AFES Bulletin 112
February 2005

Response of Bluejoint Reedgrass Dominated Stands to Mowing and Nitrogen Fertilization in Central Alaska

S.D. Sparrow[1] and M. T. Panciera[2]

[1]Professor of Agronomy in the Plant, Animal, and Soil Sciences Department, University of Alaska Fairbanks
[2]Associate Professor in the Department of Agriculture and Natural Resources, Berea College, Berea, Kentucky

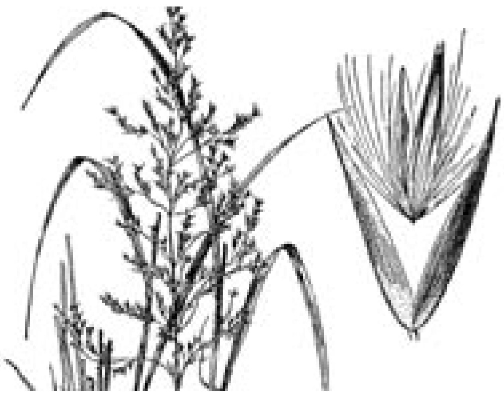
Abbreviations used in this publication: ADF, acid detergent fiber; N, nitrogen, LHS, late heading stage; LVS, late vegetative stage; MBS, mid-boot stage; 2x, cut twice; 3x, cut three times.

Summary

Bluejoint reedgrass (*Calamagrostis canadensis* [Michx.] Beauv.) is often considered a weed species, but native stands are sometimes used for pasture or hay. The purpose of this study was to determine treatment year and residual effects of mowing and nitrogen (N) fertilization management on yield and forage quality of bluejoint reedgrass in native stands in central Alaska and of mowing timing and frequency on control of bluejoint reedgrass as a weed. Total seasonal bluejoint reedgrass herbage yields averaged 0.42 tons/acre (0.94 Mg/ha) in the treatment year and 0.22 tons/acre (0.50 Mg/ha) in post-treatment years. Herbage yields under N fertilization in the treatment year averaged 0.52 tons/acre (1.16 Mg/ha) as compared to 0.22 tons/acre (0.50 Mg/ha) without N, with no differences between single and split-N applications. Yields of bluejoint reedgrass regrowth following cuttings after mid-July were low (usually < 0.17 tons/acre, 0.4 Mg/ha). Crude protein concentrations in bluejoint reedgrass tissues sometimes exceeded 20%, indicating potential for this species to produce high protein forage in central Alaska. Acid detergent fiber (ADF) values were generally between 30 and 35% and were lowest early in the season or after short intervals following harvest. Nitrogen fertilizer increased post-treatment years bluejoint reedgrass herbage yields from 0.16 tons/acre (0.36 Mg/ha) to 0.30 tons/acre (0.67 Mg/ha). Multiple harvests did not decrease total seasonal yields, indicating mowing management may not be an effective way to control bluejoint reedgrass. Previous mowing or N fertilizer treatments had little effect on subsequent year tissue crude protein or ADF concentrations. Total seasonal bluejoint reedgrass yields throughout the study seldom exceeded 0.54 tons/acre (1.2 Mg/ha), which is the approximate economic break-even yield for hay crops in central Alaska. This study indicated that with proper harvest and fertilizer management, bluejoint reedgrass can produce good quality livestock forage in central Alaska, but yields of native stands may be too low to be economical for farmers. Our results indicate that aggressive mowing (up to three cuttings per season) for a single year is not likely to provide good control of bluejoint reedgrass.

❑

Calamagrostis canadensis (Michx.) Beauv., commonly known as bluejoint reedgrass or sometimes simply bluejoint in Alaska, is widely distributed in marshes, open woods, and meadows (Hitchcock 1950) across boreal North America (Hultén 1968). Bluejoint reedgrass meadows are common in southcentral and southwestern Alaska, apparently as climax or near-climax communities (Viereck et al. 1992). The grass often forms dense stands following disturbance such as burning or clear-cut timber harvest (Viereck et al. 1992, Lieffers et al. 1993). These stands can inhibit white spruce *(Picea glauca)* seedling establishment, thus bluejoint reedgrass is often considered a serious weed in white spruce plantations (Lieffers et al. 1993). It is a common weed species in pastures and in reduced tillage agricultural fields in Alaska (Conn 1987). Native stands of bluejoint reedgrass and other native grass species sometimes provide forage for grazing for cattle *(Bos taurus)* and bison *(Bison bison)* in Alaska and western Canada (Klebesadel and Laughlin 1964, Reynolds et al. 1978, Klebesadel 1983, Gainer 1987). Forage quality of bluejoint reedgrass has been reported to compare favorably with common forage grasses in Alaska when harvested early in the growing season (Mitchell 1982, 1987), but quality declines rapidly as the season progresses (Alberts 1928, Mitchell 1987).



