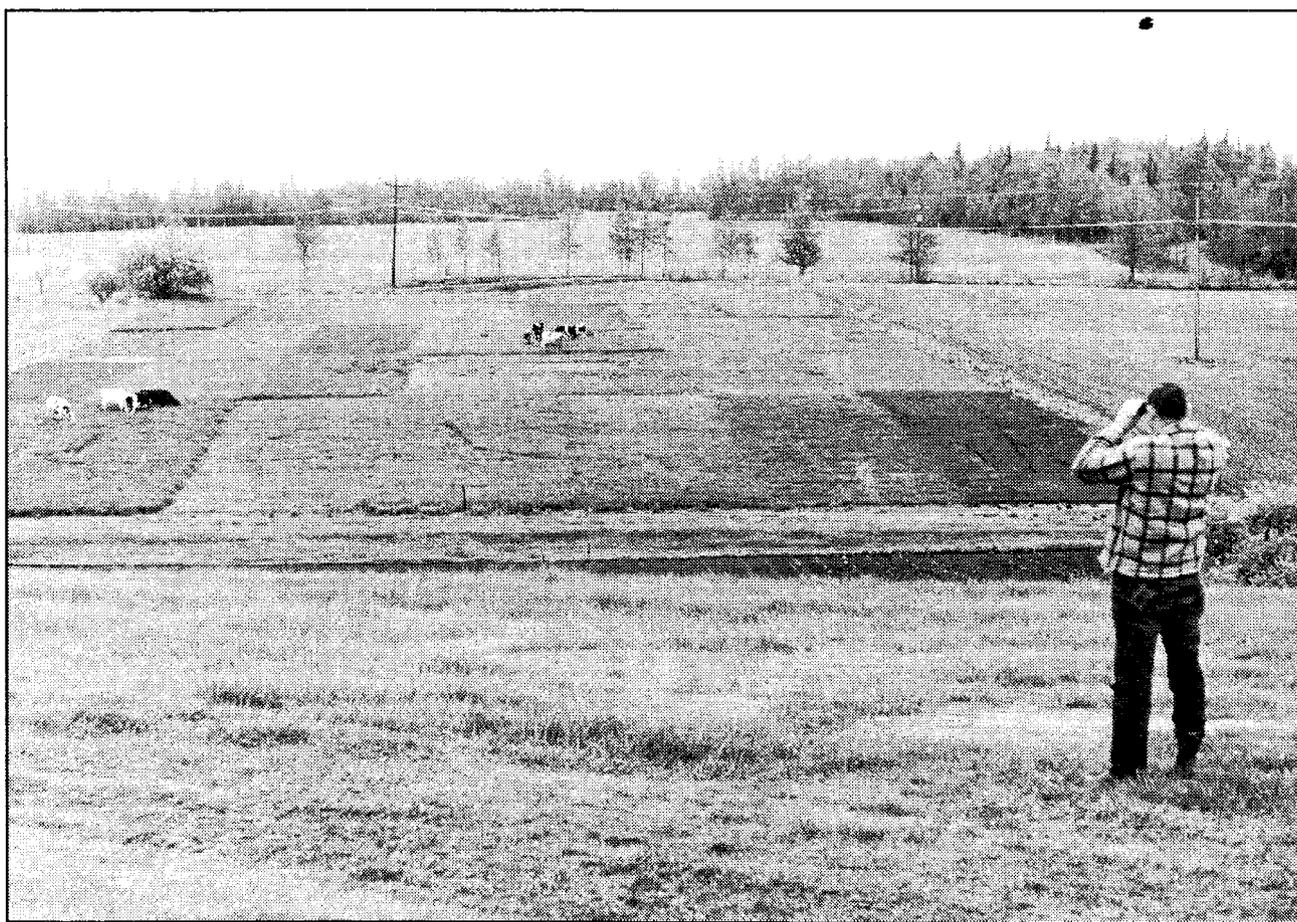


Relative Grazing Preference, Herbage Yield, *In Vitro* Digestibility, and Other Comparisons Among Seven Perennial Grasses at Various Times of the Year in Southcentral Alaska

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SUMMARY

This report summarizes a two-year study of dairy cow grazing preference among seven perennial grasses at various times during the growing season conducted at the University of Alaska's Matanuska Research Farm (61.6°N) near Palmer in southcentral Alaska. Other factors documented were herbage yields, digestibility (*in vitro* dry-matter disappearance = IVDMD), winterhardiness, and persistence of grasses.

Grasses compared were three named cultivars released by this station: 'Polar' bromegrass (*Bromus inermis* Leyss. x *B. pumpellianus* Scribn.), 'Nugget' Kentucky bluegrass (*Poa pratensis* L.), and 'Arctared' red fescue (*Festuca rubra* L.); 'Engmo' timothy (*Phleum pratense* L.) from northern Norway; 'Garrison' creeping foxtail (*Alopecurus arundinaceus* Poir.) selected in North Dakota; and two native Alaska grasses, Siberian wildrye (*Elymus sibiricus* L.) and arctic wheatgrass (*Agropyron sericeum* Hitchc.).

- Monitored observations of grazing time from entry to paddocks until satiation showed marked differences in preferences among grasses and a clear preference for Polar bromegrass during both years.

- Second choices, with no clear superiority between them, were Engmo timothy and Nugget Kentucky bluegrass.

- Least preferred of the seven grasses were Arctared red fescue, native Siberian wildrye, Garrison creeping foxtail, and native arctic wheatgrass.

- Polar bromegrass produced good early spring growth in both years but when harvested on 3 June in both years (18 to 24 in. tall) was very slow to begin vigorous regrowth, a previously known characteristic of smooth bromegrass.

- Nugget Kentucky bluegrass and Arctared red fescue, unlike bromegrass, produced rapid and vigorous regrowth after early June harvest and produced highest total yields of herbage and best distribution of yields throughout the growing season.

- There was little consistency in ranking for herbage digestibility (IVDMD) among grasses at different grazing times.

- One consistent pattern in digestibility comparisons was a general superiority of Engmo timothy over other grasses during the latter half of the growing season.

- In sharp contrast to timothy, arctic wheatgrass herbage generally was lowest in digestibility after mid-season and that wheatgrass was very little grazed at any time.

- In spring growth of 1974, before any harvests that interrupted growth, the two native grasses, Siberian wildrye and arctic wheatgrass, surpassed all other grasses (except Arctared red fescue) in herbage production, averaging 1.76 T/A on 3 June and 2.33 T/A on 12 June.

- Siberian wildrye and arctic wheatgrass, both extremely winterhardy when harvested twice per year in other studies, gave evidence in spring 1975 of severe winter injury where they had been cut three times (harvested after each two-day grazing session) in 1974.

- After slow early growth in spring of 1975, Siberian wildrye and arctic wheatgrass recovered well to produce good growth after the early June grazing & herbage removal; however, after a second grazing + harvest in late June (reps. I & III) or mid-July (reps. II & IV), those native grasses, not accustomed to harvest in the wild, recovered slowly or not at all.

- Engmo timothy, which should not have been injured by three harvests in 1974 because it has tolerated frequent harvest well in other studies, was the least winterhardy of all grasses as shown by injured stand and poor vigor of early growth in 1975.

- There was little consistent relationship between succulence of herbage and grazing preference. Although the preferred bromegrass and timothy often were among the most succulent, Kentucky bluegrass also was one of the three most-grazed grasses but often was highest in percent dry matter (was the least succulent) of the seven grasses.

- From the initial growths of all grasses in the two years, the progressively later regrowths generally increased in percent dry matter (decreased in succulence).

- Succulence and digestibility of herbage were determined on whole-plant samples, but cows grazed only the upper, more leafy portions of plants; that discrepancy may be responsible, to an unknown extent, for the poor relationships between grazing preference and (a) succulence and (b) digestibility.

- Although Nugget is a relatively short-growing, "dwarf" type of Kentucky bluegrass, and Polar bromegrass grows quite tall, the slow regrowth of bromegrass after early June harvest, contrasted with rapid regrowth of Nugget, suggests that use of separate stands of the two, or a mixture of both grasses might be evaluated in an attempt to secure a more uniform supply of pasture herbage. Engmo timothy, too, could be added for its good grazing preference, high digestibility, and tolerance of frequent harvests.

- If these most-preferred grasses were to be combined into a mixture, the different growth types and behaviors would require further study to determine compatibility of species, desirable proportions, optimum management practices, and responses of individual species to different intensities, types (pasture vs. green chop), and schedules and frequencies of utilization.

INTRODUCTION

Importance of Forages

Forage crops, a category consisting predominantly of herbaceous grasses and legumes, are grown worldwide for consumption by livestock. About 100 species of grasses and legumes are grown for forage in this country, and more U.S. land is devoted to forages than to all other crops combined (Hodgson 1976a, 1976b).

Forage crops are all characterized by a relatively high content of cellulose, hemicellulose, and lignin; as such they are indigestible by humans. Forages assume their high state of importance in world agriculture because ruminant animals can digest them, and thus produce animal products (meat, milk and other dairy products, wool, hides, etc.) useful to mankind.

Wedin *et al.* (1975) note that forages supply 89% of the feed units consumed by sheep and goats, 73% by beef cattle, and 63% by dairy cattle (the balance supplied by concentrate feeds such as grains and high-protein supplements). Hodgson (1976a) states: "Since forages provide more than half of the feed units for all livestock, and since about half of the food nutrients consumed by humans in the U.S. are of animal origin, one can conclude that from 25 to 30 percent of the food supply of the typical American is based on forage."

Utilization of Forages

The dairy cow serves as an efficient intermediary in converting forages into milk and meat, products invaluable in human nutrition (Hodgson 1979). Lactating cows require high levels of intake of highly digestible forage to promote and sustain high levels of milk production (Buxton and Mertens 1995; Hodgson 1979; McCullough 1959).

To provide a year-around supply of forage for livestock in temperate and subarctic regions, some forage growth must be harvested and preserved for winter feeding as hay, silage, or haylage.

During the growing season, dairymen have two options for utilizing green forage. It can be harvested with mechanized equipment and fed immediately as "green chop", with animals kept confined in the feeding area instead of having access to pastures. The other option is to pasture stock, with the animals themselves doing the harvesting in the field. This requires fencing but otherwise supplies feed at the lowest cost, requiring no machinery for harvest and less labor and expense than is required for the various mechanized harvest options (Bull 1995).

Forages in Alaska

Dairy cattle operations in Alaska, as elsewhere, are highly dependent upon a reliable, continuous, forage feed base. Both annuals and perennials are utilized for forage production in this state. Perennial forages are desirable and superior to annuals for soil protection, freedom from costs of annual tillage practices and annual weed control, and they provide spring pasturage earlier than can be obtained from spring-planted annuals.

Perennial legumes are much used in other world areas and are extremely valuable in pasture mixtures for their good palatability, high nutritional values, and for their symbiotic nitrogen-fixing capabilities (Archibald *et al.* 1943; Gesshe and Walton 1981; Hodgson 1976a; Ivins 1952; Johnstone-Wallace 1937; Smith *et al.* 1986). However, few perennial legumes are reliably winterhardy for use in this area (Klebesadel 1980, 1992a, 1993b, 1994c). Therefore, a single grass species or multi-species grass mixtures are used almost exclusively as the perennial forage base.

