce/moss communities, which occur on the coldest and wettest soils, ranged between 1,780 and 2,050 pounds/acre of aboveground biomass annually (147). Even though that production was half moss and most of the rest is not forage, it still indicates that a significant production potential exists for forage, should vegetation be altered by fire or other forms of clearing.

Accumulations of heavy organic mats cool soils and reduce nutrient cycling rates. That reduces annual thawing depths and restricts root exploration of mineral soils, further limiting mineral nutrient supplies. It is clear that soil development is slight on many boreal zone sites, and the chemical weathering process that releases nutrients from primary minerals and forms secondary minerals (clay) is also much retarded. Evidence of mineral nutrient limitations is shown in the need for constant fertilization of cultivated soils in this zone to maintain production of even the least demanding of forage crops (80).

All of the poisonous range plants recognized for Alaska except bracken fern occur in the boreal zone. Large losses of livestock have not occurred to plant poisoning, however. This is due mainly to lack of extensive livestock use and to abundant alternative forages for animals on these ranges.

Livestock deaths in this zone have been attributed to larkspur (7). Cattle deaths occurred in the Matanuska Valley and Fairbanks region. *Zigadenus elegans* (death camas) occurs commonly in *Populus tremuloides* (quaking aspen) stands and is a plant poisonous primarily to sheep. However, the quantities necessary to cause problems are fairly large; so it is unlikely that poisonings would occur as long as other forages are present in sufficient amounts.

Vitamin A deficiencies in Alaskan grown feeds have been reported (104). This problem is one that would occur during the winter feeding season, which is quite long in the boreal zone. Deficiencies would not be expected as long as animals were on ranges that provided green forages.

More recently, deficiencies in selenium have been reported for cattle and sheep during winter feeding seasons. These situations were related to heavy use of barley in rations, which is normally low in selenium and appears to be even lower in some Alaska-grown lots. Selenium deficiencies have not been noted in range forages in Alaska, but the number of plants tested is small. Research on trace elements is apparently needed.

ARCTIC TUNDRA ZONE

Tundra is a term frequently misused both in scientific and popular communications. Originally it was used by A. Von Middendorf (53) in 1864 to designate treeless vegetation of the Arctic. Since then it has been applied to treeless vegetation above timberline, on islands, and in the boreal zone. These latter uses ought to be avoided. The continued misuse adds confusion to vegetation classification schemes, which are independent of geographical criteria.

The arctic tundra is extensive in Alaska, occurring in a band varying from a few to more than 200 miles in width between the boreal forest and the seas (149). That of the Arctic Slope alone consists of a continuous unit more than 77,000 square miles in size, larger than the State of Nebraska (24).

Distribution of arctic tundra dips southward along the Bering Sea coast, occurring at latitudes that normally are vegetated by boreal forest types. Geographically this

The coastal plain is a flat expanse of arctic tundra broken by many northwest-oriented ponds and lakes, the largest of which, Teshekpuk Lake, is shown in this June 27, 1973 aerial oblique photo. Snow had finished melting within the past week, and lakes were still ice covered in this scene. This rangeland is frequented by migratory waterfowl and caribou. Reindeer grazing was once attempted in this region, but failed to flourish and was abandoned.

southward extension includes portions of the Seward Peninsula, the Norton Sound region, deltas of the Yukon and Kuskokwim Rivers, portions of the Alaska Peninsula, and the Aleutian Islands (149).

The southernmost extension has been included in the marine grasslands for this discussion, primarily because: (1) the latitudinal position is not arctic; (2) livestock uses are potentially different between the two zones; and (3) permafrost is not a soil condition in the marine grasslands. Reindeer and musk ox can be grazed in both areas, but cattle and sheep are not adapted to the Arctic.

Research on these rangelands far exceeds that for any location or range type in Alaska. Range studies began in 1920 with USDA; subsequently, government, industry, and private foundations have supported numerous studies, many of which provide valuable basic information regarding soil/plant/animal relationships. Data from other polar nations, such as Canada and the Scandinavian countries, are also pertinent and available. Information from Siberia is less available, however. The U.S. International Biological Program (US/IBP) Tundra Biome produced a significant quantity of information, and it was followed by RATE (Research on Arctic Tundra Ecosystems), which focused on herbivory. Significant discoveries in arctic soil fertility, plant production, and tundra grazing were described in various IBP, RATE, and industry sponsored reports. Such data are valuable for tundra range management and use, but are too detailed for this discussion. Readers with particular interest in these ranges are directed to that literature.