Calamagrostis canadensis *var.* scabra. *Image courtesy of the USDA-NRCS PLANTS Database / Hitchcock, A.S. (rev. A. Chase). 1950. Manual of the grasses of the United States . USDA Misc. Publ. No. 200. Washington, DC.*

Research on control of bluejoint reedgrass has focused on intensive clipping or use of herbicides. Hogg and Lieffers (1991) reported poor control with multiple clippings at ground level during a single growing season, but Lieffers et al. (1993) indicated that two or more cuts per year or intensive grazing over several years can keep bluejoint reedgrass under control. These same authors reported that herbicides such as glyphosate and hexazinone can provide moderate to excellent control of bluejoint reedgrass. Control of bluejoint reedgrass by glyphosate is poor in central Alaska when it is applied prior to mid-June or after early September; best control is obtained when glyphosate is applied to the grass in late reproductive stages (Conn and Deck 1991).

We initiated this study partly in response to a problem with management of a free-ranging bison herd near Delta Junction, Alaska. The bison frequently visit farmers' fields in late summer and early autumn, causing significant crop damage. Domestic grasses were planted on Delta Junction Bison Range in the early 1980s in an attempt to provide forage for the bison to discourage them from entering farmers' fields. These fields have received fairly low levels of management, and bluejoint reedgrass has become an important invader grass on much of the planted range. The bison generally enter the range in late July or early August, when bluejoint reedgrass is in the late heading stage, and palatability is poor. Productivity of bluejoint reedgrass in the pastures is estimated to be fairly low, but since it is considerably taller and coarser than the domestic grasses, even fairly low densities inhibit grazing of the domestic grasses. An important question is: Is there a way, with limited funds and low levels of management, to either control the bluejoint reedgrass to allow the domestic grasses to grow or to manage it so that it will become desirable forage for the bison when they enter the pastures? Public opposition prevents use of herbicides on most public lands in Alaska.

Farmers in the area are also looking for hardy forage grasses as alternatives to the species currently used for forage crops in interior Alaska. There is particular interest in native grasses because they are adapted to the region and are not potentially invasive, exotic species. Most hay produced in central Alaska is smooth bromegrass (*Bromus inermis* Leyss.) although some timothy (*Phleum pratense* L.) is grown. Both are introduced species and are generally better adapted to more temperate climates than that found in interior Alaska (Klebesadel, 1994).

Although management of bluejoint reedgrass has been studied extensively in other regions, either as a forage crop or as a weed, it has received little study in interior Alaska. Despite considerable work on management of bluejoint reedgrass, questions still remain about defoliation and N fertilizer effects on productivity, quality, and persistence of this grass.

The first objective of this study was to determine the effects of different mowing treatments and N fertilizer applications on treatment year and post-treatment year bluejoint reedgrass yield, forage quality, and persistence in central Alaska. Second, we wanted to determine if fairly intensive management could be used to either control growth and reduce stands of the grass as a weed or enhance its use as a forage crop. Finally, we wanted to estimate the economic feasibility of managing native stands of bluejoint reedgrass hay in interior Alaska.

Materials and Methods

We established plots in 1995 and 1996 on the University of Alaska Fairbanks Delta Field Research Site near Delta Junction (64°02'N, 145°44'W), Alaska. The plots were on old fields with native bluejoint reedgrass constituting about 50% of the stands. The fields had been cleared for agriculture about fifteen years earlier but abandoned after a single year of cropping. Study sites for the two years were about one-half mile (1 km) apart. The 1995 plots were on a Volkmar silt loam (coarse-silty over sandy or sandy-skeletal, mixed, superactive Aquic Eutrocryepts) and the 1996 plots on a Beales silt loam (sandy, mixed Typic Dystrocryepts). Study areas were selected because they had bluejoint reedgrass stand densities and soil types similar to those on the above-mentioned bison pastures. Each plot area consisted of numerous other species, including woody plants such as willow (*Salix* spp.) and quaking aspen (*Populus tremuloides* Michx.), some of which were up to 6 feet (2 m) tall; forbs such as tall fireweed (*Epilobium angustifolium* L. [Scop.]); and several species of grasses.

We selected the plot areas one year before beginning the study at each site. The entire area was mowed before plant growth began in mid-May, primarily to remove tall, woody vegetation and accumulations of dead biomass. The area was then broadcast fertilized with 45 lb N/ac (50 kg N/ha), 13 lb P/acre (30 lb P_2O_5 equivalent/acre, 15 kg P/ha), 17 lb K/acre (20 lb K_2O equivalent/acre, 19 kg K/ha), and 4.5 lb S/ac (5 kg S/ha). No further treatment was done in the preliminary year at each site.

Table 1. Sampling dates for various mowing treatments for bluejoint reedgrass *(Calamagrostis canadensis)* in central Alaska.