Moreover, very few perennial forage grass cultivars or strains adapted at more southern, mid-temperate areas of the world possess adequate winterhardiness for dependable use in this area (Klebesadel 1984, 1985, 1992a, 1993a, 1993b, 1994c; Klebesadel and Helm 1986, 1992). Accordingly, Alaska's forage breeding program has sought to develop dependably winterhardy, productive grasses adapted to climatic peculiarities of high latitudes (Hodgson *et al.* 1971a, 1971b, 1978).

Additionally, numerous inherently winterhardy native Alaskan grasses have been collected and evaluated for various characteristics and uses including forage production (Klebesadel 1969a, 1992b, 1993a, 1993c, 1994b, 1994c; Mitchell 1982, 1987).

In addition to such attributes as high levels of winterhardiness, herbage and seed production, digestibility, disease resistance, and other desirable nutritional and agronomic characteristics, superior forage grasses also should be palatable to consuming livestock (Hodgson 1979; McCullough 1959).

Palatability and Grazing Preference

A dictionary definition of palatability is "pleasant to the taste, agreeable to the palate." Ivins (1952) quotes other researchers who define palatability as "the sum of the factors which operate to determine whether and to what degree the food is attractive to the animal", that it constitutes "the connecting link between grass and the grazing animal", and he notes that several investigators believe that palatability of herbage is of greater importance than nutritive value.

Food preferences of different animal species differ greatly (Garner 1963). Except for laboratory investigations with small, caged mammals, most grazing-preference studies with herbage of various grasses and legumes have been conducted using cattle and sheep. This report and the references cited are confined for the most part to studies that involve cattle and grasses.

Whether fed in preserved forms, or as green chop, or grazed directly in the field, forage must be of high quality and also palatable to ensure high levels of intake. Marten (1970) compiled a comprehensive review of reports concerning forage palatability, definitions of the concept proposed by various investigators, and factors that influence it. Other earlier reviews of investigations concerning palatability and/or grazing preference have been presented by Garner (1963), Heady (1964), Ivins (1955) and Tribe (1950).

A review of pertinent literature, as listed in the references

of this bulletin, discloses that a considerable number of herbage characteristics and other factors have been identified or suspected of influencing palatability or grazing preference (either favorably or unfavorably) in livestock; these include:

- Appearance
- Taste
- Smell
- Touch
- Succulence
- Leafiness
- Breaking strength (toughness)
- Surface hairiness
- Surface moisture
- Other herbage available
- Time of Day
- Time of Year
- Weather conditions
- Soil conditions
- Rate of plant growth
- Breed of animal
- Previous dietary experience
- Physiological state of animal
- Protein content
- Sugars
- Carotene
- Crude fiber
- Nitrogen-free extract
- Phosphorus
- Potash
- Ash
- Mineral content
- Lignin
- Silica
- Stage of maturity
- Coumarin
- Tannins
- Plant strain or cultivar
- Mechanical texture
- Leaf scabrosity
- Fertilizer effects

Summarizing the role of palatability in grassland agriculture, Ivins (1952) quotes others in that "palatability is relative and has a profound influence on the stability of a sward, an indirect influence on the seasonal and aggregate productivity and warrants consideration in relation to the consumption of herbage and compilation of seed mixtures." However, the significance of palatability "cannot be separated from that of other factors such as inherent persistency, productivity and seasonal growth which together determine the value of grass."

Previous Grazing Studies in Alaska

Brundage *et al.* (1963) and Brundage and Branton (1967) compared nonhardy grasses and grass-alfalfa combinations for annual forage production and for dairy-cattle grazing preference at this station. Dr. A. L. Brundage and colleagues

at this station also have published several reports on pasture studies using dairy stock grazing brome grass or a brome grass-Siberian alfalfa mixture, with emphasis on pasture-management systems (Brundage and Sweetman 1964, + others). There have been no experimental comparison studies in Alaska, however, to document dairy cow grazing preferences among winterhardy perennial grasses, either cultivated or native.

Rotational pastures in Alaska generally are seeded with very simple mixtures (e.g., 2 to 3 species) or more often only one species, usually smooth brome grass or timothy. Therefore, selective grazing of differentially palatable species and the problem to regulating grazing intensity to maintain a balance among different forage species has been of little concern here. Those seeded pastures, however, frequently do contain varying amounts of the difficult-to-eradicate and generally ubiquitous quackgrass (*Agropyron repens*) and often some Kentucky bluegrass; both of those grasses tolerate close clipping or grazing, can make a valuable contribution to harvested forage or grazed pastures, and generally are of no concern in pasture management.

Need For Grazing-Preference Information

Alaska growers should be provided with credible experimental evidence of comparative palatability or grazing preferences among adapted introduced and native grasses in several different species that are known to be very winterhardy in Alaska's agricultural areas. This can assist in making prudent choices for plantings that can serve best in providing palatable, nutritious pasture and harvested forage to promote high levels of intake for desired high milk production and top health and performance in Alaska herds.

Johnstone-Wallace (1937), with experience in pasture composition and grazing management both in Great Britain and in northeastern U.S., summarized succinctly a wealth of observations and research on intensive pasture management as follows: "... cattle show a preference for pasturage consisting of short leafy herbage... a dense sward with a height of about 4 inches appears to approach the ideal. The senses of sight, taste, and smell appear to be used in determining the herbage to be eaten. The leaf is preferred to the stem. Short young herbage low in fiber is eaten in preference to old, tall, stemmy, and highly fibrous herbage. Certain grasses... are eaten in preference to others."

The last sentence relates most directly to the present study; an awareness of which of several adapted, very productive grasses would be preferred by grazing stock can be determined only by observing cattle choices among several on simultaneous offer in controlled, "cafeteria-style" experimental studies.

Alternative Herbages Available

Several investigators (Heady 1964; Ivins 1955; Rogler 1944) have noted that palatability or grazing preference of a given species is relative to alternative foods available. As an extreme example, a grass compared with several others that are *more* palatable could be rated low in palatability; conversely, if the same grass were compared with several

that were *less* palatable, it would rank high in palatability or preference. Therefore, relative preference of a species or strain, in the present study and in others, should be recognized in relation to the other choices that were available for the comparative determination.

Grasses Included in This Study

'Polar' bromegrass (predominantly *Bromus inermis* Leyss. x *B. pumpellianus* Scribn.), developed in Alaska, combines high levels of winterhardiness and herbage productivity (Hodgson *et al.* 1971a; Klebesadel 1994a, 1994b, 1994c; Klebesadel and Helm 1992; Wilton *et al.* 1966).

'Nugget' Kentucky bluegrass (*Poa pratensis* L.) and 'Arctared' red fescue (*Festuca rubra* L.) also are Alaska cultivars possessing superior turf characteristics, winterhardiness, and herbage production (Hanson 1972; Hodgson *et al.* 1971b, 1978; Klebesadel 1984, 1985, 1992a, 1992b, 1993a).

Timothy (*Phleum pratense* L.) is a species much used for forage and pasture in cool-season areas of the world. 'Engmo' timothy from northern Norway proved in trials here to be among the most winterhardy of many timothy cultivars evaluated from North America and Europe (Klebesadel 1992a; 1997b; Klebesadel and Helm 1986). However, despite its winterhardiness relative to other timothy cultivars, several studies at this location have shown it to be the least winterhardy of the seven grasses compared in this study (Klebesadel 1992b, 1993a, 1994b, 1994c).

'Garrison' creeping foxtail (*Alopecurus arundinaceus* Poir.), selected from naturalized stands of a Eurasian introduction in North Dakota (Stroh *et al.* 1978), has shown very good winter survival in earlier forage trials here (Klebesadel 1994c; Mitchell 1982).

Siberian wildrye (*Elymus sibiricus* L.) and *Agropyron sericeum* Hitchc., a high-latitude wheatgrass (hereinafter called arctic wheatgrass), are indigenous in Alaska (Hulten 1968). Both have been extremely winterhardy in evaluation trials here and have produced good yields of forage and seed (Klebesadel 1969a, 1993c; Klebesadel and Helm 1992; Mitchell 1982). Seed of the latter two species used in this study each consisted of bulked lots of several native Alaska collections selected for general desirability characteristics on the basis of limited experimental evaluations.

Although Polar bromegrass and Engmo timothy are routinely grown for forage here, neither of those, nor the other grasses listed above, have been evaluated for free-choice grazing preference by dairy stock in Alaska.

Types of Grass Growth Influence Utilization

Perennial grasses can be categorized in different ways according to their growth types, and those growth types are of significance for pasture and for other uses. One such classification refers to their behavior concerning lateral spreading growth. As illustrated in an earlier report (Klebesadel 1994c), the extremes are (a) non-spreading types, referred to as "tufted" or "bunch grasses", and (b) spreading types (via underground stems called rhizomes),

also called "sod-formers"; some (c) are intermediate between the two extreme types. Sod formers spread to fill in gaps in stands and are valuable as soil binders, a valuable attribute in protecting agricultural soils, but also useful in non-agricultural applications including revegetation and other soil conservation roles.

Of the grasses used in this study, bromegrass, Kentucky bluegrass, and creeping foxtail are sod-formers, red fescue is intermediate, and Siberian wildrye, arctic wheatgrass, and timothy are bunch type. A strange, rarely encountered anomaly has been noted, however, in Engmo timothy whereby a plant is found that produces short, horizontal, above-ground stems (stolons) that take root at the nodes.

Another categorization of grasses is that of general stature and leaf position, with some denoted as tall-growing and others short-growing, referred to by Archibald *et al.* (1943) as "top" grasses and "bottom" grasses, respectively. "Top" grasses carry their leaves up the culms and are "more suitable for hay" while "bottom" grasses have leaves more concentrated at the base of the plant and are "more suitable for grazing".

By this classification, bromegrass, creeping foxtail, and the two native grasses are tall-growing or "top" grasses, while Kentucky bluegrass and red fescue are short-growing or "bottom" grasses. North American timothy is a tall-growing or top grass (Archibald *et al.* 1943). However, Engmo and some other far-north-European timothies are intermediate between the two extreme types; they are tall growing but have a greater profusion of basal leaves that make them more tolerant of grazing pressure or frequent harvest (Klebesadel 1997b, see esp. Figs. 20,22).

Objectives of this study were to compare the aforementioned seven grasses for (a) relative grazing preference by dairy stock, (b) forage yields, (c) digestibility as measured by *in vitro* dry matter disappearance (IVDMD), (d) percent dry matter (succulence) of herbage, and (e) winterhardiness and persistence of stands. The study was conducted at the University of Alaska's Matanuska Research Farm (61.6°N) near Palmer in the Matanuska Valley of southcentral Alaska.

EXPERIMENTAL PROCEDURE

Seven perennial grasses were planted 20 June 1973 in broadcast-seeded paddocks in Knik silt loam (Typic Cryorthent). Pre-plant commercial fertilizer disked into the plowed seedbed supplied nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) at 32, 128, and 64 lb/acre, respectively. Individual paddocks measured 30 x 100 feet; a randomized complete block experimental design was used with four replications. Seeding rates in pounds of pure live seed per acre were bromegrass 20, timothy 6, Kentucky bluegrass 40, red fescue 35, creeping foxtail 25, Siberian wildrye 20, and arctic wheatgrass 20.

