

FORAGE CROPS IN ALASKA



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Pleasure horse numbers continue to grow in Alaska, increasing the need for horse pastures and hay for winter feeding. Photo by L.J. [redacted]

FORAGE CROPS IN ALASKA

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Forage crops can be defined as the aboveground growth (stems, leaves, and sometimes seed heads and immature seeds) of plants that are gathered and fed to herbivorous, domestic animals. Similar plant growth that is grazed directly by livestock in rotational or permanent pastures, but on a less extensive basis than rangelands, is also considered in this discussion.

For the most part, forage crops are herbaceous (non-woody) members of two large plant families—grasses and legumes. The grass family world-wide numbers about 5,000 species, but only about three dozen of these are important as forages. The legume family includes more than 12,000 species world-wide, fewer than 20 of which are considered to be important forage crops.

IMPORTANCE OF FORAGES

Nonetheless, those few species that have been adopted for use as forage crops are used on more agricultural acreage of the world than all of the other classes of crops combined. In the United States, about 700 million acres, or 62 percent of the land in farms, are classed as forage producing. In 1974, forages supplied 63 percent of the feed units consumed by U.S. dairy cattle, 82 percent of feed units consumed by beef cattle, and 89 percent of feed units consumed by sheep and goats (22). In Alaska in 1982, 62.7 percent of harvested acreage of all crops was represented by forages (Table 1), and that figure does not include grazed forages on pastures and rangelands. The value of harvested forage crops alone exceeded the aggregate value of all other crops combined (2).

Forage crops can be consumed by all classes of herbivorous domestic animals, including beef and dairy cattle, sheep, goats, and horses. Swine and poultry, although they possess less digestive capacity than ruminant animals, can benefit from pastures that supplement

concentrate feeds. Forages are not suited for direct human consumption because many components in such plant tissues are indigestible. In contrast, the multiple-chambered stomachs of ruminant animals, such as cattle, sheep, and goats, are ideally suited to digesting and utilizing forage crops. Thus, ruminant animals provide the invaluable function of converting forages into such useful commodities as beef, mutton, milk, butter, cheese, hides, wool, and numerous other products.

Table 1
Percent of Total Harvested Acreage in Alaska
in 1982 in Various Crop Categories
(from Brown [2]).

<u>Crop</u>	<u>Percent of harvested acreage</u>
Forages: ¹	
Grass hay ²	45.8
Grass silage	4.6
Grain hay	9.3
Grain silage	3.0
Total	62.7
Other crops:	
Barley for grain	31.5
Oats for grain	2.5
Potatoes and vegetables	3.3
Total	37.3

¹Does not include forage consumed by grazing livestock.

²Includes green-chop forage.

Forages can be grown in rotation with other crops on tilled soils; in addition, they are extremely valuable because they can be grown on soils and in situations that

are unsuited to other crops or uses. Livestock can harvest forages from permanent or semipermanent pastures that are too rough, steep, stony, or wet, or are otherwise unsuited for mechanical harvest. Open woodlands and lowland pastures along stream courses are unusable for crop production, but they provide valuable grazing to supplement cropland forages. Moreover, the fibrous-rooted, sod-forming grasses bind and hold soils better than any other agricultural crops to prevent soil losses through wind and water erosion (43, 66, 70).

FORMS OF FORAGE

Forage crops can be consumed fresh, as when they are grazed by animals or when harvested mechanically and fed shortly thereafter as "green chop" forage. Forages also can be harvested and preserved in a variety of forms for later feeding. Forms of preservation include air-dried hay, stored either loose or baled (80 to 85 percent dry matter), or more moist chopped forage stored as silage (30 to 40 percent dry matter); or haylage (50 to 60 percent dry matter). Silage and haylage are preserved in pit, bunker, or upright silos by the ensiling process that involves partial fermentation in the absence of oxygen.

Dried forages can also be compressed into wafers, cubes, or pellets. The additional processing entails increased costs, but these forms require less storage space and are more suited to shipment than the bulkier loose or baled hay. Some of these products are imported into the state.

Because forage crops are such an important base for livestock production, an assured, continuous, year-long supply of forage in one form or another must be available to livestock producers. Beef and sheep producers on Alaska's southwestern islands can graze stock on ranges for most of the year; they require a relatively small quantity of hay for feeding during short periods of snow cover during winter (28). In contrast, stockmen in south-central and interior Alaska are faced with a long winter infeeding period. This accounts for the considerable quantity of forage in the state that is harvested and stored as hay or silage for later feeding (Table 1).

Unlike many other Alaskan farm crops, forages usually are consumed on the farm or ranch where they are grown. Hence, except for some baled hay, forages generally do not enter commercial channels, although a considerable amount of hay is purchased by urban owners of pleasure horses. Concerning cattle, the quantity of forages produced on individual farms is related fairly directly to the numbers of livestock to be fed.

Several characteristics of forage crops are of major importance to the Alaskan forage grower and the live-



Sod-forming perennial grasses can be established on lands that are too steep or otherwise unsuited for tilled croplands. As on this permanent hillside pasture, such grasses provide an erosion-proof vegetative cover

and provide a return in the form of nutritious herbage when grazed by livestock.

stock manager—who is often the same person. Four of the most important of these characteristics, all of which are interrelated, are adaptation (especially concerning winter-hardiness of perennials); yield; quality; and palatability. Each can be influenced by several factors, and each can be further subdivided into contributing components.



Kodiak Island (above) and other islands to the south and west are mantled with mixed vegetation including numerous grasses. The milder winter climate there permits virtually yearlong grazing and less dependence on harvested and stored forages for winter feeding than on the mainland.