Mowing treatment	Sampling dates on Volkmar soil in 1995	Sampling dates on Beales soil in 1996
Late-vegetative stage	12 Jun.	29 Jun.
Mid-boot stage	22 Jun.	21 Jul.
Late-heading stage	19 Jul.	21 Aug.
2 mowings, 1st cut	22 Jun.	11 Jul.
2 mowings, 2nd cut	31 Jul.	21 Aug.
3 mowings, 1st cut	12 Jun.	29 Jun.
3 mowings, 2nd cut	12 Jul.	23 Jul.
3 mowings, 3rd cut	09 Aug.	21 Aug.
All plots (sampled but not mowed)	06-08 Sep.	09-10 Sep.

A complete factorial experiment consisting of 3 N fertilizer treatments and 6 harvest treatments was used at each site. Plots were 10 x 50 ft (3 x 15 m) in size and were laid out in randomized complete block designs with four replications. Phosphorus and potassium fertilizer was uniformly broadcast on all plots in late May of the treatment year at each site at a rate of 17 lb P/acre (40 lb P_2O_5 equivalent/acre, 20 kg P/ha) as triple superphosphate and 42 lb K/acre (50 lb K_2O equivalent/ac, 47 kg K/ha) as potassium sulfate. Nitrogen treatments consisted of a control (0 N applied) or 80 lb N/acre (90 kg N/ha), applied as ammonium nitrate in a single application in spring (late May) or as split application. For the split application, 40 lb N/acre (45 kg N/ha) was applied in spring and 40 lb N/acre (45 kg N/ha) applied after the first harvest or in mid-July for the no harvest treatments. Harvest treatments included: no harvest, single harvest made at late-vegetative stage, single harvest made at mid-boot stage, single harvest made at late-heading stage, two harvests, and three harvests (Table 1).

We sampled the plots by hand-clipping two 10 sq ft ($1m^2$) areas, selected randomly, within each plot. Bluejoint reedgrass was separated from other plant species at time of harvest. After hand-clipping we mowed the plots with a tractor-drawn mower set at approximately 4 inches (10 cm) height, which was about the same height that plots were hand clipped. All plots, including the no harvest treatments, were sampled near the end of the growing season, but were not mowed. Some of the plots did not produce enough regrowth for sampling at the end of the season.

Samples were dried at 140°F (60°C), weighed to determine herbage yield, ground to pass a 20-mesh screen, and analyzed for concentration of N, acid detergent fiber (ADF), and ash. Tissue N was measured by dry combustion with a CHN analyzer. Crude protein in tissue was estimated as tissue N concentration x 6.25. We determined ADF for the 1995 samples by the Van Soest method (Van Soest, 1967). In the other years, we used a modified Van Soest method (Komarek et al. 1994, 1996). We determined tissue ash concentrations by weighing residue remaining after ignition at 1,020°F (550°C) for seven hours.

In the two years after treatment at each site, aboveground plant material was harvested once in mid-to-late August and separated into bluejoint reedgrass and other species. Tissue N concentration was determined in both years for each site; ADF and ash were determined only in the first year subsequent to the treatment year.

We used analysis of variance to analyze the data as a 2 factor factorial experiment combined over site-years, with new randomization for each site year (Gomez and Gomez, 1984). The Waller-Duncan k ratio test was used to compare means when significant main effects or interactions were found (Petersen, 1994).

Table 2. Monthly growing season precipitation and average temperatures for the 1995–1998 growing seasons at Big Delta, Alaska.

Year	May	Jun.	Jul.	Aug.	Seasonal Total
Precipitation in inches (mm in parentheses)					
1995	0.87 (22)	2.95 (75)	0.94 (24)	3.94 (100)	8.70 (221)
1996	0.20 (5)	2.20 (56)	2.12 (54)	1.46 (37)	5.98 (152)
1997	1.10 (28)	1.65 (42)	2.36 (60)	3.07 (78)	8.18 (208)
1998	0.35 (9)	0.98 (25)	5.28 (134)	1.85 (47)	8.46 (215)
Long-term averages	0.79 (20)	2.52 (64)	2.75 (70)	1.97 (50)	8.03 (204)
Temperature in °F (°C in parentheses)					
1995	54.0 (12.2)	59.2 (15.1)	62.1 (16.7)	54.9 (12.7)	
1996	48.0 (8.0)	57.2 (14.0)	61.5 (16.4)	53.8 (12.1)	
1997	no data	60.6 (15.9)	63.0 (17.2)	57.7 (14.3)	
1998	49.1 (9.5)	56.1 (13.4)	60.3 (15.7)	52.0 (11.1)	
Long-term averages	46.8 (8.2)	56.8 (13.8)	60.3 (15.7)	55.4 (13.0)	

Results and Discussion

The 1996 growing season and the early part of the 1998 growing season were much drier than average, while other years were slightly wetter than average. Growing season temperatures were near or slightly above the long-term average temperature (Table 2).