Topography, Climate, and Soils

Alaska's arctic tundra ranges occur on relatively gentle and flat landforms. Those on the North Slope appear to be simply northward extensions of the shortgrass plains of eastern Colorado and western Kansas. The tundra type extends southward into the foothills of the Brooks Range, where rolling and sloping landscapes replace the flatness of the arctic plain.

Climate is characteristically cold and low in annual precipitation. Net inputs of solar radiation are so low that permafrost is continuous. That lack of energy

Foothills north of the Brooks Range contain more varied range types than the flat coastal plain, as evidenced in this westward view across the Utukok River.

reduces evaporation, which allows the precipitation to be retained, reducing the demand by plants. However, low energy also limits plant growth and decomposition and stresses animals. The peak radiation input occurs while snow cover is present; thus, forage plant growth occurs after the summer soltice.

Continual darkness during winter periods, cold temperatures, and often wind adds rigor to the climate so as to preclude ordinary livestock from the region. In spite of these conditions, it is the boreal zone and not arctic tundra that experiences the lowest temperatures in Alaska.

Soils are poorly developed because low temperatures slow chemical weathering, and permafrost prevents water percolating through but a small portion of the profile. Organic matter accumulates, and acidity is fairly high. Mineral nutrient availabilities restrict forage growth. Phosphorus and sometimes nitrogen are two nutrients commonly low in arctic tundra soils (29, 52, 93, 146).

Due to high organic matter levels, these soils are often light in volume weight (bulk density), a feature that complicates testing and interpreting fertility status. Release of nutrients from the organic matter occurs late in the season, after plant growth has begun to decline. Thus, uptake of critical elements and overwinter storage must be significant for range plant survival. That feature is most obviously important because plant growth commences before soils are thawed.

Polygonal ground features form ice wedges that are subject to thawing and subsidence when surface mats of moss are disturbed. Corrals and shelters must be located with that in mind. Readers interested in such phenomena and the thaw-lake cycle, a process that affects soils and vegetation of the arctic tundra, are referred to other sources for comprehensive discussions (23, 77, 78).

Vegetation

Arctic tundra vegetation, by definition, has no trees. Thus, herbaceous and some shrub communities typify these rangelands. Cottongrass species and various sedges commonly dominate the vegetation aspect. Webber (155) ranked 40 of 112 species near Barrow according to their relative cover and frequencies of occurrences. *Carex aquatilis* (water sedge) ranked in first place, followed by six species of mosses; then *Salix rotundifolia* (least willow) and *Poa arctica* (arctic bluegrass) in that coastal site. Inland ranges are characterized by *Eriophorum vaginatum* (tussock cottongrass); *Betula nana* (dwarf birch); and several heath forms: *Ledum decumbens* (northern Labrador-tea); *Vaccinium vitis-idaea* (mountain or low bush cranberry); *Vaccinium uliginosum* (bog blueberry); and *Empetrum nigrum* (crowberry). Dwarf and low-growing willows, including *Salix planifolia* var. *pulchra* (diamondleaf willow); *S. reticulata* (netted willow); *S. rotundifolia*; *S. ovalifolia* (ovalleaf willow); and *S. arctica* (arctic willow), also become increasingly important away from the coastal communities. Mosses predominate throughout much of these rangelands, providing cover and insulation to the soil. It is largely those insulating effects that restrict the annual thaw depth, and, in turn, the size of available root zone for higher plants and net annual decomposition of underground plant parts.

Lichens dominate rocky and better drained sites, and are most productive in the transition between boreal forest and arctic tundra zones. Important species include those of the *Cetraria* and *Cladonia* genera, both as dominating species and in value for grazing.

Plant community studies have been rather site-specific, and extensive community maps for tundra ranges are mostly nonexistent. Recent use of satellite data is furthering that effort; however, the levels of classification are restricted in the satellite data relative to that developed from aircraft imagery, and users must be certain of their needs before purchasing.

Understanding successional relationships of plants is necessary for judging range condition and trend. Arctic tundra ranges have few plants that respond as annual weeds (i.e., flourishing in overgrazed and denuded areas), as is common for most other rangelands. Conditions favoring those kinds of plants do not exist in the Arctic. Plants that most readily invade disturbed places include certain grasses, cottongrass, sedges, shrubs, lichens, and mosses, which are usually found in the climax communities. Therefore, it is the range ecologists' role to identify those plants because they indicate range conditions and effects of grazing. Several sources of information already exist. Least understood are the mosses and lichens, because educational emphasis has focused on the higher plants important to temperate zone rangelands. Education for arctic tundra range management needs to include lichens and mosses as well as vascular forage plants.