FORAGE ADAPTATION

Adaptation of forages refers to the degree of compatibility between the crop and the environment (principally climatic and soil conditions). Major climatic characteristics that influence plant adaptation include the seasonal pattern of daily duration of light and darkness, summer and winter temperatures, other winter stresses, and amount and distribution of precipitation. Although many crop species and varieties are well-adapted to Alaskan growing conditions, a great many more are not.

The most obvious examples of forages that are poorly adapted to Alaskan conditions are (a) warm season annuals that produce meager growth under Alaska's cool growing season temperatures, such as sudangrass, sorghums, field corn, and pearl millet; and (b) inadequately winter-hardy perennials that fail to survive Alaskan winters.

Winter-hardiness

All plants (trees, bushes, perennial forages, etc.), in order to survive exposure to cold winters, must respond in late summer and autumn to shortening daylengths and gradually lowering temperatures that cause the

plants to (a) store food reserves and (b) undergo physiologic changes that permit overwintering plant tissues to survive subfreezing temperatures. Many biennial and perennial forage species and varieties are adapted to areas of the world that are not subject to significant winter stresses. Forages from the southern states, for example, are totally unsuited for use in Alaska (except as annuals), for they lack the genetic capacity to prepare physiologically in autumn to withstand the freezing stresses of Alaskan winters.

Other forage species and varieties used in the northern states and southern Canada may tolerate in their area of adaptation winter temperatures as severe or more so than the low temperatures that occur during Alaskan winters. These forages often are marginally winter-hardy in Alaska; they survive mild winters here with little or no injury, but sustain significant injury or winterkill during winters of more severe stresses.

The relatively poor winter survival in Alaska of these marginally winter-hardy species and varieties adapted to latitudes more southern than Alaska has been studied here (17, 20, 21, 40, 41, 44). It is now known that their poor winter survival is attributable in considerable measure to their failure to prepare adequately for winter under the unique and unaccustomed subarctic pattern of shortening daylengths and lowering temperatures during late-summer and autumn, a pattern that is significantly different from their area of origin. This failure to adequately undergo the necessary physiological changes prior to winter causes those unadapted crops to be much more susceptible to winter stresses when they are grown in Alaska. Although such forages do have the genetic capacity to achieve high levels of winter-hardiness when exposed to the pattern of shortening day lengths and generally lowering temperatures of autumn in their area of adaptation, they fail to develop adequate winter hardiness under the unaccustomed subarctic pattern of these conditioning factors during late summer and autumn in Alaska (21, 40, 44). This means that special attention must be paid to selecting Alaskan-adapted varieties of perennial forage crops for successful performance in Alaska.

Marginally adapted perennial species that do not winterkill often sustain some degree of winter injury. Winter stresses and their effects on perennial forages vary greatly in severity from year to year (45, 46). With very slight injury, damage may be hardly discernible in reduced stands or yields. With moderate to severe injury, however, gradual recovery of the stand may require most of the growing season, and this will be reflected in slightly to markedly lowered forage yields. Moreover, a thinned forage stand is less competitive than a full stand and permits the invasion of weeds.

It is often difficult for a forage grower with a moderately winter-injured forage stand to decide whether the stand should be left to recover or should be

plowed up and re-established. Precise forage needs for the year and adequacy of forage from other sources enter into such decisions.

Management Effects on Winter Survival

In addition to the effects of adaptation (genetic influence), management effects on winter survival of perennial forages in Alaska also can be very important. In general, the timing of management operations within the growing season and the frequency or number of harvests per season have been found to have marked effects on the subsequent winter survival of forages.

Planting date can have a considerable influence on winter survival of perennial forages (36, 37). The major hazard is to plant too late for seedlings to achieve sufficient growth before the onset of winter.

In general, perennial grasses are harvested twice during Alaska's relatively short growing seasons. Under this schedule, grasses have sufficient growth time with photosynthetic tissues (leaves) intact to replenish inner reserves twice during the growing season and to respond to autumn climatic stimuli that cause plants to prepare for winter. With more frequent harvests, tall-growing grasses with few basal leaves, such as bromegrass, become more susceptible to subsequent winter injury.

FORAGE YIELD

High yields of forage are desirable to maximize efficiency of land use. High forage yield per acre is of much greater concern to a dairy farmer who grows forage on limited rotational cropland than to a beef rancher in southwest Alaska with extensive areas of year-around grazing lands. Beef producers on the mainland, who must feed stored forages during winter, also desire high yields from often limited cropland acres. Major factors that contribute to dependable, consistent high yields include the choice of Alaskan-adapted varieties of high yielding forage species and the application of optimum rates and ratios of needed fertilizer elements (1, 52, 57, 58, 59).

Forage yield and forage quality are dynamic characteristics that tend to be inversely related; that is, both change in a forage stand as the plants grow and change with time during the growing season—total dry-matter yield increases while quality generally declines.

In planning harvest dates of perennial forages that are harvested twice during Alaska's relatively short growing season, it is important to know that delaying the first harvest to obtain higher dry-matter yield results in lower quality first-cutting forage, and also shortens

the period available for regrowth for the second cutting. Therefore, the date of first harvest has a dominant effect on relative yields in the first and second harvests.

FORAGE QUALITY

Quality refers to intrinsic traits of forages that govern the performance of animals that consume them. High quality forages contribute to maximum weight gain or milk production and optimum animal health. In general, a high quality forage is very digestible and contains high levels of protein; energy; and desirable minerals (especially calcium and phosphorus); and low levels of poorly digestible components such as lignin (62, 74).