On 8 October 1973 a 20-foot strip was harvested from a representative area within each paddock, using a sickle-equipped plot mower and leaving about a 2-inch stubble. At this harvest and all future similar strip-harvests just prior to each grazing test in 1974 and 1975, a small bagged sample of herbage from each strip was dried to constant weight at 140°F and the percent dry matter in those samples used to

assess succulence of herbage and to calculate oven-dry yields of each grass available at each grazing session. An additional small bagged sample was dried to constant weight at 90°F, then ground finely for laboratory determinations of digestibility as *in vitro* dry-matter disappearance (IVDMD).

Except for the harvested 20-foot strips, all remaining 1973 growth of grasses was left in place over winter to assist in holding insulating snow cover to ensure good winter survival of Engmo timothy, known from other studies to be the least winterhardy of the seven grasses. That dead growth was clipped and removed from the entire experimental area on 29 April 1974.

Commercial fertilizer supplying N, P_2O_5 , and K_2O at 126, 96, and 48 lb/acre, respectively, was topdressed uniformly over the entire experimental area on 30 April 1974 and 21 April 1975 before grasses initiated spring growth.

A mid-season topdressing supplying N at 80 lb/A was applied to replicates I and III on 6 June 1974 and to replicates II and IV on 15 June 1974; in 1975 all four replicates



Figure 1. Agronomy foreman Darel Smith uses swather to clip grasses to short stubble on 5 June to remove uneaten herbage after 4+5 June 1975 grazing session. Grass in foreground is Siberian wildrye that recovered slowly in spring of 1975 following three harvests in 1974.

received the application in 17 June.

Grasses were grazed on a free-choice basis with four mature Holstein cows assigned at random to each of two replicates of the seven grasses (confined by relocatable electric fences) on two consecutive days at each grazing comparison. The animals were not fed prior to being driven to the experimental area shortly after 8:00 AM each grazing day. Grazing activity was recorded from an elevated vantage point using binoculars (see cover photo) at each five-minute interval from the beginning of the grazing period until satiation, when cows were removed from the experimental area, usually about 10:00 to 10:30 AM each day. Each observed cow grazing a specific grass was multiplied by five to calculate total "cow minutes" of grazing time.

Within two days after each two-day grazing session, all grass growth on the two replicates that were grazed was clipped and removed leaving about a three-inch stubble (Fig. 1).

Dates of harvest of 20-foot sample strips prior to grazing and dates of grazing during the two years were:

	1st	2nd	3rd	4th
1974:				
<u>Replicates I and III:</u>				
sampled	3 June	26 June	5 Aug	—
grazed	4+5 June	27+28 June	6+7 Aug	None
<u>Replicates II and IV:</u>				
sampled	12 June	31 July	—	—
grazed	13+14 June	1+2 Aug	None	None
1975:				
<u>Replicates I and III:</u>				
sampled	3 June	30 June	4 Aug	30 Sep
grazed	4+5 June	1+2 July	5+6 Aug	2+3 Oct
<u>Replicates II and IV:</u>				
sampled	10 June	14 July	23 Sep	—
grazed	11+12 June	15+16 July	25+26 Sep	None

RESULTS AND DISCUSSION

Seeding-Year Herbage Yields

No grazing was involved during the first year of grass growth. Seeding-year herbage yields and percent dry matter in herbage as sampled 8 October 1973 were as follows:

	Percent dry matter	Oven-dry T/A
Garrison creeping foxtail	14.9	1.37
Polar bromegrass	26.3	1.01
Arctared red fescue	17.3	0.93
Siberian wildrye	27.7	0.74
Nugget Ky. bluegrass	22.4	0.62
Arctic wheatgrass	32.0	0.48
Engmo timothy	25.0	0.45

Precipitation during the year of grass establishment was below normal. Normal precipitation for April through September at the Matanuska Research Farm is 10.17 inches; for that period in 1973 only 8.94 was received, a deficit of 1.23 inches. That deficit probably lowered seeding-year yields of all grasses, and possibly timothy more than most. In years of above-normal precipitation, seeding-year yields of timothy can surpass those of bromegrass (Klebesadel 1994b); however, in years of severe moisture deficit timothy yields usually are much lower than bromegrass (Klebesadel 1994c).

Precipitation from April through September in 1974 was 3.56 inches below normal and, in 1975, 1.12 inches above normal.

Herbage Yields, Winterhardiness, and Persistence of Grasses

The amount of herbage available to stock at each grazing session was determined from the representative sample strip harvested from each paddock just prior to entry of cows (Fig. 2). All grasses survived the first winter with vigorous growth in spring of 1974, and Arctared red fescue, Siberian wildrye, and arctic wheatgrass were especially productive in the first harvests on 3 June (replicates I and III) and on 12 June (replicates II and IV) (Fig. 2). All but Engmo timothy,

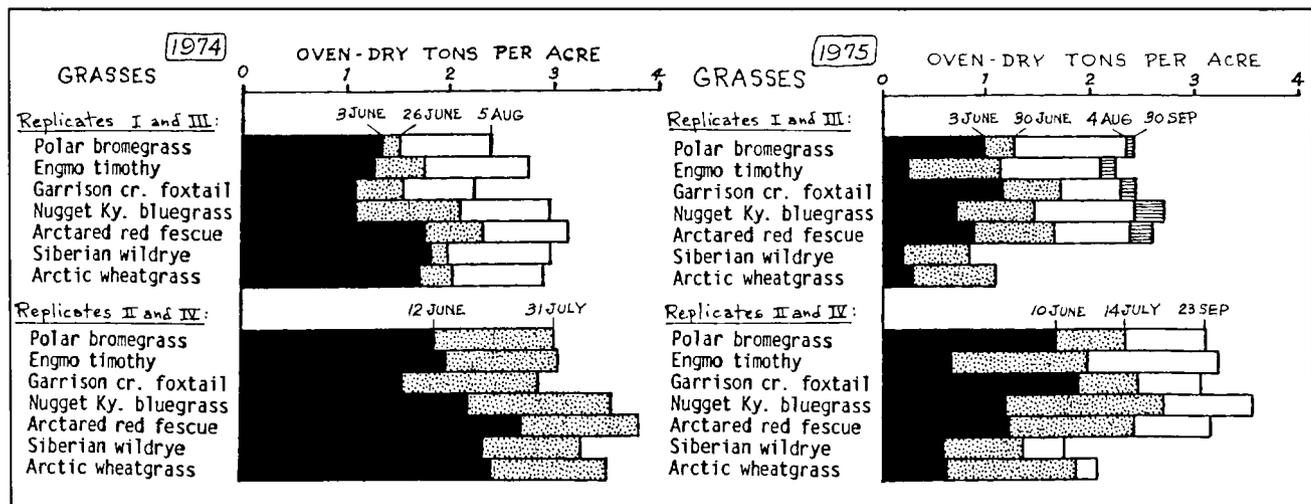


Figure 2. Amounts of herbage available to cows as determined from sample strips mowed from paddocks just before each two-day grazing session during the two years. Sampling dates are shown above the top bar in each graphed group.

Table 1. Development notes for the seven grasses as recorded just prior to each grazing session during the two years.

Sampling dates	Polar bromegrass	Engmo timothy	Garrison cr. foxtail	Nugget Ky. bluegrass	Arctared red fescue	Siberian wildrye	Arctic wheatgrass
1974							
Replicates I and III:							
<u>3 June:</u>							
Height ¹	22-24	16-18	20-22	8-10	14-16	16-18	20-22
Develop.	Very early boot stage	Mid-boot to very early heading	Late boot to early heading	Early to mid heading	Early heading	Pre-boot stage	Very early boot stage
<u>26 June:</u>							
Height	6-8	10-12	12-14	6-8	10-12	6-8	6-8
Develop.						Stand thin	
<u>5 Aug:</u>							
Height	22-24	18-20	16-18	8-10	10-12	18-20	14-16
Develop.	Few heads, pre-anthesis	Early anthesis (1-4 hds/ft ²)	Vegetative	Vegetative	Vegetative	Late boot to early heading (1-4 hds/ft ²)	Many heads (10-15 hds/ft ²)
Replicates II and IV:							
<u>12 June:</u>							
Height	36-38	24-26	24-26	12-14	20-22	24-26	24-26
Develop.	Late boot to early heading	Late boot to fully headed	Fully headed, mid-anthesis	Fully headed, pre-anthesis	Fully headed, pre-anthesis	Early boot stage	Fully headed, pre-anthesis
<u>31 July:</u>							
Height	28-30	14-16	24-26	12-14	16-18	18-20	18-20
Develop.	Very few heads, pre-anthesis	Early anthesis (2-6 hds/ft ²)	Headed, in anthesis	No heads	No heads	Late boot to early heading	Many heads, pre-anthesis
1975							
Replicates I and III:							
<u>3 June:</u>							
Height	18-20	6-8	18-20	6-8	10-12	8-10	10-12
Develop.	Early to mid-boot stage	Winter-injured	Mid-boot to very early	Pre-to-early boot stage head stage	Pre-to-early boot stage	Vegetative	Vegetative
<u>30 June:</u>							
Height	8-10	16-18	14-16	7-9	12-14	18-20	18-20
Develop.	Fully headed but very few heads (0-1 hd/ft ²)	Late boot to fully headed, (10-15 hds/ft ²)	No heads	Late boot to fully headed (5-10 hds/ft ²)	Fully headed, pre-anthesis (0-1 hd/ft ²)	Mid-to-late boot to very early heading	Near fully headed, pre-anthesis (8-10 hds/ft ²)
<u>4 Aug:</u>							
Height	24-28	16-18	16-18	8-10	12-14	4-8	4-8
Develop.	Late boot to early head, few heads	Very early anthesis (2-4 hds/ft ²)	No heads	No heads	No heads	Very sparse growth	Very sparse growth
<u>30 Sep:</u>							
Height	3-5	5-6	7-9	6-7	6-7	3-6	4-6
Develop.	No heads	No heads	No heads	No heads	No heads	Very sparse growth	Very sparse growth
Replicates II and IV:							
<u>10 June:</u>							
Height	25-28	12-14	22-24	8-10	12-14	14-18	16-18
Develop.	Late boot to very early heading	Winter-injured, no heading yet	Late boot to early heading	Mid-to-late boot stage	Late boot to early heading stage, very leafy	No heading yet	Very leafy, no heading yet
<u>14 July:</u>							
Height	17-19	18-20	12-14	6-8	12-14	14-16	16-20
Develop.	No heads	Pre-anthesis (15-20 hds/ft ²)	No heads	No heads	No heads	Early heading, pre-anthesis (2-5 hds/ft ²)	Late boot to early heading stage (10-20 hds/ft ²)
<u>23 Sep:</u>							
Height	14-18	10-14	14-16	8-10	8-12	8-12	6-10
Develop.	No heads	A few heads, early anthesis	No heads	No heads	No heads	Very thin stand	Very thin stand

¹Height of topmost leaves in inches; height of heads usually somewhat taller.

Siberian wildrye, and arctic wheatgrass showed good survival after the second winter.