Treatment year

Total seasonal yields

Total seasonal bluejoint reedgrass herbage yield on the Volkmar soil in 1995, when averaged across all treatments, was 0.45 tons/acre (1.01 Mg/ha), which was significantly ($P< 0.05$) higher than the average yield of 0.39 tons/acre (0.87 Mg/ha) on the Beales soil in 1996. Total seasonal yields were not significantly affected by cutting treatment. Total seasonal mean herbage yield for N fertilized treatments was 0.51 tons/acre (1.16 Mg/ha) compared to 0.22 tons/acre (0.50 Mg/ha) for the treatments that did not receive N fertilizer. Total yields did not differ between single and split-N applications.

The bluejoint reedgrass yields in this study were lower than those often reported for southcentral Alaska, which usually has wetter and longer growing seasons than central Alaska. Unfertilized native stands there have been reported to yield in excess of 2.0 tons/acre (4.5 Mg/ha), although yields near 1 ton/acre (near 2 Mg/ha) are more typical (Klebesadel and Laughlin 1964). Mitchell (1982) and Laughlin et al. (1984) reported annual yields of >2.6 tons/acre (> 6 Mg/ha) for both planted and native stands when fertilized with N at rates of 120 lb/acre (134 kg/ha) or higher. The relatively low yields in this study may have been due to a number of factors including: moisture limitation, suboptimal nutrient levels, and impure stands. Bluejoint reedgrass grows under a wide range of soil moisture conditions, but needs moist conditions for best growth (Lieffers et al., 1993). Our sites had sandy subsoils and thus low water storage capacities, so moisture was likely limiting, especially for the 1996 growing season. These soils are typically low in plant available nutrients (Schoephorster, 1973; Van Veldhuizen and Knight, 2004) and our fertilizer rates were relatively low to correspond with those used on the Delta Junction Bison Range. Also, purer bluejoint stands would likely have resulted in higher yields as substantial portions of the biomass in this study were made up of other species.

Table 3. Bluejoint reedgrass and other species herbage yield under various cutting and nitrogen fertilizer treatments in 1995 and 1995.

Cutting treatment	Bluejoint reedgrass		Other species	
	1995	1996	1995	1996
	Tons/acre (Mg/ha in parentheses)			
Late vegetative stage, 1st harvest	0.25 (0.56)	0.07 (0.15)	0.09 (0.20)	0.18 (0.40)
Mid-boot stage, 1st harvest	0.24 (0.54)	0.37 (0.82)	0.26 (0.58)	0.47 (1.06)
Late heading stage, 1st harvest	0.43 (0.96)	0.45 (1.00)	0.61 (1.36)	0.56 (1.26)
2-cut, 1st harvest	0.29 (0.65)	0.20 (0.44)	0.35 (0.79)	0.44 (0.99)
2-cut, 2nd harvest	0.16 (0.36)	0.14 (0.31)	0.12 (0.27)	0.08 (0.18)
3-cut, 1st harvest	0.18 (0.40)	0.08 (0.17)	0.12 (0.27)	0.24 (0.53)
3-cut, 2nd harvest	0.24 (0.54)	0.18 (0.40)	0.25 (0.55)	0.11 (0.24)
3-cut, 3rd harvest	0.15 (0.34)	0.07 (0.16)	0.06 (0.13)	0.06 (0.14)
Late vegetative stage, late sampling	0.27 (0.61)	0.32 (0.72)	0.16 (0.36)	0.13 (0.30)
Mid-boot stage, late sampling	0.14 (0.31)	0.02 (0.05)	0.08 (0.19)	0.01 (0.02)
No harvest, late sampling	0.36 (0.80)	0.37 (0.83)	0.38 (0.86)	0.42 (0.95)
Standard error of mean	0.04 (0.09)		0.06 (0.14)	
Waller-Duncan k ratio for cutting treatment†	0.09 (0.20)		0.16 (0.35)	

† Means that are different by more than the Waller-Duncan k ratio are significantly different at k = 100 (approximately $\alpha = 0.05$).

The overall mean yield for species other than bluejoint reedgrass was 0.44 tons/acre (0.98 Mg/ha). Response to N fertilizer by other species was similar to bluejoint reedgrass. The no-N treatment yielded 0.34 tons/acre (0.76 Mg/ha) which was significantly lower than the fertilized treatments which yielded an average of 0.50 tons/acre (1.10 Mg/ha), with no difference between the single and split applications.

Individual samplings

Individual harvests showed rather dramatic differences for bluejoint reedgrass herbage yields, with significant differences between years and among fertilizer treatments and cutting regimes. Yields were lowest for early season cuttings and increased for single harvests as the season progressed, except the no harvest treatment produced lower yields than the late heading harvest (Table 3). The low yields for early harvests in 1996 compared to 1995 were probably because of early season dry conditions in 1996 (Table 2). The decreased yield for the no-cut as compared to the late heading mowing was likely because the no-cut treatment had senesced to the point that it had dropped many of its leaves, and hence had reduced biomass by the time it was sampled in September.