Forage quality is usually highest at immature stages of growth and declines rapidly when forage plants near maturity. Just as quality generally decreases with advancing stages of plant growth, dry-matter yield increases. It is the grower's task to harvest a forage (weather permitting) at the stage of growth that represents the ideal compromise between declining quality and increasing yield. In agricultural districts of south-central and interior Alaska, typical first-cutting date for perennial grasses is near June 20-25. Second cuttings normally are harvested in late August to mid-September.

Different classes of livestock may differ in forage quality requirements, and this may influence a decision on the timing of harvests. For example, a grower would sacrifice some dry-matter yield to obtain higher quality forage for high producing dairy cattle. On the other hand, forage in a maintenance ration for wintering horses or beef cows might be adequate at lesser quality, so a rancher might harvest somewhat later than a dairy farmer, opting for higher forage dry-matter yield at some compromise in quality.

Forage quality often declines between the time when the crop is cut and the time when it is fed. Rain that occurs during the process of field-curing hay before storage can lower quality. Leaf losses during drying and handling can further diminish its quality, as can spoilage, if hay is baled or stored loose with excessively high moisture content. Other quality losses occur with excessive time in storage. For example, the nutritionally important carotene (provitamin A), which is abundant in green plants but declines rapidly in bleached, weathered, or molded hay, undergoes further losses during long periods of storage.

Testing Forage Quality

The best predictive estimate of forage quality can be

made on the basis of crop species, growth stage at harvest, fertilizers applied, and growing conditions. Grower experience and earlier laboratory test results provide fairly accurate guidelines for harvesting forages at the optimum compromise between dry-matter yield and quality.

However, more accurate values for several quality factors can be derived through laboratory analyses of forages (62). These services are performed by the Alaska Agricultural Experiment Station laboratory (through the University of Alaska Cooperative Extension Service) as well as by private laboratories. Actual qualitative measurements of forages provide the basis for knowing how best to supplement them to formulate optimum full-feed rations for each class of livestock. Some of the most useful and available laboratory measurements of forage quality components include (a) crude protein; (b) digestibility (*in vitro* dry-matter disappearance = IVDMD); and (c) metabolizable energy (derived by formula from IVDMD). Analyses for other quality constituents, including specific minerals, also can be ordered.

FORAGE PALATABILITY

Desirable animal performance is fostered by high intake of very digestible, high quality forage, and intake (ingestion) requires that a forage be palatable. The term palatability refers to physical and chemical characteristics of forage plants that influence the consuming animals' choice for ingestion among two or more forages (61). Taste, smell, and physical condition of the forage can influence its palatability to livestock. These factors, in turn, can be influenced by plant species, stage of growth of plants, adequacy of soil moisture and nutrients, method of preservation, spoilage, and other factors.

In general, most commonly used, high quality Alaskan forages possess good palatability. Experimental pasture trials in which relatively small paddocks of different grass species are available simultaneously to grazing stock can reveal marked differences in grazing preference (5, 16); however, these relative preferences can differ as the grasses advance through progressively later stages of growth (5).

In pastures with mixed forage species, grazing cattle can exercise considerable selectivity among available plants. For example, they obviously find the commonly grown bromegrass, timothy, and bluegrass more palatable than the weedy grass called foxtail barley, for they graze the first three closely but reject the latter. Consequently, the foxtail barley is permitted to grow unchecked, and it reseeds and becomes more abundant. This grazing selectivity usually causes overgrazed, under-fertilized permanent and semipermanent pastures to become

dominated by this and other unpalatable weeds. Weedy areas in such pastures should be mowed shortly after the foxtail barley heads out and before such weedy species can produce viable seed. Badly infested pastures should be tilled and replanted if topography and other limitations permit.

Fecal and urine spots in pastures stimulate grasses to grow dark green, succulent, and taller than in the surrounding areas. However, despite the excellent appearance of the grass, such spots are avoided by grazing cattle, because objectionable smell or taste makes them less palatable.

GRASS MORPHOLOGY VERSUS USE

Various grass species differ considerably in growth form, and these differences determine how well a given grass will perform in various categories of use. The gross physical structure or growth form produced by a grass (a) changes with phenological development (as the grass advances through successive growth stages); (b) is governed by the particular genetic make-up of the species, ecotype, or variety; (c) can be altered within the growing season depending on how the grass is managed; and (d) determines how successfully a grass will perform and persist under different uses and management systems.

Forage production is only one of several ways in which grasses are employed in Alaska; they are also used for turf and for revegetating roadbanks and other disturbed areas, for grassed waterways, and for numerous other soil protection and amenity purposes.

Within the forage production arena, different types of growth are desirable for different types of forage production. The tall-growing stems of smooth bromegrass, for example, make that species ideal for machine harvest and good recovery of herbage. The shorter growing Kentucky bluegrass and red fescue, in contrast, possess more basal leaves that are easily lost during harvest procedures. The growth form of these latter species make them ideal for use in pastures and lawns, however, for they endure frequent partial defoliation with an abundance of leaf tissue left intact near the soil surface to continue uninterrupted photosynthetic (food manufacture) activity. In contrast, when the taller growing bromegrass is harvested frequently, it may be weakened and predisposed to winter injury. Engmo timothy, intermediate between these extremes, is a fairly tall growing grass that also possesses an abundance of basal leaves. If harvested frequently or grazed continuously, the basal leaves predominate, making it appear as a coarse turfgrass.