Perennial grasses grow very rapidly during the month of June in this area (Klebesadel 1992b, 1994a, 1997a, 1997b). Tall-growing grasses, especially bromegrass and timothy, may regrow quite slowly if that June growth is interrupted by harvest or grazing in early-to-mid-June that removes most of the growing points hidden within the culms.

This uneven production of herbage, especially by bromegrass, is seen in the very low second-cutting yields on 26 June 1974 and 30 June 1975 after first cuttings on 3 June in both years (Fig.2); similar patterns of slow recovery in response to interrupted early growth have been noted in earlier reports (Klebesadel 1992b, 1994a, 1997a, 1997b; Matches and Burns 1995; Smith *et al.* 1986). Brundage and Branton (1967) and Brundage and Sweetman (1964) noted that the very uneven distribution of herbage production of such tall-growing perennials (i.e., overabundance followed by slow recovery growth, when a constant supply of pasture is needed) makes their efficient use for pasturage difficult.

Nugget bluegrass and Arctared red fescue not only tended to be highest in total yields in both years but also provided the most uniform production, regrowing more rapidly than the taller-growing grasses following harvests in early June (Fig.2). The superior total forage production with uniformly good regrowth throughout the growing season of subarctic-adapted Kentucky bluegrasses and red fescues compared with many other grasses and legumes has been noted in other studies (Klebesadel 1992b, 1994c).

As noted earlier (Klebesadel 1992b) the good season-long production of Kentucky bluegrass in this subarctic area is quite different from the poor mid-season productivity of this species at more southern latitudes (Smith *et al.* 1986). As stated by Rohweder and Albrecht (1995) in Wisconsin, "Full season grazing plants are nonexistent in climates with hot summers." There the greater heat and often drouthy conditions during mid-summer generally induce non-productive summer dormancy; more active growth then resumes there with onset of cooler late-summer and autumn temperatures.

Total yields of grasses in 1974 ranged from 2.21 T/A for Garrison creeping foxtail to 3.79 T/A for Arctared red fescue. Yields of the two native grasses in 1974 were good, averaging 3.13 T/A while the five named cultivars averaged 2.96 T/A.

However, the two native grasses averaged only 1.43 T/A in 1975 while the five cultivated grasses averaged 2.85 T/A. The native grasses historically have not undergone selection for tolerance to harvest, and it is seen that they were less productive in 1975 where they had been harvested three times in 1974 (replicates I and III) than where they had been harvested only twice (replicates II and IV) (see Fig.2). In another study at this station, arctic wheatgrass was less vigorous and relatively unproductive in spring where it had been harvested three times during the prior year than where it had been harvested only twice (Klebesadel 1994b).

Availability of Herbage

Several investigators have recognized that an ample supply of each strain or species compared must be available for a realistic and credible ranking when different herbage are evaluated during free-choice grazing trials (Hardison *et al.* 1954; Fontenot and Blaser 1965; McCullough 1959; Springfield and Reynolds 1951).

That consideration was not an issue in the present study owing to the large-sized paddocks and with few animals grazing. All grasses compared were present with good stands and growth at each grazing session; the only instances of modest availability of herbage were the slow recovery in replicates I and III of winter-injured timothy, Siberian wildrye, and arctic wheatgrass at the first grazing in 1975 (4+5 June), and the very thinned stands of the two native grasses that regrew poorly after the third harvest in 1975 (Table 1, Fig.2). In summary, herbage of all grasses was generally adequate for legitimate grazing comparisons at virtually all grazing sessions.

Comparative Grazing Preferences

Very marked differences were noted in the grazing preferences shown for the seven grasses (Fig.3). Those preferences were generally similar in both years and, except for some relatively minor discrepancies, were quite similar at the different grazing times during the two growing seasons.

In broad overview, the three grasses most avidly consumed were Polar bromegrass, followed by Engmo timothy and Nugget Kentucky bluegrass. The least preferred were Garrison creeping foxtail and arctic wheatgrass. Only slightly more grazed than the latter two, and only at certain of the times offered, were Arctared red fescue and Siberian wildrye.

Polar bromegrass: Polar was selected to a considerable extent over all other grasses in total time grazed in both years; it was especially favored by a wide margin over all other grasses during the 13+14 June and the 6+7 August sessions in 1974 (Fig. 3). In contrast, it was surpassed somewhat at the late grazing (2+3 Oct 1975) by timothy and Kentucky bluegrass; however, at that time the bromegrass regrowth was quite minimal (3- to 5-inch height) with timothy and Kentucky bluegrass showing somewhat more and taller growth (Table 1, Fig.2). The poor utilization of bromegrass by cattle late in the year also agrees, however, with earlier observations by dairy specialists Dr. A.L. Brundage and W.J. Sweetman at this station.¹

Other investigators also have found smooth bromegrass among the most preferred grasses in free-choice grazing trials elsewhere (Gesshe and Walton 1981; Hurd and Pearse 1944; Marten and Donker 1968; Rogler 1944; Springfield and Reynolds 1951; Wilkins and Hughes 1932).

Engmo timothy: The total time cows grazed timothy was roughly one-half that for bromegrass in both years (Fig.3). A curious and noteworthy facet of timothy utilization is the very considerable attention given it on 4+5 June 1974 (in replicates I and III) when it was 22 to 24 inches tall and in very early boot stage (Table 1), and the very minimal grazing time it received shortly thereafter on 13+14 June 1974

¹Personal communication

(in replicates II and IV) when the grass was 36 to 38 inches tall and in late-boot to early-heading stage.

Brundage and Branton (1967) noted a similar avid consumption of common (annual) ryegrass (*Lolium multiflorum*) by dairy stock at early-heading stage, followed by a marked rejection a short time later in favor of the other alternative, orchardgrass-alfalfa, when the ryegrass was past anthesis and had become a more stemmy and rank herbage.

In the present study, grazing time on timothy surpassed all others and equaled that of bromegrass on 1+2 August 1974 (Fig.3) when it was 14 to 16 inches tall and in early anthesis but with only a modest amount of heading (Table 1). Engmo was as much grazed as bromegrass and Kentucky bluegrass at the late dates (25+26 Sep and 2+3 Oct) in 1975, and more than bromegrass in early October.

Brundage *et al.* (1963) compared a nonhardy strain of timothy with other perennial grasses that are nonhardy here (orchardgrass, tall oatgrass) and annual ryegrass, each grown alone and each grown with a nonhardy, southern-adapted alfalfa, for grazing preference as annual pasture by dairy stock at this station. Timothy ranked near average among the eight species or combinations offered on six different grazing sessions in two years, better by itself than with alfalfa, and was among the most preferred grazing options late in the season (September) as was found in the present study.

Timothy often has ranked among the preferred species in free-choice, grazing-preference studies with cattle elsewhere (Archibald *et al.* 1943; Beaumont *et al.* 1933; Cowlshaw and Alder 1960; Gomm 1969; Ivins 1952; Wilkins and Hughes 1932).

Nugget Kentucky bluegrass: Though only about half as much grazed as Polar brome, Nugget was approximately equal in total time grazed to Engmo timothy, slightly less in 1974 and slightly more in 1975 (Fig.3). Nugget was grazed appreciably in all of the 12 grazing sessions in the two years.

In broadcast-seeded stands Nugget produces an amazingly high density of seed heads in the first year following the year of planting, as seen in this study in 1974 and as reported earlier (Klebesadel 1984). In contrast, broadcast stands produce relatively few heads in subsequent years, as noted also in this study in spring of 1975. In spring of 1974, cow grazing time was considerably less on 4+5 June (replicates I and III), when Nugget was just beginning to head, and on 13+14 June (replicates II and IV) when the grass was fully and profusely headed (Table 1, Fig.3), than with either of the August grazings when no heads were present.

Other investigators who found Kentucky bluegrass to be intermediate in grazing preference among a number of grasses include Springfield and Reynolds (1951) and Wilkins and Hughes (1932). Beaumont *et al.* (1933) cite some studies

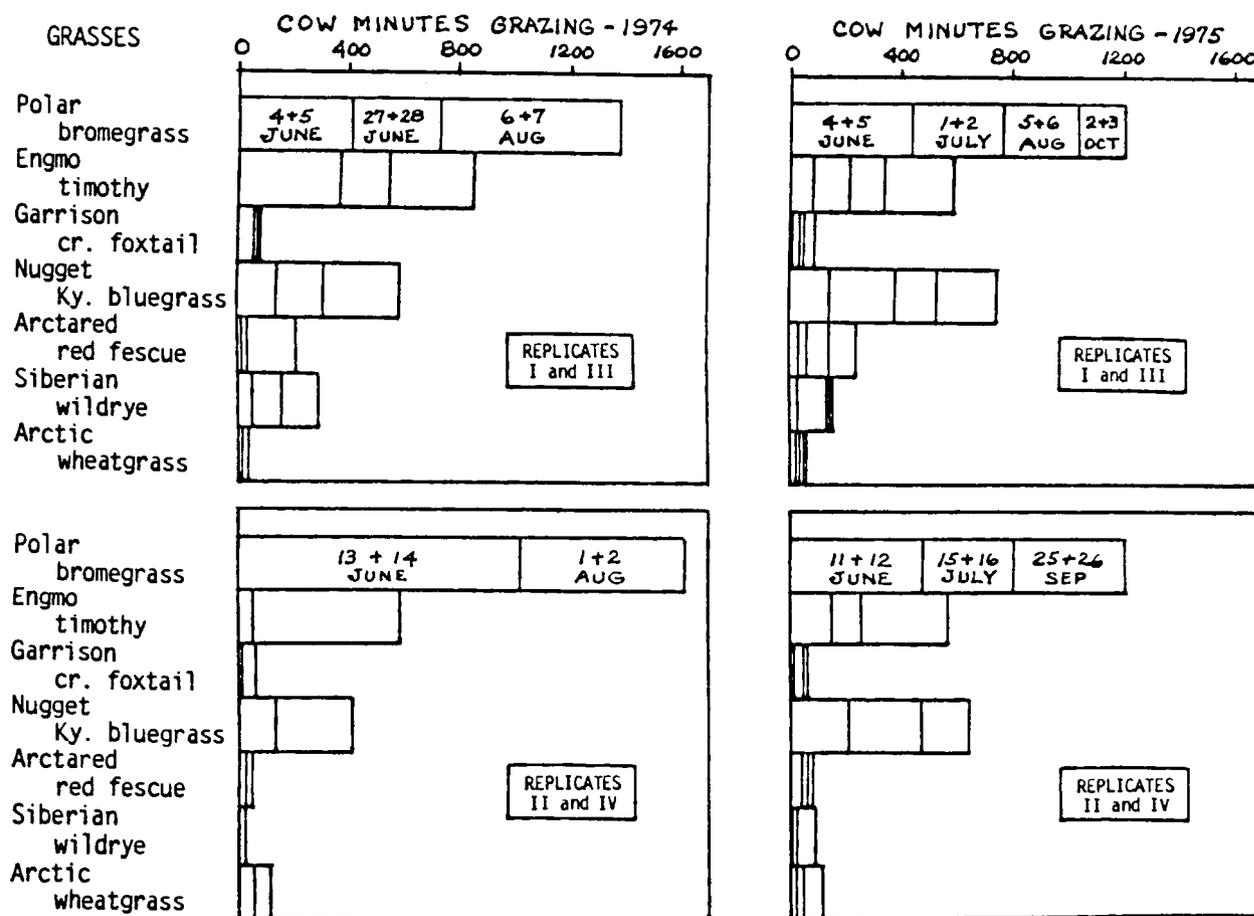


Figure 3. "Cow minutes" of grazing time on the seven grasses as recorded for each 2-day grazing session during the two years. Dates of grazing are shown in top bar in each graph group.

that ranked this species high in grazing preference while others ranked it low. Archibald *et al.* (1943) reported it second from last among seven grasses.