Bluejoint reedgrass regrowth was very poor following cutting after about mid-July, and poor regrowth made it impossible to resample several of the late defoliation treatments, thus we have not shown data for the September sampling for the late heading or the multiple-cut regimes. The poor late-season regrowth may be because the short growing seasons typical of the region have conditioned plants to initiate dormancy early, causing plants to allocate late-season resources into reserves rather than aboveground growth (Klebesadel 1994). Mitchell (1982) and Laughlin et al. (1984) reported good regrowth and high yields with two harvests per season, and Klebesadel and Laughlin (1964) found higher yields for second harvests when the first harvest was made in June on plots near Palmer, in southcentral Alaska. On the other hand, Klebesadel (1965) reported low regrowth following early July harvests of bluejoint reedgrass and found single harvest yields, when harvested at the early heading stage, to be higher than yields for a double-cut harvest regime. Lower total seasonal yields of bluejoint reedgrass with multiple harvests compared to a single harvest were reported in Alberta (Corns and Schraa 1962).

Bluejoint reedgrass yield response to N fertilizer was not significant ($P < 0.05$) for the earliest mowings (late vegetative stage, first cut of triple harvest), possibly because early-season moisture limitations prevented rapid early growth. For all other harvests, N fertilized plots produced higher yields than the no-N treatments (data not shown). The single N application yielded more bluejoint reedgrass herbage than the split-N application for early and single cuts, but these differences were not always significant. For late-season harvests, single and split-N applications generally produced similar yields; the only exception was the September sampling of the late vegetative stage harvest in which the split-N application produced highest yields. Laughlin et al. (1984) and Mitchell et al. (1983) reported that a second N fertilizer application produced higher yields than did a single early application in southcentral Alaska. The lack of response to split-N application for most treatments in our study may have been because the short growing season did not allow plants time to respond to the late application. Water limitations may have exacerbated the short-season effect by inducing dormancy. 'Engmo' timothy (*Phleum pratense* L.), which was developed at 70° N in Norway, produces little regrowth and no stems following cutting in central and northern Alaska, while more southern adapted timothy cultivars produce stems and significant yields following harvest (Klebesadel and Helm 1986).

Other species response to mowing treatments generally followed a pattern similar to that of bluejoint reedgrass (Table 3). Since we did not separate other species' biomass, we do not know which species had highest yields or which ones were most affected by the treatments. Regrowth of other species was poor for all treatments, even those harvested early in the growing season, and yields of regrowth following harvests made after about mid-July were extremely low.

The proportion of the total biomass which was made up of bluejoint reedgrass varied from less than 0.3 to almost 0.7, with much higher values for early-season cuts in 1995 than in 1996 (data not shown). When averaged across both years, yield of bluejoint reedgrass as a proportion of total yield tended to increase in regrowth, especially in multiple-cut treatments, indicating that aggressive harvest regimes may be a way to manage native stands to increase the proportion of bluejoint reedgrass, at least with the species present in our study. The mean proportion of yield which was constituted by bluejoint reedgrass was 0.45 when no N was applied compared to 0.56 for N fertilized treatments, with no difference between single and split-N applications.

Crude protein concentrations in bluejoint reedgrass herbage tissue varied considerably (Table 4), with some values exceeding 20%. Tissue crude protein concentrations, when averaged over all treatments, were slightly but significantly ($P < 0.05$) higher in 1996 (13.9%) than in 1995 (12.0%). Although higher values have been reported for this grass when harvested very early in the growing season, we have not found reports of crude protein this high for bluejoint reedgrass harvested at similar growth stages (Corns and Schraa 1962, Klebesadel and Laughlin 1964, Mitchell 1987). Crude protein concentrations for first cuttings decreased rapidly as the season progressed. Crude protein levels in tissue were generally high for regrowth, and values were highest for the shortest regrowth intervals. When averaged over all mowing treatments, the lowest tissue crude protein concentrations were in the no-N treatment. A significant mowing treatment by N treatment interaction in our study revealed that first harvest samples often had higher tissue N levels following the single N application, while regrowth generally had higher values following split applications.

Acid detergent fiber concentrations ranged from about 27% to 37%, (Table 5). Our ADF concentrations for the early harvests were within the range considered typical for grass hay harvested in the late-vegetative to early heading stages (Van Soest 1994). The ADF concentrations for first harvest treatments increased with maturity but concentrations in regrowth tissue were often also relatively high, especially if no N fertilizer was applied. Nitrogen fertilizer treatments often resulted in significantly ($P < 0.05$) lower ADF concentrations compared to no-N, but ADF concentrations usually did not differ between single and split-N applications. Early-season ADF values were similar in 1995 and 1996, but were usually considerably lower for late-season samplings in 1996 than in 1995 (data not shown). This was probably because first harvests were made later in 1996, resulting in less mature regrowth in that year. We have not been able to find bluejoint reedgrass ADF values in the literature, but Corns and Schraa (1962) reported lowest crude fiber concentrations in new regrowth in bluejoint reedgrass tissue in Alberta, with no effect from fertilizer. Klebesadel and Laughlin (1964) reported crude fiber concentrations in bluejoint reedgrass tissue in southcentral Alaska ranging from about 20% for samples collected very early in the growing season to near 35% for samples collected at about the time of senescence.