So-called "sod-forming" grasses are those that



Oats and awnless barley can be grown in alternate strips (as shown here) to preclude inter-species competitive effects that occur in totally mixed stands. Windrows of wilted barley and oats are being chopped into a

forage wagon. This operation, followed by transfer into silo, totally mixes the oats and barley.

spread vegetatively by the growth of underground stems, called rhizomes. Examples of some grasses that spread vigorously by this means are smooth brome grass, Kentucky bluegrass, quackgrass, reed canarygrass, creeping foxtail, and beach wildrye. Examples of other grasses that also display this growth behavior, but spread less vigorously, are red fescue, meadow foxtail, and native bluejoint. This underground spread is valuable in filling gaps in stands and in helping to bind soils against erosional forces. Too-vigorous vegetative spread can render older grass stands less productive. When this occurs, stands are said to be "sod-bound" and require higher rates of fertilizers to maintain forage productivity.

Grasses that do not spread by underground rhizomes or aboveground stolons are called bunchgrasses. These produce a tufted growth or clump that gradually enlarges as tillers are produced around the outer edge of the tuft. Examples are timothy, slender wheatgrass, annual bluegrass, and Bering and tufted hairgrasses.

SPECIFIC FORAGE CROPS

Forage crop species, like other plants, can be

categorized by life span (see Table 2) into (a) annuals—plants that die after completing their life cycle within one growing season, such as spring oats and annual ryegrasses; (b) winter annuals and biennials—plants that die after completing their life cycle during two growing seasons, such as winter rye and biennial sweetclovers; and (c) perennials—plants that normally live for an indefinite time longer than two years, such as brome grass, timothy, and alfalfa.

ANNUAL FORAGES

Among the continuing mainstays of forage production in Alaska are the annual oat-pea, oat-vetch, or oat-barley mixtures. These mixtures consist of approximately equal quantities of oats + Canadian field peas, oats + common vetch, or oats + awnless barley planted in spring and harvested once in late summer (6, 7, 13, 19, 32, 34). These crops usually are preserved as hay or silage (Table 1).

Another annual forage that produces well in Alaska and finds favor with some dairymen is annual ryegrass (5, 16, 50). This grass is valuable for its retention of high



High-producing dairy cows require a year-around, abundant supply of palatable, nutritious forage. The summer grazing season can be extended into autumn by use of tetraploid annual ryegrass, as shown being grazed by cows on October 7.

herbage quality and feeding value when it is at leafy stages of growth, which last until the occurrence of hard frost in October. Perhaps the best way to use this grass in Alaska is to seed it in spring with another annual forage such as oats, oats-peas, or oats-barley. With early planting and early harvest of the cereal forage, a sufficient portion of the growing season remains for the annual ryegrass to regrow to provide a good late-season pasture or green-chop (50). Some dry hay should be fed to avoid a diarrhea effect that occurs when ryegrass is consumed alone. After heading, annual ryegrass rapidly becomes stemmy and less desirable as a forage, particularly to grazing stock (5).

Another annual crop that is often confused with ryegrass because of name similarity is the cereal rye. Both summer-annual (sown in spring) and winter-annual (sown in late summer for production the following year) types of this crop exist. The winter-annual type, called winter rye, can be used for spring pasture in Alaska. The most winter-hardy varieties of winter rye survive Alaskan winters much better than the most winter-hardy varieties of winter wheat, winter barley, or winter oats. Only the most winter-hardy rye varieties should be used in Alaska, and they should be planted no later than mid-August, perhaps immediately following an early harvest of an oat-pea or oat-barley crop (36, 38).

Annual forages produce good yields with less fertilizer input (especially nitrogen) than perennial grasses. However, the annual costs of seed, seedbed preparation, planting, and weed control during establishment must be weighed against annual forages. Oat-pea, oat-vetch, and oat-barley mixtures are harvested only once late in the growing season, while perennial grasses usually are harvested at least twice per season.

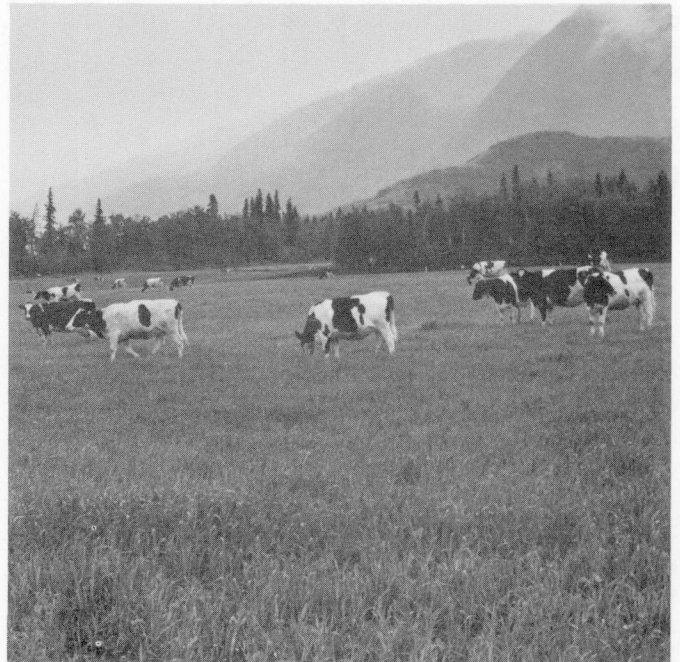
As mentioned in the previous discussion on crop adaptation, warm-season annual forages are unsuited for use in Alaska. They make very little growth due to prohibitively cool growing seasons.