Arctared red fescue: Except for being grazed for a fair amount of time on 6+7 August 1974, and for a somewhat lesser time on 5+6 August and 2+3 October in 1975, red fescue was grazed very little during the other nine grazing sessions (Fig.3). This poor acceptance of red fescue was perplexing because from physical appearance (to humans) it appeared ideal for grazing with visually attractive, abundant leafiness with few seed heads (after the initial abundant heading in June of 1974); this would lead one to suspect its rejection could be related to odor or taste.

Other reports present conflicting results on the relative grazing preference of red fescue. Dubbs (1960), comparing 17 grasses under dryland conditions in central Montana, reported that red fescue ranked with smooth bromegrass and timothy among the five most-grazed grasses.

Elliott and Baenziger (1973) in Canada stated that red fescue is "extremely palatable in all seasons" and reported its use in mixtures for both dryland and irrigated pastures. In contrast, Hanson (1972) referred to it as "not highly palatable".

Wilkins and Hughes (1932) in Iowa compared four of the grasses included in the present study in a grazing-preference study and reported a ranking of those four identical to the present results with smooth bromegrass preferred, followed in order by timothy, Kentucky bluegrass, and red fescue. Similarly, Beaumont *et al.* (1933), comparing eight grasses for grazing preference by milk cows, found that timothy ranked first but red fescue was "grazed very slightly" and ranked second to last. Cowlshaw and Alder (1960) in England also reported that red fescue ranked very low in grazing preference among several grasses.

It was noted earlier (Klebesadel 1993a) that several horses, having equal access to stands of timothy, smooth bromegrass, annual ryegrass, Kentucky bluegrass, and red fescue in an unplanned incident late in one growing season, grazed five different strains of red fescue avidly to the virtual exclusion of all other grasses.

Garrison creeping foxtail: This grass was virtually ungrazed during all sessions in both years (Fig.3). These results are somewhat surprising in view of the claim of Stroh *et al.* (1978) that Garrison was "excellent" in palatability. They reported that in two North

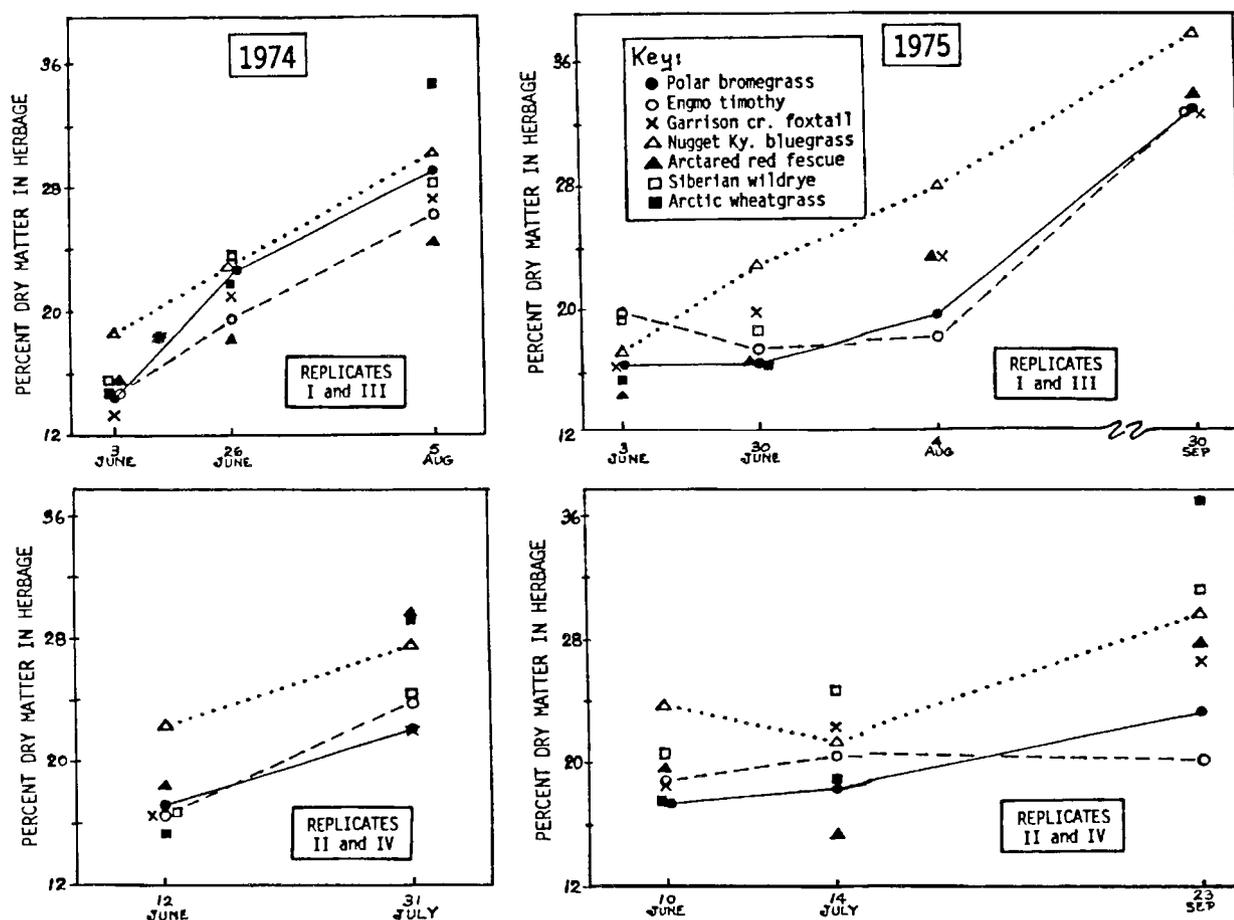


Figure 4. Percent dry matter in herbage of the seven grasses during the two years as determined from sample strips mowed from paddocks just before each two-day grazing session. Connecting lines are drawn only for the three most grazed grasses (to avoid a too-complicated graph). Each graph value is a determination for a new growth of each grass; therefore, connecting lines serve only for ease of following values for a given species, not changes within the same growth of herbage.

Dakota trials Garrison was preferred by Holstein and Hereford cattle over smooth brome grass, reed canarygrass, and tall oatgrass. Hanson (1972) reported that Garrison produces "high-quality forage" but did not comment on its use for pasture or grazing characteristics.

Siberian wildrye: This native Alaska grass was grazed to a limited extent on three of the 12 sessions; 27+28 June and 6+7 August in 1974, and 1+2 July in 1975 (Fig.3). Beyond those, the grass attracted very little grazing attention.

Gomm (1969) in Montana reported that Siberian wildrye was not consumed early by cattle grazing 127 species of grasses but was included in a group of "secondarily palatable" grasses that were "... well utilized after the most palatable forage was removed..."

Arctic wheatgrass: Very little grazing time was recorded for this grass at any of the 12 grazing sessions. The harvest schedules used with replicates I and III in 1974 resulted in very slow growth in spring of 1975 for arctic wheatgrass and Siberian wildrye and later, very thinned stands during the latter portion of the 1975 growing season; however, those two native grasses were grazed very little even when they offered an abundance of leafy herbage earlier in the study.

Previous Dietary History

Several investigators who have studied animal grazing preferences have concluded that previous dietary history influences grazing choice. Cowlshaw and Alder (1960) cite four factors that affect grazing habits of a ruminant animal, "previous (dietary) history" being one. (Others are palatability of herbage, physiological state of animal, and environment of the herbage). Rogler (1944) stated: "cattle may tend to graze more readily species they have previously eaten..."

Provenza and Balph (1988) discuss this matter at length, contending that "... dietary habits of livestock are shaped largely by the foraging environment where the animals are reared."

Launchbaugh and Provenza (1991) stated: "A diet selection system based on learning and memory would include the following elements: (1) mother as a social model, (2) cautious sampling of novel foods, and (3) the formation of food preferences and aversions based on gastrointestinal consequences."

Item (2) of the foregoing statement could rationalize to some extent the very tentative and minimal grazing in the present study of the two native grasses and creeping foxtail, species that were available to the animals for the first time. Item (3) would suggest that the preferential consumption of brome grass, timothy, and Kentucky bluegrass was related to the grazing animals' accustomed diet and previous pasturage, and thus could be based on familiarity and previous satisfactory "gastrointestinal" result.

Much of the preserved silage and hay consumed by the station herd consists of brome grass; that species with Kentucky bluegrass, timothy, and quackgrass, the latter a frequent volunteer in area croplands, are the principal components of pastures at this station.

Percent Dry Matter in Herbage

Among several characteristics of herbage reported as favorably influencing palatability or grazing preference is high succulence (low percent dry matter) of the plant material.

Springfield and Reynolds (1951), comparing eight grasses in Arizona, found a positive relation between succulence and grazing preference; they noted also that cattle grazed less discriminantly when mature grasses were wet from rain or heavy dew. Archibald *et al.* (1943) in Massachusetts also reported grazing preference for succulence among seven grasses. Marten (1970) cited others with similar results, and noted also that succulence generally decreases in herbage with advancing maturity, and that fertilization with nitrogen can increase succulence (decrease percent dry matter) of grasses (see also Klebesadel 1994b, p.15).

In the present study, timothy and brome grass, two of the three grasses most grazed, often (but not consistently) were among the grasses lowest in percent dry matter (highest in succulence) (Fig.4). In contrast, Kentucky bluegrass, the other preferred species, usually was among those least succulent (highest in percent dry matter).

At progressively later regrowths during both years the percents dry matter of herbage generally increased (Fig.4). Herbage in early June were generally most succulent, ranging mostly between 14% and 20% dry matter. The greatest range among species was seen for 23 September 1975 with Engmo timothy at 20% dry matter and arctic wheatgrass at 36.6%.

Digestibility (IVDMD)

Opinions of investigators differ on the relationship of herbage digestibility to grazing preference (Marten 1970). Fontenot and Blaser (1965) concluded that animals usually selectively graze herbage that is higher in digestibility than other material available. In contrast, Buckner *et al.* (1967) found a negative association between digestibility and palatability with certain grasses.

In the present study, an herbage digestibility/grazing preference relationship was not consistent. The best association was with Engmo timothy. Engmo, one of the preferred herbage, often surpassed all other grasses in digestibility, especially at (but not limited to) grazing sessions from late July to late October (Fig.5). Engmo also was highest in digestibility at both June samplings in 1974; however, although grazed well on 4+5 June it was little grazed on 13+14 June. The generally high levels of digestibility determined for Engmo timothy herbage agree with other reports for the same grass at this station (Klebesadel 1994b; Mitchell 1987).

Polar brome, the most grazed grass, was often intermediate in digestibility.