In this study, ash concentrations in herbage ranged from near 5% to almost 13% (Table 6), with much greater variation in 1995 than in 1996. When averaged across all mowing treatments, plots with no N applied produced herbage with higher ash concentrations than those receiving fertilizer. With most mowing treatments, ash concentrations were similar in single and split-N applications. Ash concentrations decreased with maturity for first harvest samples, especially for fertilized treatments, but no discernible pattern was found for regrowth ash concentrations. Ash values were found to decrease from 10% early in the growing season to as low as 4% at seed drop in bluejoint reedgrass in southcentral Alaska (Klebesadel and

Table 4. Crude protein concentrations in bluejoint reedgrass tissue under various cutting and nitrogen fertilizer treatments in 1995 and 1995.

Cutting treatment	No N applied	Single N application	Split N application
		%	
Late vegetative stage, 1st harvest	14.6	20.5	20.7
Mid-boot stage, 1st harvest	9.1	12.0	11.5
Late heading stage, 1st harvest	6.4	7.2	6.9
2-cut, 1st harvest	11.6	15.9	13.2
2-cut, 2nd harvest	11.5	13.1	18.0
3-cut, 1st harvest	14.3	21.7	20.0
3-cut, 2nd harvest	13.3	18.7	19.1
3-cut, 3rd harvest	13.3	17.0	17.4
Late vegetative stage, late sampling	7.7	6.4	9.1
Mid-boot stage, late sampling	11.8	12.6	16.0
No harvest, late sampling	4.4	5.8	6.0
Standard error of mean: 0.98			
Waller-Duncan k ratio for cutting treatment†: 1.9			

† Means that are different by more than the Waller-Duncan k ratio are significantly different at k = 100 (approximately α = 0.05).

Table 5. Acid detergent fiber concentrations in bluejoint reedgrass tissue under various cutting and nitrogen fertilizer treatments in 1995 and 1995.

Cutting treatment	No N applied	Single N application	Split N application
		%	
Late vegetative stage, 1st harvest	30.4	27.5	28.2
Mid-boot stage, 1st harvest	33.3	32.9	32.7
Late heading stage, 1st harvest	33.4	33.9	33.5
2-cut, 1st harvest	33.1	32.1	33.8
2-cut, 2nd harvest	36.6	33.4	30.1
3-cut, 1st harvest	31.0	26.6	27.9
3-cut, 2nd harvest	34.4	31.2	31.3
3-cut, 3rd harvest	36.0	31.1	32.0
Late vegetative stage, late sampling	33.8	31.5	31.2
Mid-boot stage, late sampling	33.3	29.6	28.7
No harvest, late sampling	37.1	35.6	34.4
Standard error of mean: 1.21			
Waller-Duncan k ratio for cutting treatment†: 3.0			

† Means that are different by more than the Waller-Duncan k ratio are significantly different at k = 100 (approximately α =0.05).

Table 6. Ash concentrations in bluejoint reedgrass tissue under various cutting and nitrogen fertilizer treatments in 1995 and 1995.

Cutting treatment	No N applied	Single N application	Split N Application
		%	
Late vegetative stage, 1st harvest	8.0	7.3	7.6
Mid-boot stage, 1st harvest	7.4	6.2	6.2
Late heading stage, 1st harvest	7.1	5.3	5.6
2-cut, 1st harvest	7.3	6.2	6.6
2-cut, 2nd harvest	10.3	7.1	6.8
3-cut, 1st harvest	8.3	7.4	7.6
3-cut, 2nd harvest	8.9	6.8	6.8
3-cut, 3rd harvest	10.8	7.4	7.6
Late vegetative stage, late sampling	11.0	6.8	5.8
Mid-boot stage, late sampling	13.1	9.0	7.5
No harvest, late sampling	9.3	5.8	6.2
Standard error of mean: 0.39			
Waller-Duncan k ratio for cutting treatment†: 0.7			

† Means that are different by more than the Waller-Duncan k ratio are significantly different at k = 100 (approximately α = 0.05).

Laughlin 1964).

Post-treatment years

Bluejoint reedgrass yields were low in the post-treatment years (Table 7), averaging only 0.23 tons/acre (0.51 Mg dry matter/ha) in the first post-treatment year and 0.21 tons/acre (0.48 Mg/ha) in the second post-treatment year. Yields following any treatment never exceeded 0.40 tons/acre (0.90 Mg/ha). We found significant interactions for post-treatment year X mowing treatment, post-treatment year X N fertilizer treatment, and mowing treatment X N fertilizer regime. When averaged over both years and all N treatments, the previous multiple cuts produced slightly higher yields (0.24 tons/acre or 0.54 Mg/ha) than the single or no-cut treatments (0.21 tons/acre or 0.47 Mg/ha). The higher yields following multiple harvests may have been due to increased tillering due to the frequent defoliation.