PERENNIAL FORAGES

In contrast to the short life span of annual forage crops, perennial forages represent a special form of agricultural crop. Few other plants could withstand the harvest and removal of virtually all of their above-ground growth at least twice per year, yet meet their own requirements for life and persist year after year as healthy, vigorous plants. This unique capability of perennial forages (a) contributes to their value as a continuous vegetative cover that prevents erosional soil loss; (b) circumvents the labor and costs necessitated by the annual tillage required for other crops; and (c) provides earlier pasturage or first-cutting forage than is obtainable from annual crops. Perennial grasses, however, normally require higher rates of fertilization, especially nitrogen (57, 58, 59), to achieve maximum yields than do annual forages.

Legumes

Legume forages, which are widely used in other states and Canada, are valued highly there, for they equal or surpass grasses in palatability and nutritional value. Moreover, legumes are also prized for their ability to incorporate otherwise unavailable atmospheric nitrogen into plant tissues, which adds to their nutritional worth as well as enriching the soil (47). However, the



Adapted perennial forage grasses are the mainstay of the forage supply for Alaska's dairy herds. With adequate fertilization and proper stocking rates, these grasses provide abundant, nutritious summer pasture. Ungrazed stands of the same grasses in other fields produce hay and silage for winter feeding.

important legume forage species and varieties that are so valuable and widely used in other areas are not dependably winter-hardy in Alaska.

Because of the several desirable characteristics of legumes as forage crops, legume improvement research has been pursued in Alaska to develop dependably winter-hardy varieties of introduced species for Alaskan use. Considerable progress in this area has been made with alfalfa (41, 54); red clover (26); and sweetclover. Potential for use also may be found in birdvetch (48) and alsike clover; the latter legume is somewhat more tolerant of soil acidity than the others.

Alaskan varieties of Alaskland red clover and Denali alfalfa have been developed, but seed supplies currently are very limited. Although these varieties are more winter-hardy in Alaska than any other varieties of alfalfa and red clover, neither is as winter-hardy as the hardiest perennial grasses commonly used. Mainly for this reason, no legume forages are currently grown on a significant scale in Alaska; however, the probability of their wider use in the future in areas of Alaska with favorable soil and climatic conditions is quite likely. Continued increases in hardiness development in each species will enhance their dependability, and increases in seed supplies of new, superior varieties will permit their wider use.

Many legume species are native to Alaska. Those judged to offer the greatest potential for forage use have been evaluated (39). Although their adaptation to the Alaskan climate confers superior winter-hardiness, they are generally deficient in other important agronomic characteristics and therefore offer little potential for widespread use.

INTRODUCED GRASSES

Because perennial forage legumes are generally deficient in winter-hardiness, perennial forage production in Alaska is primarily dependent on the hardier grasses. Moreover, the sometimes complex grass mixtures used in other parts of the United States are seldom used for forage in Alaska. One or two species, at most, are seeded.

Once they are established, adapted, cool season, perennial grasses require only annual applications of top-dressed fertilizers to be productive. And among all crops grown, perennial grasses are without equal in the stabilization and conservation of soils. Where topsoil is thin, or where erosion potential from wind or water is high, perennial grasses provide a productive crop while protecting and holding precious soil in place. But forages, like other crops, generally are most productive on deeper soils that provide adequate water holding capacity to supply needed moisture to crops during

drouthy periods. Most agricultural areas in Alaska are characterized by barely adequate precipitation, especially during the first half of the growing season. Supplemental overhead sprinkler irrigation, while adding to production costs, is used by some farm operators to assure needed production when precipitation and soil moisture become deficient.

Prior to the development of Alaskan varieties of grass and the recognition of superior timothy winter-hardiness in certain varieties from northern Europe, the only option for Alaskan farmers was to purchase seed of forages commonly grown in the conterminous 48 states or Canada (27). These generally poorly adapted perennials often are deficient in winter-hardiness for dependable use in Alaska. More appropriate for Alaska are certain forage crops from the northernmost areas of Scandinavia; those varieties are better attuned to Alaska's north-latitude climatic influences than varieties of more southern origins in North America. Of even greater importance to Alaskan growers has been the development, through resident plant breeding and selection programs, of new perennial forage grass varieties possessing ideal adaptation to the Alaskan environment.

The perennial grasses most commonly seeded in Alaska are smooth brome grass and timothy. The follow-



Smooth brome grass is Alaska's most dependable and widely used perennial forage grass seeded on rotational croplands and pastures. Northern-adapted varieties serve well for hay, silage, green-chop, or pasture. Experimental studies, as shown above, determine productivity, quality, and persistence of brome grass on various harvest schedules.

ing is a discussion of those two species and other grasses as they relate to forage production in Alaska.

Smooth Bromegrass

This cool-season grass is a sod-forming, long-lived perennial that serves well as pasture (12, 14, 15) or preserved as hay or silage. Polar bromegrass (23, 37, 75), developed in Alaska, represents some hybridization between winter-hardy selections of introduced smooth bromegrass and northern-adapted native bromegrass. Polar is the most winter-hardy variety of this grass available to Alaskan growers. Seed supplies of Polar are sometimes inadequate to meet demands, but attempts to increase local seed production are continuing. When Polar seed supplies run short, farmers plant the most winter-hardy of the introduced bromegrass varieties (Carlton, Manchar, or Canadian commercial). Seed availability of these bromegrasses usually is good. There are many varieties of bromegrass grown in the conterminous 48 states that are inadequately winter-hardy for dependable use in Alaska. This is especially true of varieties of "southern type" smooth bromegrass and Regar meadow bromegrass.