Usually grasses such as *Puccinellia* (alkali grass); fescues; *Deschampsia caespitosa* (hairgrass); bluegrasses; wheatgrasses; and *Trisetum spicatum* (downy oatgrass) invade dry sites. Representatives of those plants are common along streams and around fox and ground squirrel diggings.

Braya purpurascens (purplish braya); *B. glabella (pilosa)* (smooth braya); and *Cochlearia officinalis* (scurvy-grass) are three common mustard family plants that invade denuded sites. Specific conditions dictate the resulting community. I have found that the braya invasion does not become significant until about four years following clearing. Then seed production of colonizing plants is sufficient to develop large populations. Occasionally, when conditions are favorable, a few members of the annual, northern tansy mustard (*Descurania sophioides*) will appear, but I have never seen numbers of those individuals even approach those of the two braya species.

On the transition between tundra and boreal ranges, alders often invade bare soil if seed sources are nearby. *Peltigera*, a foliose (leaf-like) lichen, may invade barren wet sites, and *Stereocaulon*, a short-growing fruiticose (branched) lichen, invades barren dry sites.

Minor disturbances result in somewhat different responses than where total plant cover is killed. On wet sites, pendant grass (*Arctophila fulva*) increases after disturbances of climax communities. Arctic sweet Colt's foot (*Petasities frigidus*); bigelow sedge (*Carex bigelowii*); and dupontia (*Dupontia fisheri*) increase following disturbance. Minor compaction of the organic mat can result in a flush of flowering by cottongrass. On slightly drier sites, mountain foxtail and polargrass (*Arctagrostis latifolia*) increase with disturbances. On lichen sites, *Cladonia alpestris*, a climax reindeer lichen, seems most vulnerable to grazing; and in Lapland, *C. alpestris* dies out under grazing, leaving *C. rangiferina* and *C. mitis*. More detailed information on lichen responses to grazing is available in a translation from Finland (3).

Grazing Season

Unlike rangelands of the coastal forest and boreal zones, which have definite nonuse seasons, the tundra ranges are used yearlong by reindeer (caribou) and musk ox. Plant communities grazed during winter differ from those used in summer. Given freedom to choose, reindeer and caribou naturally include a variety of plants in their diets, but during winter, lichens comprise the bulk of forage consumed. Reindeer owners usually reserve lichen dominated areas for winter grazing. Palmer (107) concluded lichens were important probably because of availability, not because they were nutritionally essential for reindeer during winter. Lichens are primarily a source of energy and are low in protein and minerals. Animals forced to exist on only lichens for long periods fare poorly.

Snow has characteristics that affect winter grazing patterns. Areas of unfavorable snow that prevent cratering (digging) by reindeer for forage may dictate boundaries of range units. If those features are consistent from year to year, perhaps they ought to be considered as much as vegetation patterns in selecting grazing units.

Early spring grazing occurs on areas that are first to lose snow cover. Thus, south-facing slopes attract reindeer during early spring calving time. Caribou migrate to these ranges in late winter, and new growth and flower parts of several plants have been specifically recorded as important in diets during that season (76). Such types should be recognized by range managers and avoided during summer in order to maintain range plant vigor on these critical areas.

Summer grazing is seldom limited, and most authorities consider it in excess of available winter range. It is the summer ranges which produce reindeer weight gains. During the remainder of the year, animals are either holding their own or losing weight. High quality summer range must be maintained.

Sites that provide escape from insects in summer may be damaged by overuse, and these areas ought to be properly managed.

Native Grazers

Arctic tundra is the natural grazing land for caribou (reindeer) and musk ox. Seasonally, a few moose and large numbers of waterfowl use some of these rangelands. Several small mammal species occupy important niches.

Caribou and reindeer are of the same species, the reindeer being domesticated from wild caribou herds and kept on tundra and northernmost boreal ranges of Lapland, Russia, and Siberia. The domestication is reported to have occurred about 3,000 years ago. Documentation of reindeer ownership exists in Norway beginning about 1,100 years ago and in Siberia about 1,480 years ago. (3)

In those countries, the wild form is relatively scarce and competes little with domestic herds. For North America, the situation is reversed; competition for range forage is keen because dietary choices are very similar between tame and wild forms. Of greatest concern to reindeer owners is the loss of tame animals to wild herds. The interbreeding effects on wild populations' vigor and characteristics is not currently believed significant (75). Effects of reindeer grazing on caribou range is believed important because the domestic form is more intensive in use of an area and it takes greater portions of plants than caribou. Since winter range is most limiting for both wild and domestic forms, the competition there is viewed as most critical (75).