Hogg and Lieffers (1991) found that although repeated clipping did not affect dry matter yield in the following season, it increased plant density. Laughlin et al. (1984) reported that bluejoint reedgrass in a natural stand in Alaska became denser with two harvests per year when fertilized adequately. We did not measure plant density in this study; however, our densities were probably initially fairly low, as indicated by the relatively low yields and the presence of nearly 50% in non-bluejoint yield. Thus it makes sense that increasing plant density would increase yields. When averaged over both post-treatment years and all mowing treatments, the no-N treatment produced lowest yields (0.16 tons/acre, 0.36 Mg/ha) and the split-N application produced highest yields (0.30 tons/acre, 0.67 Mg/ha). Mitchell (1979) also found a carryover effect from fertilization of bluejoint reedgrass.

The N fertilizer effect was especially evident in the first post-treatment year, but by the second post-treatment year, only the split-N treatment produced yields that were significantly higher than the other treatments (data not shown). Apparently, more of the residual N following the split-N treatment remained in plant-available form. These differences were not found for all mowing treatments. For example, no differences among fertilizer treatments were found for the triple-cut treatment, and there was no difference between the single and split-N application for the no-cut treatment. When no N fertilizer had been applied, the multiple-cut treatments produced higher yields than other mowing treatments. This indicates that repeated defoliation, at least during a single year, is not a useful way to reduce subsequent year bluejoint reedgrass growth in central Alaska.

Bluejoint reedgrass has been reported to be highly intolerant of annual harvest or continuous grazing (Aamodt and Savage 1949; Klebesadel 1965; Mitchell and Evans, 1966), especially when not fertilized properly (Klebesadel 1965, 1983). However, Hogg and Lieffers (1991) reported that clipping to ground level four times over a season did not suppress growth of bluejoint reedgrass the following year in northern Alberta. Several authors have reported that in southcentral Alaska, with proper management, bluejoint reedgrass can withstand and maintain good yields with at least two harvests per year over several successive years (Laughlin et al. 1984; Mitchell 1982, 1986). Corns and Schraa (1962), in central Alberta, reported that while repeated harvests greatly reduced yields of

Table 7. Bluejoint reedgrass yields in years following various mowing and nitrogen fertilizer treatments. Yields are averaged across two post-treatment years at two locations.

Previous mowing treatment	No N applied	Single N application	Split N application
	Tons/acre (Mg/ha in parentheses)		
No harvest	0.15 (0.34)	0.23 (0.51)	0.26 (0.59)
Late vegetative stage	0.12 (0.26)	0.16 (0.37)	0.35 (0.79)
Mid-boot stage	0.13 (0.29)	0.16 (0.36)	0.28 (0.64)
Late heading stage	0.15 (0.33)	0.23 (0.51)	0.29 (0.66)
Double cut	0.21 (0.47)	0.20 (0.44)	0.38 (0.85)
Triple cut	0.21 (0.46)	0.23 (0.51)	0.21 (0.48)
Standard error of mean: 0.029 (0.065)			
Waller-Duncan k ratio for cutting treatment†: 0.06 (0.13)			

† Means that are different by more than the Waller-Duncan k ratio are significantly different at k = 100 (approximately $\alpha = 0.05$).

Table 8. Yields of species other than bluejoint reedgrass in years following various mowing and nitrogen fertilizer treatments. Yields are averaged across two post-treatment years at two locations.

Previous mowing treatment	No N applied	Single N application	Split N application
	Tons/ac (Mg/ha in parentheses)		
No harvest	0.21 (0.48)	0.42 (0.94)	0.54 (1.21)
Late vegetative stage	0.25 (0.57)	0.21 (0.48)	0.35 (0.78)
Mid-boot stage	0.23 (0.52)	0.25 (0.57)	0.26 (0.59)
Late heading stage	0.21 (0.48)	0.26 (0.58)	0.27 (0.60)
Double cut	0.15 (0.33)	0.20 (0.45)	0.21 (0.48)
Triple cut	0.14 (0.28)	0.20 (0.45)	0.20 (0.46)
Standard error of mean: 0.038 (0.086)			
Waller-Duncan k ratio for cutting treatment†: 0.08 (0.17)			

† Means that are different by more than the Waller-Duncan k ratio are significantly different at k = 100 (approximately $\alpha = 0.05$).

fertilized and unfertilized bluejoint reedgrass compared to a single harvest, the grass was able to persist under even the most extreme harvest management (up to seven harvests per year).