The native Alaskan pumpelly bromegrass will very likely see increased use for forage production and soil stabilization and conservation purposes in the future. It resembles smooth bromegrass in appearance and growth characteristics, and it is extremely winter-hardy and produces good seed yields (37, 40, 43, 44). With two harvests per year, second cuttings of pumpelly brome are lower yielding than hardy varieties of smooth brome.

Timothy

This cool season bunchgrass is much used for forage in Europe and North America. Engmo, an introduction from northernmost Norway, is the most winter-hardy and most widely used variety of timothy in Alaska, although Engmo is not as winter-hardy as Polar bromegrass. Timothy is somewhat less tolerant of moisture deficit than bromegrass, but is somewhat more tolerant of soil acidity than bromegrass.

Creeping Foxtail

Garrison, a variety of creeping foxtail from the northern states, is quite winter-hardy, and its use may increase in the state. Creeping foxtail is a rhizomatous (sod-forming) grass, like smooth bromegrass and reed canarygrass, and can be useful for protective soil cover as well as for forage. Seed supplies of Garrison are often limited.

Reed Canarygrass and Meadow Foxtail

The most winter-hardy strains of both of these species are less winter-hardy than Polar bromegrass and Engmo timothy, but both are more tolerant of soil acidity than the latter two grasses. Reed canarygrass and meadow foxtail are used where soils are somewhat more acidic and winter stress is not severe; therefore, they are more used on the Kenai Peninsula than elsewhere in the state. The Canadian variety of reed canarygrass, Frontier, should be preferred for Alaskan use over varieties of more southern adaptation. There are no named varieties of meadow foxtail. Meadow foxtail closely resembles timothy when headed, but seeds of meadow foxtail retain hairy, seed-enclosing structures upon threshing, whereas timothy seed is naked after threshing. Therefore, meadow foxtail seed lots are fluffy and light and feed through planting mechanisms with more difficulty.

Kentucky Bluegrass

This perennial, sod-forming grass is sometimes seeded in pasture mixtures, but is a frequent invader even where it is not planted. It is an excellent pasture grass if kept grazed in the leafy stage. As with other grasses, Kentucky bluegrass tends to become less palatable to grazing stock after seed heads emerge.

Kentucky bluegrass is most used as a lawn grass in Alaska, where winter-hardy varieties such as the locally developed Nugget are unsurpassed when mowed to produce a dense, durable turf. However, winter-hardy Kentucky bluegrass also can be very productive of forage on good soils that are well-supplied with moisture. Its main disadvantage as a harvested forage is that it is shorter than bromegrass and timothy. The vacuum action of flail-type harvesters can recover more of this short growth than mowing and raking.

Red Fescue

Red fescue is native to Alaska but, like Kentucky bluegrass, much of the seed planted in Alaska is imported. Within both species, varieties available from other areas show a great range in winter-hardiness when grown in Alaska (49), and care should be taken to select only hardy varieties for use. No introduced red fescues are as winter-hardy as the Alaskan variety Arctared (25). Second choice for use in Alaska are the Canadian varieties Duraturf and Boreal. U.S. varieties such as Illahee, Ranier, and Clatsop are relatively nonhardy in Alaska (40, 49). Red fescue has finer leaves and spreads less vigorously underground than Kentucky bluegrass. Winter-hardy varieties that are adequately supplied with



Experimental studies are used to determine agronomic characteristics and the potential value of native grasses for various uses. In this photo, bluejoint (left plot) and polargrass (right) show excellent persistence and

moisture and soil fertility are productive of forage (64). Like Kentucky bluegrass, red fescue tolerates frequent defoliation (as in lawn use), and therefore withstands close, frequent grazing in pastures.

Quackgrass

This member of the wheatgrass family is a very winter-hardy, sod-forming perennial that thrives under Alaskan growing conditions. It is generally considered to be a weed because of its ability to spread rapidly into new field areas, and because of the cost and difficulty of eradicating it after it is established. It spreads both by seeds and vegetatively by vigorous growth of rhizomes (underground stems). Its spread is further aided when pieces of rhizomes adhere temporarily to tillage equipment. By this process, quackgrass spreads within a field, from field to field, and sometimes from farm to farm. A great many cropland fields in Alaska that have been in production for an extended period contain significant infestations of quackgrass. Tillage alone will not eradicate quackgrass in the cool, semi-humid Alaskan environ-

ment; the only effective means of eradicating this persistent grass in Alaska is through use of appropriate chemical weed killers.

vigor on June 21 following two forage harvests per year during the two previous years.

Despite the serious weed problems of this grass in grain crops, potatoes and other vegetables, lawns, and flower gardens, it is nonetheless a very productive (69) and often inadvertently used forage grass. Prior to emergence of seed heads, the leafy growth of quackgrass is superficially similar to—and often mistaken for—brome grass. They are easily differentiated after heading, because the seed head of quackgrass is a slender spike, as is typical of other wheatgrasses, while brome grass has a branched seed head (panicle), as do oats and bluegrass.

NATIVE ALASKAN GRASSES

Bluejoint

Early visitors to Alaska's southern coast marveled at the extent and apparent productivity of the grasslands they saw (71). Most of Alaska's tall-grass rangeland was

then and is now dominated by the native perennial called bluejoint reedgrass or simply bluejoint. This was undoubtedly the dominant forage grass used by the early Russian settlers in Alaska. Its use has continued for the nearly 200 years that cattle have been kept in this state (27, 55). Bluejoint is also cut for "wild hay" in native stands in Canada and the midwestern United States.