The poorest association was evident with Nugget Kentucky bluegrass; although one of the three most grazed grasses it was usually intermediate to low (often lowest) in digestibility (Fig. 5).

Siberian wildrye and arctic wheatgrass generally ranked high in digestibility in early June of 1975, yet were little grazed. The very low digestibility values for arctic wheatgrass for late July and later agree with an earlier report

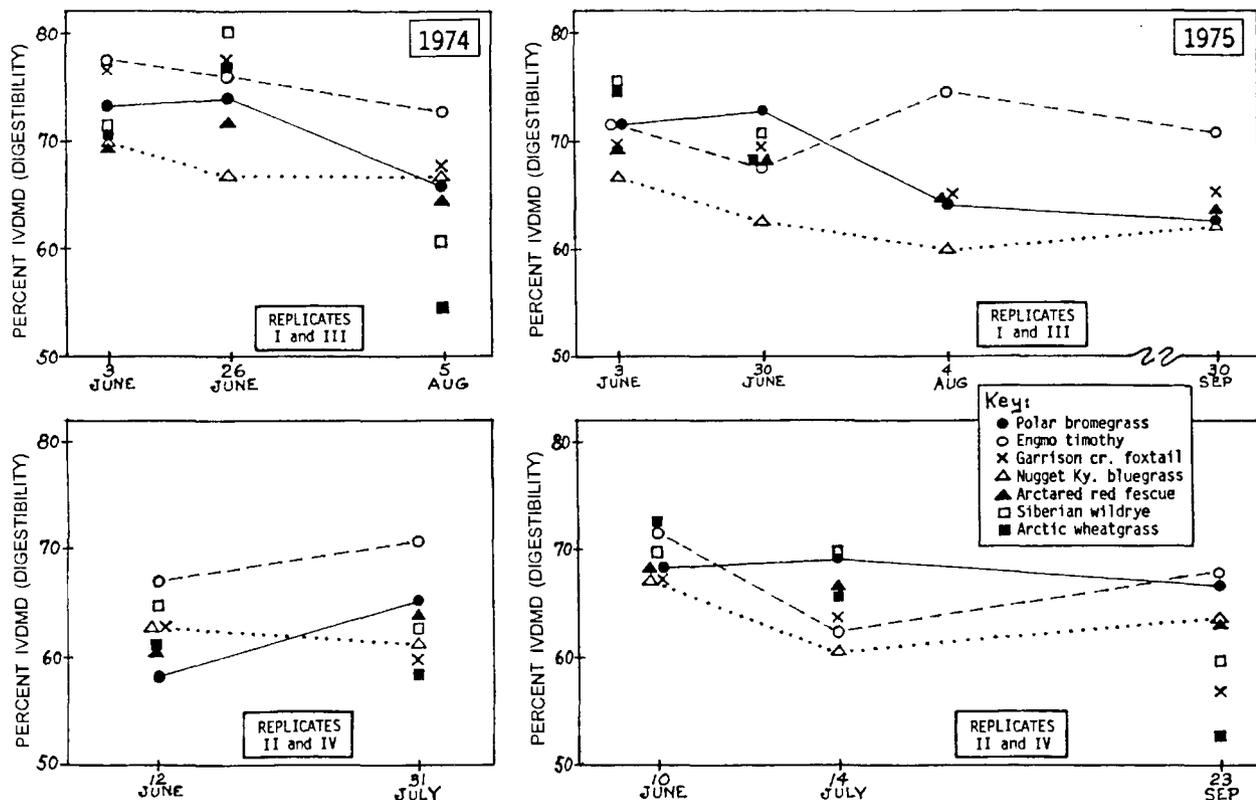


Figure 5. Percent digestibility (IVDM) of herbage of the seven grasses during the two years as determined from sample strips mowed from paddocks just before each two-day grazing session. Connecting lines are drawn only for the three most-grazed grasses (to avoid a too-complicated graph). Each graph value is a determination for a new growth of each grass; therefore, connecting lines serve only for ease of following values for a given species, not changes within the same growth of herbage.

wherein digestibility of arctic wheatgrass in second growth of the season was lowest of seven grasses (Klebesadel 1994b).

Percent IVDM in the present study ranged from 54% to 80% in 1974 and from 52% to 76% in 1975. In general there was little consistency in the ranking of grasses throughout the two growing seasons (Fig. 5). In summary, digestibility of whole-plant herbage did not relate well with grazing preferences in this study.

Mitchell (1987) at this station compared nine grasses for several herbage-quality characteristics; he reported that timothy and smooth bromegrass often were highest in digestibility (IVDM) and two of the native grasses tended to be lowest.

Analyses of Whole Plants Versus Grazed Portions

Hardison *et al.* (1954) recognized that determinations of characteristics for entire plants logically should not be expected to bear a close relationship to characteristics of only the upper (mostly leaves) portions of plants usually grazed. They found that grazed herbage (upper, more leafy portion) was more digestible and considerably higher in crude protein, ether extract, and ash, and lower in crude fiber, than whole plants. Thus, the poor agreement found in the present study between digestibility of whole plants harvested to a short stubble in the mowed strips and grazing preference (for uppermost portions of herbage) perhaps should not be surprising.

In further support of that contention, Fontenot and Blaser (1965) reported that dry-matter digestibility was consistently higher for the top half of plants than for the bottom half, and milk production was higher for cows grazing the top half of pasture herbage than for those that subsequently grazed the lower portions of plants.

Pritchard *et al.* (1963) showed that different plant parts differ in digestibility and that they change at different rates during the growing season. Kilcher and Troelsen (1973) reported bromegrass leaves higher in crude protein, digestible energy, and gross energy, and lower in lignin than stems.

Hardison *et al.* (1954) refer to analyses of "hand-plucked herbage samples" as providing a better estimation of characteristics of herbage actually consumed. Such plucked samples can be obtained from wire pasture-cage enclosures put in place before grazing and opened for sampling after the surrounding area is grazed. Hand harvest from the protected, caged growth is then done to an extent that simulates the amounts and extents grazed by the animals.

Fertilizer Effects

All grasses in this study received identical, adequate fertilizer treatment; thus no grazing-preference differences are attributable to fertilizer effects. However, several references discuss this subject and certain previously unreported instances of fertilizer/grazing relationships have been noted

in Alaska; therefore a brief discussion of this subject-matter area is merited.

Many published reports are in agreement that fertilization enhances grazing preference, and Marten (1970) summarized many of those study results. Some showed simply that fertilization enhanced grazing preference over unfertilized forages.

Numerous reports noted increased palatability of grasses as a result of nitrogen fertilization alone (unless rates were excessive); some deduced that the enhanced palatability might be due to increased growth, more succulence, more desirable chemical composition, or a combination of those factors.

Other reports cited by Jones (1952) and Marten (1970) found enhanced palatability with phosphorus fertilization. Koblet (1950) in Switzerland reported that application of phosphorous and lime to alpine pastures improved phosphorus content of herbage, those areas were preferred by freely moving cattle, and that grazing preference persisted over several years.

A similar effect was noted some years ago at the University of Alaska College Research Farm near Fairbanks. Dr. W.M. Laughlin and then station superintendent S.H. Restad fertilized a large upland bromegrass pasture with nitrogen, then added phosphorus fertilizer to a portion of it. When the station dairy herd was given access to the entire fertilized area, cows displayed a marked preference for grazing in the area that had received phosphorus in addition to the nitrogen.²

Dr. Laughlin also related a similar observation concerning a fertilizer-comparison experiment on a Matanuska Valley lowland meadow of mixed native vegetation including grasses and forbs but dominated by native sedges. After some dairy bulls inadvertently had broken into the experimental area, it was noted that their grazing had been confined almost entirely to plots that had been fertilized with phosphorus.²

Species Versus Intraspecific Differences

Many investigations on palatability or grazing preference among different grasses refer only to the species, reporting, for example, "timothy was grazed more than orchardgrass."

There has arisen, however, an awareness that different cultivars (named varieties), strains, or selections *within* a species can differ in grazing preference. Marten (1970) lists a number of reports that have found such differences within a considerable number of grass and legume species.

Thus, it may be well to identify cultivars or strains used in grazing-preference studies, as has been done with five of seven grasses compared in this study.

Applications of These Findings

These results indicate that dairymen in Alaska have three well adapted, very winterhardy, nutritious, palatable, and highly productive (with adequate fertilizer nutrients and precipitation or supplemental irrigation) grasses for pasture use. Each, however, has a minor shortcoming that tends to preclude its utilization as best for "all" purposes.

Engmo timothy winterhardiness is the one exception to the above description of these grasses. Engmo is markedly more winterhardy than any North American timothies, and

equivalent in hardiness to other very winterhardy timothies of northern Europe (Klebesadel 1997b), but can be winter-injured (as during the 1974-75 winter of this study) or killed by occasionally very stressful winters (Klebesadel 1992b, 1994b, 1994c, 1997b).

For its virtues, Engmo, as shown in this study and in other earlier reports (Klebesadel 1994b; Mitchell 1987), is unsurpassed in digestibility among northern-adapted perennial grasses evaluated in Alaska. Its good grazing preference and tolerance of frequent utilization thus qualify it well for pasture or green-chop purposes.

Nugget, selected for turf use, is considered by stature to be a "dwarf" form of Kentucky bluegrass. As such, its predominance of basal leaves suits it well for pasture use also, but not for harvest as a hay crop, as is occasionally done when cropland pasture growth exceeds grazing needs. The yields reported here are for harvest using a small-plot mower that left a somewhat shorter stubble than would be left by farm-scale equipment.

Smooth bromegrass, the most-grazed of the seven grasses in this study, is not a totally ideal pasture grass. It is known from earlier studies (Klebesadel 1994a, 1997a) that smooth bromegrass in Alaska is ideally utilized with no more than two defoliations (cuttings) per year as would be done in harvest for hay, silage, or haylage, the first cutting in late June or early July and the second in late August or early September. Repeated moderate to heavy pasturings throughout the growing season logically would lower food-reserve levels within plants, leading to poor winter survival and persistence.

In contrast to bromegrass, studies at this location (Klebesadel 1992b, 1997b) have shown that Engmo timothy (when not followed by unusually severe winters), and subarctic-adapted Kentucky bluegrass strains, tolerate more frequent utilization. Their growth form, unlike smooth bromegrass, retains functional basal leaves after more frequent grazing or harvesting. The basal leaves of plants of that growth type continue uninterrupted photosynthesis. Thus, to initiate new growth, such plants are not obligated to draw heavily upon stored reserves (a weakening process) as is bromegrass. In fact, the basal-leaf abundance of Engmo and Kentucky bluegrass is benefited by more frequent utilization than bromegrass can tolerate; with only two harvests per year the basal leaves of Engmo and Kentucky bluegrass become overly shaded and thus less functional.

The prospect emerges from these findings of combining the three most-preferred grasses together in a mixture with the aim of combining the various attributes of those species. However, such a course would require additional work to devise desirable proportions of each (seeding rates), and to determine how the mixture (and individual components) would respond and persist under various schedules and frequencies of utilization. Management of mixed-species pastures is more complex than for a single species.

Effects of Selective Grazing on Vegetational Change in Mixed Stands

Rogler (1944) stated: "When cattle are first turned onto a

²Personal communication

(mixed species) pasture the preferred species will be closely grazed. As the season advances those grasses that are less palatable become more prevalent and those most palatable less prevalent. When this occurs, the diet then changes to less palatable species.”