Waterfowl migrate to the tundra in summer. While there, they reproduce and moult. During these critical periods they need good sources of nutrition for producing eggs and new plumage and for the development of young. Mobility of moulting birds is limited; therefore, they need particular sites that affords them readily accessible forage and escape habitat from predators (37). Competition for forage by other grazers and disturbances from reindeer herds and herders during these critical periods would have highly undesirable affects on the bird population. Consequently, range users must know locations of critical waterfowl habitat and avoid obvious conflict.

The importance of small mammals to arctic tundra grazing centers on two points: (1) direct competition between those animals and large herbivores (caribou/reindeer) for nutrients and energy, and (2) the contribution of the small grazers to nutrient cycling and overall range productivity.

Diet determinations show that the collard lemming feeds heavily on willow, a favorite plant for reindeer and caribou. The brown lemming eats grasses and sedges, which are also staples in the reindeer and caribou diets. The tundra vole likes willow, grasses, sedges, and a variety of broad-leaved herbaceous (non-woody) plants (forbs). Therefore, competition for forage exists between reindeer and three dominant small mammals of the Arctic (15, 16).

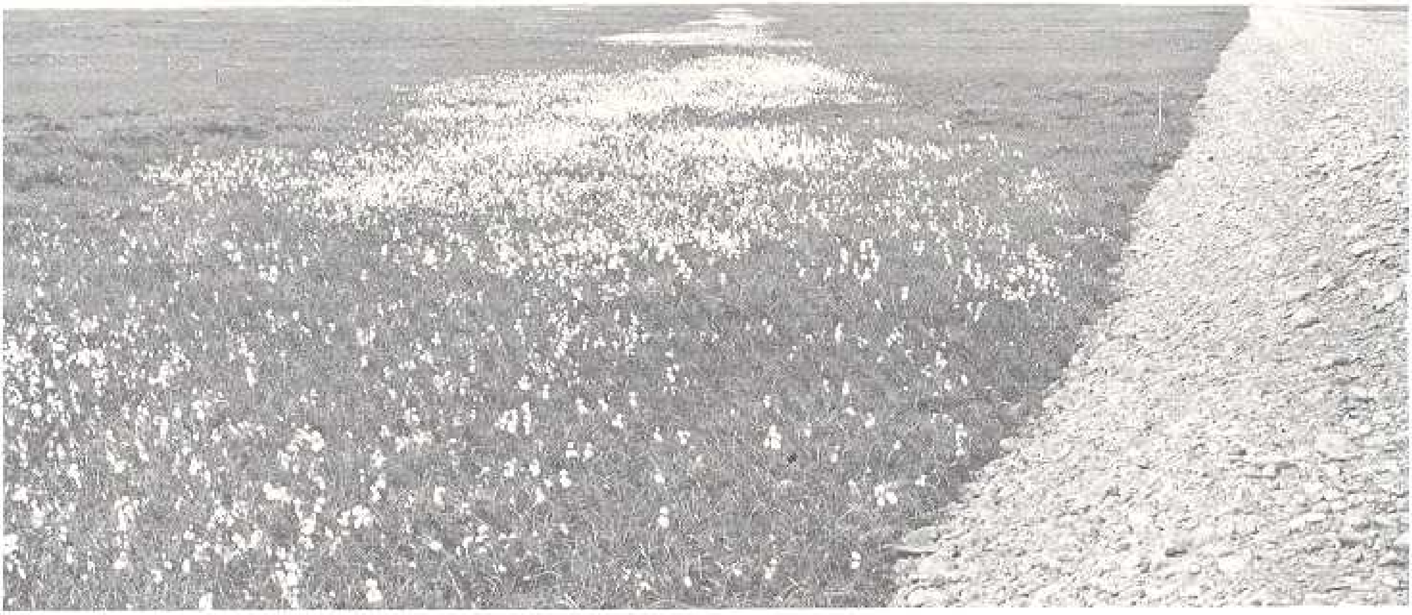
Intensity of small mammal effects has been calculated in terms of energy ingested at Barrow and Prudhoe Bay. The Barrow site had no caribou, so only small mammal use was determined there. Energy intakes for caribou and small mammals was estimated at Prudhoe (17). Those findings showed that small mammals were significant consumers of energy at both locations. Energy intakes of small mammals at Prudhoe ranged from about half those of caribou when both life forms were low in numbers to more than 10 times those of caribou when both groups' populations were high. During low population years, small mammals at Barrow consumed nearly as much energy as caribou at Prudhoe Bay during low population periods. However, when small mammal numbers were high at Barrow, they consumed nearly 100 times more energy than caribou when caribou populations peaked at Prudhoe Bay.