Advantages of bluejoint as a forage grass in Alaska include its widespread occurrence in extensive stands (31, 55, 65); its extreme winter-hardiness and ideal adaptation to the Alaskan environment; its ability to grow well on considerably more acidic soils than the commonly used, introduced forage grasses (65); and its good forage productivity when properly managed (31, 63, 65).

Problems are encountered in utilizing virgin stands of the grass owing to the typically heavy surface layer of organic debris in various stages of decomposition that has accumulated from many earlier years' growth (55, 65). This layer often is very hummocky and requires either removal by burning or blading (31), or leveling through mechanical mixing of the surface organic mat and underlying mineral soil (65). If left in place, this layer prevents most top-dressed fertilizers from reaching the living grass, through both physical impedance and biological incorporation.

When unfertilized bluejoint in Alaska has been subjected to relatively intensive utilization through grazing or mechanized harvest, stands of this tall-growing grass have persisted poorly (55, 65). To maintain bluejoint stands, some ranchers harvest stands only once in alternate years. Bluejoint is persistent and productive, however, with one or two harvests per season from adequately fertilized stands from which excessive accumulations of surface organic debris have been removed (31, 58, 65).

There are certain difficulties in utilizing bluejoint as a seeded cropland forage, which would be a desirable course on soils that are too acidic for other forage grasses. These include relatively low seed yields (66), extremely small seeds that require special processing during threshing (51), and very slow seedling growth during establishment of stands.

Considerable information has been derived in Alaska during recent years on changes in quality of bluejoint forage throughout the growing season, responses of the grass to fertilizers and stand modification, nutritional value at various growth stages, and how best to manage it for good yields of quality forage (31, 55, 58, 62, 63, 65, 69). An Alaskan variety of bluejoint, Sourdough, has been selected, primarily for use in revegetation (66, 68).

Polargrass

Another tall-growing, extremely winter-hardy

native grass called polargrass has widespread distribution in Alaska and superficially resembles bluejoint (33, 66, 67, 69). Like bluejoint, polargrass has extremely small seeds. Polargrass does not exist in native stands as extensive as those of bluejoint, but is at least as productive of forage where precipitation and soil moisture are abundant. It is among the first grasses to show symptoms of moisture stress and to become less productive when moisture becomes limiting.

Seed supplies of polargrass are very limited. Seed of the Alaska variety Alyeska has been increased for revegetation plantings (66, 67). However, seed expense, limited availability, and greater stand establishment problems of polargrass, as compared with bromegrass or timothy, will preclude its use as a cropland forage for at least the immediate future.

Beach Wildrye

This coarse grass is mostly confined to coastal areas. It is common on tidal flats, coastal dunes, beaches, and shorelines from northern California to arctic Alaska. Despite the extreme length of its range, beach wildrye seldom exists in broad, extensive stands. On Kodiak Island and other coastal agricultural areas in Alaska, useable stands of beach wildrye have been grazed and occasionally preserved as hay or silage (27).

This grass typically produces little seed, spreading primarily by vegetative means with a vigorous network of underground stems. Beach wildrye has been evaluated in seeded plots on upland soils where it grows and produces fairly well, but develops a relatively open stand that lacks the denseness of more productive forage grasses.

Hairgrass

Two native Alaskan species of hairgrass offer considerable potential for forage use (69). Bering hairgrass occurs naturally on lowlands all along Alaska's southern coast. Tufted hairgrass is more widespread; its native range covers most of the state.

Both produce an abundance of basal leaves, which impart greater tolerance to grazing pressure than grasses that do not. On the more heavily stocked areas of Kodiak Island, the formerly widespread and dominant bluejoint, which tolerates close grazing poorly, has been gradually supplanted by hairgrass. In many such areas, bluejoint has been virtually eliminated, and hairgrass dominates.

Other Native Species

Alaska has a considerable diversity of native grass

species in addition to the few discussed previously. Several others contribute to the vast range resource in the state, and some can contribute harvested or pastured forage in local situations.

The largest genus of native grasses in Alaska is bluegrass (more than two dozen species). Others which contribute to the forage resource include several other reedgrasses related to bluejoint, several wheatgrasses, other hairgrasses, fescues, two species of holy grass, and alpine timothy.

Sedges are grasslike in appearance, but are not true grasses; they can be utilized as forage where they are abundant. Some species of sedge are used for forage in Canada and Iceland. Sedges usually grow in sites that are well-supplied with moisture. The sedge genus Carex is quite extensive and includes more than 100 species that are native to Alaska.

Kelp and Seaweeds

Native range grasses and forbs on Alaska's southwestern islands are supplemented in livestock diets by kelp and seaweed that become accessible when they wash up onto the island beaches. These ocean plants have a long history of artificial harvest in the coastal United States and Europe for processing into meal for feeding to cattle, sheep, swine, and poultry. Kelp and seaweed are known to contain nutritionally valuable vitamins, amino acids, and mineral elements. Therefore, island ranchers find it less necessary to provide salt and mineral supplements to island stock.

POISONOUS PLANTS

Certain native plants that have lethal or sublethal effects when consumed by livestock have been and will continue to be a threat in permanent pastures in Alaska. The two most evident types of effects of toxic plants on ruminants in Alaska are (a) sublethal poisoning or death of the animal consuming the plants, and (b) congenital effects resulting in death, physical deformity, or nervous system disorders of calves or lambs as a result of the mother animal ingesting toxic species at certain critical periods during fetal development.