In a similar vein, Ivins (1955) related: “That palatability differences exert a long-term effect on the stability of a sward is generally agreed...” Similarly, Heady (1964), Jones (1952), and Marten (1970) cite studies that also concluded that overgrazing of the most palatable grasses results in their stand losses in mixtures. Thus, in mixed-species pastures, palatability differences can result in over-use to the detriment and gradual elimination of heavily grazed species (Hurd and Pearse 1944; Springfield and Reynolds 1951). Those species gradually thinned or eliminated within a mixed stand have been called “decreasers”. In contrast, the less palatable, less-grazed, and thus less-pressured species (or those which by growth type are better able to withstand close grazing) become more prominent (= “increasers”).

Two instances of such species shifts have been recognized in Alaska, one ascribable to disparate growth types, the other to palatability differences. On Kodiak Island, cattle grazing pressure has virtually eliminated bluejoint (*Calamagrostis canadensis*) from many range areas that were formerly dominated by that species, and it has been supplanted by hairgrasses (*Deschampsia* spp.) and fescues (*Festuca* spp.) (Klebesadel and Laughlin 1964).

The tall-growing bluejoint tends to be totally defoliated when grazed; it then must draw upon stem-base/root reserves to regrow, for leaf removal halts photosynthetic activity. Thus over time it becomes weakened and so is less tolerant of sustained grazing pressure. In contrast, the increaser species that have supplanted bluejoint have an abundance of basal leaves for ongoing photosynthetic activity, even under moderate grazing pressure; they are thus favored and have become dominant. It should be noted that stands of native bluejoint can remain vigorous if harvested only once or twice per year, but then only if supplied annually with adequate levels of complete fertilizer (N+P+K), similar to the needs of other forage grasses (Klebesadel 1965, 1994b).

In local permanent and semi-permanent pastures, the apparently unpalatable (certainly ungrazed) foxtail barley (*Hordeum jubatum*) sustains no defoliation pressure. Accordingly, it heads abundantly, maturing much seed that, due to stiff, divergent awns, is easily wind-scattered and thus gradually assumes a more dominant presence in such pastures (Klebesadel 1983). Only mowing such pastures before seed is produced can thwart foxtail barley’s spread by seed dispersal.

Formulating a Full-Season Pasture Program

Although the planning and implementation of complete pasture-management systems in Alaska must be formulated to fit each operator’s specific needs, and they lie beyond the scope of this report, certain points might be raised for consideration.

The herbage yields on 30 September for grasses previously grazed three times during 1975 (replicates I and II) were very low (Fig.2), even though grasses had a full seven

weeks for regrowth. Similar poor late-season productivity of five species of perennial grasses in a fourth cutting in late September (following a third cutting in mid-August) at this station has been reported earlier (Klebesadel 1992b).

For best stand health, that late-season growth of perennial grasses should not be grazed or harvested anyway, unless the stand is to be terminated. During the latter portion of the growing season, perennial grasses de-emphasize aerial growth, diverting photosynthesis product into stored food reserves (Smith *et al.* 1986). Perennial, tall-growing grasses need that leafy growth in place during all of September and prior to freeze-up for photosynthetic activity and restoration of stored food reserves to permit good winter survival and vigorous growth the following spring.

Annual ryegrass can serve well to extend the pasture season through September and early October thus providing a needed rest and recuperation period for perennial grasses. In contrast to perennial grasses, annual ryegrass grows actively during the latter portion of the growing season, produces high yields of leafy, nutritious, and palatable herbage (Brundage and Branton 1967; Klebesadel 1968; Mitchell 1984). It requires no winter-preparation period since it is an annual; thus it can be grazed intensively during September and October. Growing-season management procedures, including mid-season harvest dates to obtain abundant, non-heading late-season growth for pasture or green-chop utilization have been reported (Klebesadel 1968).

At the beginning of the growing season, winter rye, planted in late summer of the previous year, can provide useful early pasture in advance of the availability of grazable growth on perennial grasses (Klebesadel 1969b). Such early winter rye pasture can be grazed heavily as the stand logically would be destroyed by tillage to plant a different crop when perennial-grass herbage becomes usable. Rohweder and Albrecht (1995) note: “When (perennial) pastures are grazed too early, productivity of forage plants is lowered by premature leaf removal.”

As pointed out by others (Matches and Burns 1995; Rohweder and Albrecht 1995) incorporation of pastures into an overall efficient and adequate forage program requires and effectual combination of skillful management and use of desirable species.

CONCLUSIONS

Much of what is "known" about reasons for grazing preference and herbage palatability necessarily remains conjectural and informed guesswork. Observations, patterns, analyses, and other results form a considerable volume of research literature. If all of those findings contributed toward uniform consensus on the subject, it would now be well understood; unfortunately, many study results contradict findings in others.

In the present study, little in the way of correlative associations between herbage characteristics and grazing preference can be established; that failure may be due in part to the fact that virtually all of the above-ground plant growth was harvested to determine succulence and digestibility while only the mostly leafy upper portions of plants were grazed. The one solid conclusion is a generally consistent ranking of grasses for grazing preference at all grazing sessions and in both years.

Dairy stock showed strong and relatively consistent differences in preferential grazing among the seven northern-adapted perennial grasses. Total cow-minutes grazing time over 12, two-day pasturing sessions over two years ranked the grasses for relative grazing preference as follows: Polar brome grass > Engmo timothy = Nugget Kentucky bluegrass > Arctared red fescue = Siberian wildrye > Garrison creeping foxtail = arctic wheatgrass.

Ranking of the four major cultivated grasses agreed well with several other grazing-preference studies; in those brome grass and timothy usually ranked high, Kentucky bluegrass often intermediate, and red fescue intermediate to low, also.

On the basis of results in this study, the two native grasses are unlikely candidates for pasture use. Their subarctic adaptation, excellent winterhardiness when not harvested more frequently than twice per year, and very good seed-production capabilities (Klebesadel 1969a, Klebesadel and Helm 1992) may suit them for other practical uses in the North.

The excellent productivity and winterhardiness of Arctared red fescue and Garrison creeping foxtail are offset for pasture purposes for dairy cattle by their generally negative grazing preference. Those grasses, too, can and do serve well in other avenues of use.

Smooth brome grass ranked first in grazing preference. However, as noted in earlier studies that species is difficult to utilize efficiently for grazing. If the rapidly developing first growth in late May / early June is not grazed heavily, it soon becomes tall and poorly suited for grazing. If, on the other hand, intensive grazing or machine harvest in early June removes the growing points as those shoot apices begin movement upward inside the culms, growth tends to cease generally until new basal tillers begin to elongate; this phasic initiation of new growth from tillers occurs normally in late June / early July. Brundage and Sweetman (1964) found that neither irrigation nor nitrogen fertilization could hasten that development of new basal tillers.

The slow regrowth of brome grass after early June defoliation, the need for a constant supply of pasturage, the more rapid regrowth of Nugget Kentucky bluegrass, and the good

grazing preference and excellent winterhardiness of both suggests that separate stands of both, or a pasture mixture of the two may have merit. Although Nugget was the Kentucky bluegrass evaluated in this study, that relatively short-growing cultivar was selected primarily for turf use. Another study (Klebesadel 1992b) that evaluated 12 subarctic-adapted strains of Kentucky bluegrass, revealed that several, and some taller-growing, were about as winterhardy as Nugget and capable of producing three to over four tons of oven-dry herbage with four cuttings per year. Further evaluations of such strains for grazing preference, and for use alone or in mixtures, could be informative and potentially very useful.

Engmo timothy, for its good palatability and digestibility, reasonably good winterhardiness, and tolerance of more frequent harvest than brome grass (Klebesadel 1994b, 1997b; Klebesadel and Helm 1986) could be a logical third element in a mixture for pasture or green-chop purposes. Such a three-grass mixture should be investigated for relative rates of seeding, growth compatibility, and general performance under different management scenarios.