It appears as if this competition is related to relative distributions of the wild caribou and small mammals. The prevalence of one form occurs where the other is less dominant (46). Knowledge of that ought to be important to persons selecting key reindeer ranges.

There is evidence suggesting that the small grazers serve an important function in maintaining forage plant production in the Arctic. Where these creatures were prevented from grazing by erecting exclosures, tundra productivity was reduced to about half of that which was grazed. Investigators concluded that response was due to reduced mineral nutrient cycling. Because nutrient cycling rate depends upon decomposition of dead plant tissues and is suppressed by low temperatures in the Arctic, it seems reasonable that warm-blooded animals that digest such plant materials would contribute significantly to the nutrient flow rates, especially if those animals were active when soil microbes were inactive. Such is the situation with the lemmings; their numbers are often greatest during winter as they graze and reproduce beneath the snow.

Range Carrying Capacity

Arctic tundra carrying capacities were first estimated by Palmer (56) in 1922 at 30 acres per reindeer per year. The estimate was later revised upward to range between 35 and 40 acres, and by 1941 he was allowing as much as 65 acres on poorer sites. By 1968 the BLM used



Arctic vegetation is often limited by soil nutrients. Sometimes increases in phosphorus and/or nitrogen produce striking effects, as in this photo showing a profusion of cottongrass flowerheads marking the route of a rollegon vehicle that crushed standing dead vegetation and slightly compressed the organic mat, which temporarily increased decomposition rates.

200 to 1,000 acres per head per year for Seward Peninsula ranges.

Calculating range carrying capacity is more complex than simply measuring forage production and dividing by the annual forage requirements of a grazing animal. Understanding the plant palatabilities and seasonal preferences of animals, tolerances to grazing by various forage plants, effects of terrain features, storm patterns, past grazing, competition from wild grazers, and year to year variation in forage production are some of the factors affecting range carrying capacity. Therefore, original estimates such as those of Palmer is 1922 would be expected to change as information about the rangelands became available.

Determining annual productivity for arctic tundra ranges is more difficult than for herbaceous range types, which produce an easily identified annual crop of forage. Estimates of plant biomass on tundra ranges vary from about 2,600 to 67,500 pounds per acre. Biomass data contain the carry-forward of annual growth as: (1) standing dead from herbaceous plants; (2) accumulated stem growth in shrubs; and (3) large accumulations of lichen and moss biomass. Because biomass carry-forward is very high in arctic tundra, production data can prove unreliable when used to estimate carrying capacity of these ranges.

Annual productivity estimates are less available because they are relatively difficult to obtain. Karmakova and Webber (70) gave figures for various types in the Meade River vicinity. Their data showed an annual average biomass increase of about 880 pounds per acre, including mosses and lichens. Allowances for unpalatable shrubs and uselessness of mosses as forage plants must be considered. Therefore, only 500 to 650 pounds of that production may be useable for reindeer (caribou) and musk ox, if 100 percent of the growth were to be consumed. Since only a percentage of the annual increase can be taken and still maintain integrity of the forage stand, practical utilization would be much less than that (i.e., 75 to 300 pounds per acre).

Canadian researchers calculated annual productivities for two tundra sites, one in Alaska and one in Yukon Territory (157). Their data compared well with those of Karmakova and Webber, ranging between 250 and 1,035 pounds total biomass per acre annually. Year to year variations were also estimated at 20 percent in the Canadian studies.

The amount of forage needed by reindeer was first estimated in Alaska by Palmer (111) at 10 pounds per day, which included wasted and rejected portions (orts) for penned animals. He considered the species as rather wasteful, consuming between 37 and 57 percent of forage offered, depending upon the types of plants being fed. White and Trudell (159) discovered that grazing reindeer removed from six to 10 times more forage than they ingested when tethered for brief grazing sessions. It is not known if that waste included significant portions of current growth or if it was all standing dead. Their report indicated reindeer preferred grazing cottongrass tussocks that had been cropped the previous year, suggesting standing dead was avoided and spot grazing occurs on tundra ranges.

Winter range carrying capacities are especially difficult to estimate due to lack of data on lichen regrowth in response to grazing. Caribou are calculated to need at least 10 m² of vigorous lichen per day (0.67 acres per month during winter). Pruitt (120) reported that caribou could only feed twice on a given area during winter, because cratering affected snow conditions so as to make further foraging too difficult. In Finland, lichen ranges need four to five years of rest between grazing periods (3). There should be further study of energetic costs of cratering under various snow conditions relative to the quantity of lichens available in order to rate winter range quality of Alaska. Figures for rating Lapland ranges have been given (3), but should not be used in Alaska because snow is softer on the Lapland range. More high-quality forage would be needed on range types with relatively difficult snow conditions than on types that could be cratered with less effort. Because tundra grazers spend two-thirds of their lives grazing snow-covered ranges, it appears that greater efforts are now needed to research winter range technology.