Perhaps the most deadly plant in Alaska is water-hemlock, a plant common along streams and in marshy areas (30, 42). Tall larkspur has been responsible for

cattle deaths in several areas. This native larkspur is related to and resembles the common delphinium of flower gardens. It occurs in lowlands, in woodland pastures, and on well-drained uplands. Seaside arrowgrass, which is not a true grass, is common on tidal flats. Plants suspected of causing congenital injury to calves and lambs are false hellebore and nootka lupine (60).

Most poisonous plants cannot persist on tilled croplands. However, all of the above toxic plants, and others discussed elsewhere (42), frequently grow in association with desirable forage species in permanent pastures. Poisoning of grazing animals is not restricted to the growing season; swamp horsetail has been lethal to horses on lowland range during winter in the Matanuska Valley (56).

THE FUTURE

Forages currently are the most widely grown crops in Alaska. Adapted varieties thrive when grown on good soils with proper management, and most potential agricultural areas of Alaska are suited to the production of forages. Forage crops will continue to play a dominant role in Alaska as long as the livestock enterprises that utilize forages prosper. The potential for expanded production of forages in Alaska is limited only by available lands and by the scale of livestock production for which forages are produced.

An agricultural research program of meaningful scale and scope has been active in subarctic Alaska for only a very few years, far fewer than programs in the 48 conterminous states. Research can contribute much toward Alaskan agricultural development and stability through continued improvement of crop varieties, study of fertilizer action and biological activities in cold soils, devising superior management techniques, studies to understand problems in crop winter survival, and other advances.

Future research contributions, increased farmer and rancher acceptance and use of superior crop varieties, improved management practices, and other technological advances appropriate to subarctic agriculture will insure against hazards in forage and livestock production and will assist overall food production in northern latitudes. Alaska will then be less dependent on distant food production and long, expensive, and vulnerable routes of supply.

Table 2
Common and Latin Names of Plant Species Discussed

<u>Plants</u>	<u>Common name</u>	<u>Latin name</u>
I. ANNUALS:		
Introduced grasses:	Annual ryegrass	<i>Lolium multiflorum</i>
	Barley	<i>Hordeum vulgare</i>
	Field corn	<i>Zea mays</i>
	Oats	<i>Avena sativa</i>
	Pearl millet	<i>Pennisetum typhoides</i>
	Sorghum	<i>Sorghum bicolor</i>
	Sudangrass	<i>Sorghum sudanense</i>
	Winter rye	<i>Secale cereale</i>
Introduced legumes:	Common vetch	<i>Vicia sativa</i>
	Field pea	<i>Pisum arvense</i>
II. BIENNIALS:		
Introduced legumes:	White sweetclover	<i>Melilotus alba</i>
	Yellow sweetclover	<i>Melilotus officinalis</i>
III. PERENNIALS:		
Introduced grasses:	Creeping foxtail	<i>Alopecurus arundinaceus</i>
	Kentucky bluegrass ¹	<i>Poa pratensis</i>
	Meadow brome grass	<i>Bromus biebersteinii</i>
	Meadow foxtail	<i>Alopecurus pratensis</i>
	Quackgrass	<i>Agropyron repens</i>
	Red fescue ¹	<i>Festuca rubra</i>
	Reed canarygrass	<i>Phalaris arundinacea</i>
	Slender wheatgrass ¹	<i>Agropyron trachycaulum</i>
	Smooth brome grass	<i>Bromus inermis</i>
	Timothy	<i>Phleum pratense</i>
Introduced legumes:	Alfalfa	<i>Medicago sativa</i>
	Alsike clover	<i>Trifolium hybridum</i>
	Birdsfoot trefoil	<i>Lotus corniculatus</i>
	Birdvetch	<i>Vicia cracca</i>
	Crownvetch	<i>Coronilla varia</i>
	Red clover	<i>Trifolium pratense</i>
	Sainfoin	<i>Onobrychis viciaefolius</i>
	Siberian alfalfa	<i>Medicago falcata</i>
	White clover	<i>Trifolium repens</i>

¹Also native in Alaska

Table 2 (continued)

Native grasses:

Alpine timothy	<i>Phleum alpinum</i>
Beach wildrye	<i>Elymus mollis</i>
Bering hairgrass	<i>Deschampsia beringensis</i>
Bluegrass	<i>Poa</i> spp.
Bluejoint	<i>Calamagrostis canadensis</i>
Fescue	<i>Festuca</i> spp.
Hairgrass	<i>Deschampsia</i> spp.
Holy grass	<i>Hierochloe</i> spp.
Polargrass	<i>Arctagrostis arundinacea</i>
Pumpelly bromegrass	<i>Bromus pumpellianus</i>
Reedgrass	<i>Calamagrostis</i> spp.
Wheatgrass	<i>Agropyron</i> spp.

IV. WEEDS AND
POISONOUS PLANTS:

False hellebore	<i>Veratrum eschscholtzii</i>
Foxtail barley	<i>Hordeum jubatum</i>
Nootka lupine	<i>Lupinus nootkatensis</i>
Seaside arrowgrass	<i>Triglochin maritima</i>
Tall larkspur	<i>Delphinium glaucum</i>
Waterhemlock	<i>Cicuta mackenzieana</i>

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This semipermanent pasture shows differential utilization of palatable and unpalatable grasses by grazing cattle. Palatable grasses such as Kentucky bluegrass, shown in the foreground, have been heavily grazed, while the equally available but unpalatable weedy grass called foxtail barley, shown here in scattered clumps, has not been grazed. This permits it to grow tall, produce seed heads, and eventually mature seed, if it is not clipped shortly after seed heads appear to prevent it from spreading further.

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