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REFERENCES

- Archibald, J.G., E. Bennett, and W.S. Ritchie. 1943. The composition and palatability of some common grasses. *Jour. Agric. Research* 66:341–347.
- Beaumont, A.B., R.E. Stitt, and R.S. Snell. 1933. Some factors affecting the palatability of pasture plants. *Jour. American Soc. Agronomy* 25:123–128.
- Brundage, A.L., and C.I. Branton. 1967. Ryegrass and orchardgrass–alfalfa for annual forage and pasture in south–central Alaska. *Jour. Dairy Science* 50:856–862.
- Brundage, A.L., and W.J. Sweetman. 1964. Comparative utilization of irrigated bromegrass under rotational and strip grazing. *Jour. Dairy Science* 47:528–530.
- Brundage, A.L., W.J. Sweetman, L.J. Klebesadel, N.E. Michaelson, and C.I. Branton. 1963. Grasses and alfalfa for annual forage and pasture in south central Alaska. *Jour. Dairy Science* 46:1260–1265.
- Buckner, R.C., J.R. Todd, P.B. Burrus, and R.F. Barnes. 1967. Chemical composition, palatability, and digestibility of ryegrass–tall fescue hybrids ‘Kenwell’, and ‘Kentucky 31’ tall fescue varieties. *Agronomy Jour.* 59:345–349.
- Bull, L.S. 1995. Forages for dairy cattle. p. 295–301. (In) R.F. Barnes, D.A. Miller, and C.J. Nelson (Eds.) *Forages: The Science of Grassland Agriculture. Vol.II.* Iowa State University Press, Ames, IA.
- Buxton, D.R., and D.R. Mertens. 1995. Quality–related characteristics of forages. p. 83–96. (In) R.F. Barnes, D.A. Miller, and C.J. Nelson (Eds.) *Forages: The Science of Grassland Agriculture. Vol. II.* Iowa State University Press, Ames, IA.
- Cowlishaw, S.J., and F.E. Alder. 1960. The grazing preferences of cattle and sheep. *Jour. Agricultural Science* 54:257–265.
- Dubbs, A.L. 1960. Production and quality of seventeen grasses grown on dryland, Mocassin, Montana, 1954–56. *Proc. Montana Crop Imp. Short Course, Bozeman, MT.*
- Elliott, C.R., and H. Baenziger. 1973. Creeping red fescue. *Agriculture Canada Pub.* 1122.
- Fontenot, J.P., and R.E. Blaser. 1965. Symposium on factors influencing the voluntary intake of herbage by ruminants: Selection and intake by grazing animals. *Jour. Animal Science* 24:1202–1208.
- Garner, F.H. 1963. The palatability of herbage plants. *Jour. British Grassland Soc.* 18:79–89.
- Gesshe, R.H., and P.D. Walton. 1981. Grazing animal preferences for cultivated forages in Canada. *Jour. Range Management* 34:42–45.
- Gomm, F.B. 1969. The palatability of range and pasture grasses in Montana. *Montana Agric. Exp. Sta. Bull.* 619.
- Hanson, A.A. 1972. Grass varieties in the United States. U.S. Department of Agriculture Handbook 170. U.S. Government Printing Off., Washington, DC.
- Hardison, W.A., J.T. Reid, C.M. Martin, and P.G. Woolfolk. 1954. Degree of herbage selection by grazing cattle. *Jour. Dairy Science* 37:89–102.
- Heady, H.F. 1964. Palatability of herbage and animal preference. *Jour. Range Management* 17:76–82.
- Hodgson, H.J. 1976a. Forage crops. *Scientific American* 234:61–75.
- Hodgson, H.J. 1976b. Forages, ruminant livestock, and food. *Bioscience* 26:625–630.
- Hodgson, H.J. 1979. Role of the dairy cow in world food production. *Jour. Dairy Science* 62:343–351.
- Hodgson, H.J., A.C. Wilton, R.L. Taylor, and L.J. Klebesadel. 1971a. Registration of Polar bromegrass. *Crop Science* 11:939.
- Hodgson, H.J., R.L. Taylor, A.C. Wilton, and L.J. Klebesadel. 1971b. Registration of Nugget Kentucky bluegrass. *Crop Science* 11:938.
- Hodgson, H.J., R.L. Taylor, L.J. Klebesadel, and A.C. Wilton. 1978. Registration of Arctared red fescue. *Crop Science* 17:524.
- Hulten, E. 1968. *Flora of Alaska and neighboring territories.* Stanford University Press, Stanford, CA.
- Hurd, R.M., and C.K. Pearse. 1944. Relative palatability of eight grasses used in range reseeding. *Jour. American Soc. Agronomy* 36:162–165.
- Ivins, J.D. 1952. The relative palatability of herbage plants. *Jour. British Grassland Soc.* 7:43–54.
- Ivins, J.D. 1955. The palatability of herbage. *Herbage Abstracts* 25:75–79.
- Johnstone–Wallace, D.B. 1937. The influence of grazing management and plant associations on the chemical composition of pasture plants. *Jour. American Soc. Agronomy* 29:441–455.
- Jones, L.I. 1952. Measurement of palatability. p. 1348–1353. (In) *Proceedings 6th International Grassland Congress.*
- Kilcher, M.R. and J.E. Troelsen. 1973. Contribution of stems and leaves to the composition and nutrient content of irrigated bromegrass at different stages of development. *Canadian Jour. Plant Science* 53:767–771.
- Klebesadel, L.J. 1965. Response of native bluejoint grass (*Calamagrostis canadensis*) in subarctic Alaska to harvest schedules and fertilizers. *Proceedings IX International Grassland Congress, Sao Paulo, Brazil,* p. 1309–1314.
- Klebesadel, L.J. 1968. Getting the most out of ryegrass in Alaska. *Alaska Agric. Exp. Sta. Forage Research Report* 4A.
- Klebesadel, L.J. 1969a. Siberian wildrye (*Elymus sibiricus* L.): Agronomic characteristics of a potentially valuable forage and conservation grass for the North. *Agronomy Jour.* 61:855–859.
- Klebesadel, L.J. 1969b. Winter survival and spring forage yields of winter rye varieties in subarctic Alaska as influenced by date of planting. *Agronomy Jour.* 61:708–712.
- Klebesadel, L.J. 1980. Birdvetch: Forage crop, ground cover, ornamental, or weed? *Agroborealis* 12:46–49.
- Klebesadel, L.J. 1983. Forage crops in Alaska. *Alaska Agric. Exp. Sta. Bull.* 63.
- Klebesadel, L. J. 1984. Far–north–adapted bluegrasses from areas with rigorous winter climate perform best in southcentral Alaska. *Agroborealis* 16(1):37–42.

- Klebesadel, L.J. 1985. Hardening behavior, winter survival, and forage productivity of *Festuca* species and cultivars in subarctic Alaska. *Crop Science* 25:441-447.
- Klebesadel, L.J. 1992a. Effects of planting date and latitude-of-adaptation on seeding-year development, winter survival, and subsequent seed and forage production potential of grasses and legumes in subarctic Alaska. *Alaska Agric. and Forestry Exp. Sta. Bull.* 86.
- Klebesadel, L.J. 1992b. Seasonal distribution of forage yield and winter hardiness of grasses from diverse latitudinal origins harvested four times per year in southcentral Alaska. *Alaska Agric. and Forestry Exp. Sta. Bull.* 90.
- Klebesadel, L.J. 1993a. Fescue grasses differ greatly in adaptation, winter hardiness, and therefore usefulness in southcentral Alaska. *Alaska Agric. and Forestry Exp. Sta. Bull.* 92.
- Klebesadel, L.J. 1993b. Winter survival of grasses and legumes in subarctic Alaska as related to latitudinal adaptation, pre-winter storage of food reserves, and dry-matter concentration in overwintering tissues. *Alaska Agric. and Forestry Exp. Sta. Bull.* 94.
- Klebesadel, L.J. 1993c. Winterhardiness and agronomic performance of wildryes (*Elymus* species) compared with other grasses in Alaska, and responses of Siberian wildrye to management practices. *Alaska Agric. and Forestry Exp. Sta. Bull.* 97.
- Klebesadel, L.J. 1994a. Bromegrass in Alaska. V. Effects of various schedules and frequencies of harvest on forage yields and quality and on subsequent winter survival of several strains. *Alaska Agric. and Forestry Exp. Sta. Bull.* 102.
- Klebesadel, L.J. 1994b. Comparative winterhardiness of cultivated and native Alaskan grasses, and forage yield and quality as influenced by harvest schedules and frequencies, and rates of applied nitrogen. *Alaska Agric. and Forestry Exp. Sta. Bull.* 99.
- Klebesadel, L.J. 1994c. Winterhardiness, forage production, and persistence of introduced and native grasses and legumes in southcentral Alaska. *Alaska Agric. and Forestry Exp. Sta. Bull.* 101.
- Klebesadel, L.J. 1997a. Bromegrass in Alaska. VI. Effects of a broad array of harvest schedules and frequencies on forage yield and quality and on subsequent winter survival of cultivars Manchard and Polar. *Alaska Agric. and Forestry Exp. Sta. Bull.* 104.
- Klebesadel, L.J. 1997b. Timothy in Alaska: Characteristics, history, adaptation, and management. *Alaska Agric. and Forestry Exp. Sta. Bull.* 105.
- Klebesadel, L.J., and D. Helm. 1986. Food reserve storage, low-temperature injury, winter survival, and forage yields of timothy in subarctic Alaska as related to latitude-of-origin. *Crop Science* 26:325-334.
- Klebesadel, L.J., and D. Helm. 1992. Relationship of latitude-of-origin to winter survival and to forage and seed yields of wheatgrasses (*Agropyron* species) in subarctic Alaska. *Alaska Agric. and Forestry Exp. Sta. Bull.* 88.
- Klebesadel, L.J., and W.M. Laughlin. 1964. Utilization of native bluejoint grass in Alaska. *Alaska Agric. Exp. Sta. Forage Research Report* 2.
- Koblet, R. 1950. The improvement of natural meadows and pastures in Switzerland. *Jour. British Grassland Soc.* 4:277-280.
- Launchbaugh, K.L., and F.D. Provenza. 1991. Learning and memory in grazing livestock application to diet selection. *Rangelands* 13:242-244.
- Marten, G.C. 1970. Measurement and significance of forage palatability. *Minnesota Agric. Exp. Sta. Scientific Jour. Series Paper no. 7117.* p. D1-D55. (In) *Proceedings National Conf. on Forage Quality Evaluation and Utilization*, Lincoln, NE, Sep. 1969. Nebraska Center for Continuing Education, Lincoln, NE.
- Marten, G.C., and J.D. Donker. 1968. Determinants of pasture value of *Phalaris arundinacea* L. vs. *Bromus inermis* Leyss. *Agronomy Jour.* 60:703-705.
- Matches, A.G., and J.C. Burns. 1995. Systems of grazing management. p. 179-192. (In) R. F. Barnes, D.A. Miller, and C.J. Nelson (Eds.) *Forages: The Science of Grassland Agriculture*. Vol. II. Iowa State University Press, Ames, IA.
- McCullough, M.E. 1959. Conditions influencing forage acceptability and rate of intake. *Jour. Dairy Science* 42:571-574.
- Mitchell, W.W. 1982. Forage yield and quality of indigenous and introduced grasses at Palmer, Alaska. *Agronomy Jour.* 74:899-905.
- Mitchell, W.W. 1984. Ryegrasses: An option for an annual forage crop in Alaska. *Alaska Agric. Exp. Sta. Bull.* 64.
- Mitchell, W.W. 1987. Grasses indigenous to Alaska and Iceland compared with introduced grasses for forage quality. *Canadian Jour. Plant Science* 67:193-201.
- Pritchard, G.I., L.P. Folkins, and W.J. Pigden. 1963. The *in vitro* digestibility of whole grasses and their parts at progressive stages of maturity. *Canadian Jour. Plant Science* 43:79-87.
- Provenza, F.D., and D.F. Balph. 1988. Development of dietary choice in livestock on rangelands and its implications for management. *Jour. Animal Science* 66:2356-2368.
- Rogler, G.A. 1944. Relative palatabilities of grasses under cultivation on the northern Great Plains. *Jour. American Soc. Agronomy* 36:487-496.
- Rohweder, D.A., and K.A. Albrecht. 1995. Permanent pasture ecosystems. p.207-223. (In) R.F. Barnes, D.A. Miller, and C.J. Nelson. (Eds.) *Forages: The Science of Grassland Agriculture*. Vol. II. Iowa State University Press, Ames, IA.
- Smith, Dale, R.J. Bula, and R.P. Walgenbach. 1986. (5th ed) *Forage management*. Kendall/Hunt Publishing Co., Dubuque, IA.
- Springfield, H.W., and H.G. Reynolds. 1951. Grazing preferences of cattle for certain reseeding grasses. *Jour. Range Management* 4:83-87.

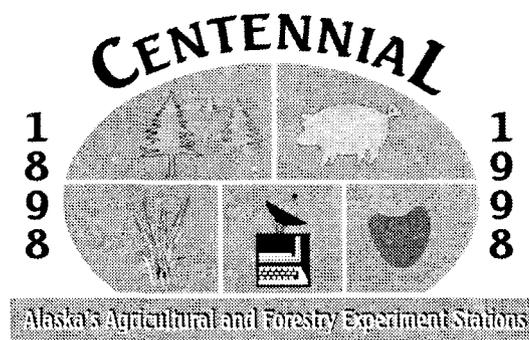
Stroh, J.R., J.L. McWilliams, and A.A. Thornburg. 1978. 'Garrison' creeping foxtail. U.S. Department of Agriculture-Soil Conservation Service Pub. SCS-TP-156.

Tribe, D.E. 1950. The behavior of the grazing animal; a critical review of present knowledge. Jour. British Grassland Soc. 5:209-224.

Wedin, W.F., H.J. Hodgson, and N.L. Jacobson. 1975. Utilizing plant and animal resources in producing human food. Jour. Animal Science 41:667-686.

Wilkins, F.S., and H.D. Hughes. 1932. Agronomic trials with reed canary grass. Jour. American Soc. Agronomy 24:18-28.

Wilton, A.C., H.J. Hodgson, L.J. Klebesadel, and R.L. Taylor. 1966. Polar brome grass—a new winterhardy forage for Alaska. Alaska Agric. Exp. Sta. Circ. 26.



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