Limitations

The most obvious vegetation limitation is availability of winter range. Next would probably be its relatively slow recovery from overuse. The damaging effects of fire on lichen ranges is quite significant in that regard. Dry, lichen-dominated sites are highly susceptible to fires, and they are slow to recover. These sites are also apt to be most important for winter musk ox (88) and reindeer range. Recovery of tussock tundra is relatively prompt, with annual productivity returning after as few as two growing seasons (156, 122). Birch-heath types, with crowberry and lowbush cranberry components, are slower to rejuvenate compared to northern Labrador-tea and cloudberry (*Rubus chamaemorus*) types (122).

Mineral nutrient deficiencies in forage include calcium and phosphorus in lichens and some vascular plants (146). Protein is also deficient in lichens. These components ought to be considered first as supplements for animals on winter range. Undoubtedly, further study will show that other elements are low in forage plants.

Low available phosphorus and nitrogen in soil restricts plant growth in arctic tundra. There is evidence that competition between lichens and vascular plants is linked to biochemical relationships between lichens and fungi that grow symbiotically on the higher plants' roots (mycorrhizae) (25, 83). Furthermore, fertilizing soils to enhance vascular plant growth has been observed to reduce the lichen component.

Only *Andromeda polifolia* has been mentioned as a problem plant for reindeer (Table 1). There are several poisonous plants on these ranges, but losses from other factors overshadow any problems with toxic plants. Insect harassment is a well-known factor, for which the USDA expended significant efforts in clearing a vaccine against the warble fly (154). Losses of reindeer through straying with passing caribou herds is perhaps the single largest problem with reindeer herds now in Alaska. This topic was recently reviewed by Klein (75). Social and economic constraints are significant factors limiting the expansion of the industry in Alaska and Canada, according to several observers over the years (67, 107, 118, 131, 133, 140, 144). In a Canadian venture, costs exceeded returns by a ratio of three to one (131). Some have suggested that the game ranching approach could overcome some of those problems (74, 131).

MARINE GRASSLANDS

Geographical Extent and Topography

These rangelands occur on the lower portions of the Alaska Peninsula and on the Aleutian Islands. The islands extend more than 1,000 miles offshore, forming a separation between the Bering Sea and the Pacific Ocean. Of volcanic origins, some islands consist of snow-capped mountaintops surrounded by varying extents of lowlands, which support vegetation suitable for range. Often these rangelands are dissected by gullies and canyons eroded by streams, making land travel around the island difficult to impossible for livestock. Other islands are relatively low in elevation and have subdued topographic features.

Climate and Soils

Precipitation is typical of marine-influenced systems; its effectiveness is enhanced by low evaporation rates. As Amundsen (8) stated, "Amchitka climate is one of the world's cloudiest!" The Aleutian Islands have a well-earned reputation for foul weather, which was experienced by a large number of troops during World War II (140). Although daily temperatures often fluctuate only a few degrees, the weather is hardened by persistent wind and dampness. The dampness entirely prevents the curing of hays on these islands. It is fortunate for grazing animals that temperatures are mild enough to keep low-lying sites generally snow free in winter. Otherwise, keeping livestock on these ranges would be impossible on a year-around basis. The annual period of frost-free days was recorded for Amchitka at 75 (8).

Soils of these ranges have not been studied to any significant extent except for those on Amchitka, which were examined and analyzed by Everett (44) in connection with experiments by the U.S. Atomic Energy Commission, which later became the Energy Research and Development Administration. This was similar to the commission's earlier sponsorship of work in the arctic tundra for the Cape Thompson region.

Chemical and physical weathering of the igneous rock, volcanic ash, other parent material and organic matter have resulted in organic and mineral soil formation on Amchitka. The organic soils are confined to low, wet areas. Mineral soil formation occurs topographically above 300 feet in elevation, the site of organic soils. Some evidence suggests that the organic soils may have occurred higher in previous geologic times, but due, perhaps, to climatic changes, those have since eroded, leaving mineral Inceptisols (beginning soils). Barren areas occur at the highest elevations. Wind erosion and solifluction (mass movement) were the primary physical forces mentioned by Everett (44) that affected the Amchitka soils. Pattern ground and sorted stone rings were also formed in places during periods when periglacial climate prevailed. Sands were also found in certain locations.

For most of the sites, soil textures were loams and siltloams in surface horizons. They were acidic, in the pH 4.2-5.1 range, and varied from 40 to about 90 percent in organic matter (50 to 20 percent organic carbon). On disturbed sites, pH ranged from 4.9 to 8.2 and had organic matter contents between 0.8 and 6.7 percent, according to Mitchell (98). A consistent need for nitrogen and phosphorus fertilization was noted in order to establish grass seedlings on the island. Potassium levels were apparently adequate in the soil, however. Amchitka soil absorbed about half the phosphorus of that absorbed by soil from Simeonof Island (97), suggesting that allophane, a positively-charged, noncrystalline mineral occurring commonly in volcanic ash, was greater in Simeonof soils. Occurrences of allophane have been associated with soil fertility problems with phosphate, boron, and other negatively-charged soil nutrients. Volcanic ash layers were reported in Amchitka soils, but generally not at the surface (44).

Grazing Use

Grazing on the Aleutians was largely absent prior to the coming of Russians and Europeans. Wild waterfowl seasonally used the islands and probably constituted their largest herbivores. Later rats, cattle, sheep, goats, pigs, horses, and reindeer were introduced. Anderson, (9) gave a synopsis of Aleutian livestock ventures. Table 2 shows data from BLM leases in November 1972. There may be reason to question some of these data because more recent information given by Savage, Talbot, and Hedrick (127) indicated livestock numbers on Simeonof Island in 1972 were 335 head, as opposed to the 256 head shown in Table 2.

Vegetation

Vegetation communities have been surveyed on the Aleutian Islands for their potential livestock use by individuals in various government agencies and, most recently, under contract to interests holding leases. Results from much of this activity is unknown in the literature and, consequently, unavailable. Perhaps the first records of range reconnaissance were by Alberts in 1928 (4). He reported that range forage was plentiful on the islands he visited. Mountain slopes were judged good sources of summer range, and dunegrass and sedge were found at heads of bays. Alberts suggested these might be cut for silage, noting that winter feeding was necessary

Table 2
Bureau of Land Management Livestock Leases for Aleutian Islands (November, 1972 data).

				Livestock on lease				
Location	Lease Number	Allotted Acreage	Maximum Authorized Animal Units	Bulls and Steers	Cows	Calves	Sheep	Horses
Akutan E 1/2	A-062012	41,500	100	6	14	10	—0—	2
Chernabura	A-061517	7,248	200	30	35	27	—0—	—0—
Sanak E 1/3	A-059782	10,100	250	68	114	—0—	—0—	—0—
Simeonof	A-053672	10,850	275	41	134	81	—0—	4
Umnak E 2/3	A-030488	255,360	2,500	41	60	31	6,092	17
Umnak W 1/3	A-030544	115,497	2,000	100	70	30	3,420	39
Unalaska E 1/2	A-057947	60,000	200	19	29	11	5	6
Unalaska W 1/2	A-060872	151,915	2,000	63	89	48	6,000	110
Wosnesenski	A-050739	7,500	75	22	47	—0—	—0—	—0—

during February, March, and April, except in certain locations.

Savage, Talbot, and Hedrick (127) presented plant community data for Simeonof Island, including classification into six communities (including barren). Their data also contained percent composition by green weight. Figures showed communities and relative percent of island occupied as: mesic *Empetrum nigrum* heath, 44 percent; Mesic *Festuca rubra* grassland, 31 percent; wet *Eriophorum angustifolium/Carex lyngbyaei* meadow, 15 percent; dry *Elymus arenarius (mollis)* grassland, 4 percent. Amundsen (44) listed the four major plant communities on Amchitka Island as: upland grass, crowberry-grass-sedge, crowberry-sedgegrass, and sedge-lichen, in ascending relative wetness.

Comparing data from the two islands shows a preponderance of lichen biomass on Amchitka. Vascular vegetation on both islands is dominated by crowberry, a low evergreen shrub that has little value for ungulates. *Rubus arcticus*, nagoon berry, is a low creeping shrub. Plant preferences by animals could vary considerably among islands depending upon species composition of respective ranges.

Grazing Seasons

Livestock can graze yearlong on many of these islands. Accounts of animals left unattended for several years can be found. It is fortunate that winter feeding requirements are minimal because weather for hay curing is rare.

Carrying Capacity

Range carrying capacity figures are unavailable. The best estimates must be extracted from forage production data.

Amundsen (44) gave annual vascular plant production for various vegetation types on Amchitka. Vegetation production, not counting lichens or mosses, averaged 577 pounds per acre. Maximum production was 4,666 pounds per acre and occurred in an area drained by a pond. Minimum production, 277 pounds per acre, occurred in lichen dominated areas. These figures indicate the production on Amchitka was similar to the arctic tundra's average. Annual stocking rates of 60 to 120 acres per animal unit could probably be expected for most islands, if the Amchitka values are accurate representations for the region.

Limitations

Limitations to livestock operations on the Aleutians were identified by Anderson (9) as: first, lack of capital; second, lack of transportation; and third, lack of stockmen with the ability to succeed in a livestock operation. Ransom (124) reported that the weather prevented breeding and reproduction of horses for the Aleutian Livestock Company. He indicated that some prosperity occurred with sheep production, but concluded that transportation and marketing problems would likely overshadow economic successes. In Wright's (165) account of ranching on Chirikof, transportation and its associated problems were the dominating difficulties discussed.

From these viewpoints and the accounts of livestock, including reindeer that have existed on various islands successfully without supplemental winter feeding, it is clear that, biologically, some of these ranges are suited to yearlong livestock production. The major limitations preventing development and security for the operator have been and still are socioeconomic.

CONCLUSIONS

A search of the literature has revealed a significant number of reports pertaining to Alaska's rangelands. There are clearly more articles and a more complete array of studies on the arctic tundra types than for any other rangeland in the state. Yearlong grazing is possible on arctic tundra and marine grassland ranges. Brief, productive grazing seasons characterize uses of coastal and boreal forest ranges. Cultivated forage potentials are adequate to accommodate livestock winter feeding requirements, but weather patterns are frequently unfavorable for haymaking. Consequently, silagemaking has been repeatedly recommended. Harvesting winter forage when crops are of good quality is also recommended, because quality falls rapidly as plants age. When cattle and sheep numbers increase on ranges, problems of distribution and nonuniform use are likely to increase. Research on stocking rates, grazing systems, plant responses, and animal production is needed for much of the range types near current farming areas and population centers.

Low temperatures retard soil chemical and biological decomposition processes, and resulting organic matter accumulations may significantly affect range productivity. In addition to the effect of low net annual radiation on temperatures and plant production, the daylength feature has to be recognized in caring for animals at high latitudes in winter months. Evidences of mineral nutrient deficiencies for wildlife and livestock have been discovered. Studies are likely to reveal more nutrient limitations as technology advances. Stockmen need to remain alert to recognize problems and be prepared to supplement rations in feedlots and on the range.

The regional ecological potential for interior and coastal forest ranges is tree and shrub cover. Maintaining herbaceous forage plants will require continual vigilance and periodic treatment. Most ranges of the state are in excellent ecological condition, but for many livestock operations in forest zones, maintaining excellent ecological climax will not be the desired objective.

Wildlife considerations vary among the several regions of Alaska. In some areas competition between wildlife and livestock will be keen; in other areas it will be absent. Little is known about potential conflicts in many areas; speculations may be prevalent, but most are without basis. Considerable research and cooperation among responsible agencies on several facets of that problem are in order.

Experiments with grazers uncommon in other states, such as yak, musk ox, and hybrids between wildlife and domestic animal counterparts, have been attempted with some success in Alaska. Terminating some of those trials appeared to be unrelated to potentials for successes. Perhaps selections from among those projects should be reconsidered for future use.

For some zones, transferring technology to Alaska appears more promising from international sources than from temperate regions within the United States. International cooperation on reindeer technology dates back to the introduction of reindeer to Alaska. Similar efforts for other animals may be equally fruitful.

The Russian author, Dr. Svetlana G. Fedorova (45), after a comprehensive study of published and archival records, concluded that three factors weakened Russian colonial Alaska: (1) the region was too remote from main metropolis centers; (2) Alaska had severe and generally unfavorable conditions for agriculture; and (3) the colonial Russian-American Company was restricted (presumably by the Czarist government). With regard to the second point concerning Alaska's agriculture, there are acceptable biological potentials for range livestock production, even highly favorable in select instances and seasons. The elements of rangelands, suitable soils, climate for growing winter feed, and significant demands for red meat are all present. Putting those components together is not easily guaranteed, but the concept that Alaska is generally unsuited for agriculture should not be readily embraced. Neither should unrealistic projections of huge and highly profitable ranches springing up overnight be given trust. An orderly, well-founded plan that allows for maximum ingenuity, resourcefulness, and individual achievement will prove most reliable and rewarding for all concerned.

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