Overall average yields for species other than bluejoint reedgrass were slightly but significantly ($P \leq 0.05$) higher in the first post-treatment year (0.27 tons/acre, 0.60 Mg/ha) than in the second post-treatment year (0.24 tons/acre, 0.54 Mg/ha). Yields were lowest from plots receiving no previous N (0.20 ton/acre, 0.44 Mg/ha), medium for those having received a single application (0.26 tons/acre, 0.58 Mg/ha), and highest following the split-N treatment (0.31 tons/acre, 0.69 Mg/ha). The only significant interaction for other species yields was N fertilizer regime by mowing harvest treatment. The no-cut and early season single cut (late vegetative stage) produced higher yields following split-N fertilizer applications than other fertilizer treatments; other previous mowing treatments seldom showed a significant response to previous N fertilization (Table 8). Overall, the response to previous mowing treatments tended to be opposite that of bluejoint reedgrass (compare Table 7 with Table 8).

The proportion of yield made up by bluejoint reedgrass in post-harvest years was usually near or below 0.5 (Table 9), with no significant difference between years. We found a significant effect of previous mowing treatments, with late cuts

Table 9. Average percent of bluejoint reedgrass yield of total herbage yield in years following various mowing and nitrogen fertilizer treatments. Data are averaged across two both post-treatment years at two locations.

Previous mowing treatment	No N applied	Single N application	Split N application
		%	
No harvest	42	39	32
Late vegetative stage	33	43	49
Mid-boot stage	36	39	50
Late heading stage	41	48	52
Double cut	58	50	65
Triple cut	61	53	52
Standard error of mean: 5.0			
Waller-Duncan k ratio for cutting treatment†: 10			

† Means that are different by more than the Waller-Duncan k ratio are significantly different at k = 100 (approximately $\alpha = 0.05$).

generally showing higher proportion of bluejoint reedgrass yields than early single cuts. Multiple cuts produced the highest proportions. This effect was most evident following the split-N application, with bluejoint reedgrass making up almost 65% of the total yield following the double-cut with split-N application treatment, compared to only about 32% for no-cut treatment with split-N application. Thus, aggressive cutting regimes with a midseason application of N may be used to increase the proportion of bluejoint reedgrass in mixtures with other native species in interior Alaska. This may not be true for mixtures containing domestic forage grasses, such as exists on the Delta Junction Bison Range. Two cuts per year appears to be the optimum number to produce the highest ratio of bluejoint reedgrass to other species yields in years subsequent to the treatment year. We do not know what the effect would be of continuous aggressive harvests over time and longer-term studies with better accounting of all species are needed to develop adequate recommendations.

Crude protein concentration in bluejoint reedgrass tissue was significantly higher in the first post-treatment year (7.1 %) than in the second (5.7%). We found a significant post-treatment year by mowing treatment by fertilizer treatment interaction. In the first post-treatment year, the previous multiple mowings produced higher protein herbage with no N applied than did other harvest treatments (data not shown). Differences in crude protein concentrations were small (usually less than 0.5%) across previous fertilizer treatments and mowing treatments, and thus were likely of little practical significance.

Bluejoint reedgrass tissue ADF and ash concentrations, which were measured only in the first post-treatment year samples, tended to be lower following multiple or late-season single cuts than the no-cut or early-season single cuts. ADF concentrations differed by less than 5% and ash less than 0.5% (data not shown). These differences were likely too small be of much significance from a forage quality standpoint. Previous N fertilization had little effect on tissue ash or ADF, except the ADF concentrations were slightly, but significantly ($P < 0.05$) lower for the N fertilized treatments than the nonfertilized treatments following multiple harvest treatments (data not shown). Tissue ADF concentrations were always greater than 30%.

Economic implications

Based on current prices in central Alaska, a hay farmer would need to produce about 0.53 tons /acre (1.2 Mg/ha) of hay to break even for square bales and about 0.67 tons/acre (1.5 Mg/ha) for round bales. This is based on fertilizer costs of $50/acre ($125/ha), operating costs other than baling of $40/acre ($100/ha), and baling costs of $30/ton ($27/Mg) for square bales and $16.50/ton ($15/Mg) for round bales (production costs and hay values supplied by Mr. Phil Kaspari, Cooperative Extension Service agent in Delta Junction, Alaska). Smooth bromegrass and timothy hay in square bales in the Delta Junction area of Alaska currently sells for about $200/ton ($220/Mg) and in round bales it sells for about $150/ton ($165/Mg). The higher value of square bales more than compensates for the higher baling costs, resulting in a lower break-even yield.

We do not know if bluejoint reedgrass hay would sell for the same price as other grass hays in the area. However, assuming similar prices, even the highest yields in this study would have resulted in net losses for a hay farmer. While higher yields of native stands of bluejoint reedgrass may be possible in central Alaska on better soils and with better weed control, this study raises doubts about the feasibility of commercially growing this species as a hay crop in interior Alaska. In low management pastures, such as the Delta Junction bison pastures, bluejoint reedgrass may have potential for early summer grazing or even late summer grazing if properly timed mowings are made in early summer.

Conclusion

Because of low yields, bluejoint reedgrass is likely to continue to be viewed mostly as a weed in interior Alaska. More research is needed on proper management of pasture or hay lands to control bluejoint reedgrass. Our results indicate that if the goal is to control bluejoint reedgrass by mowing, a single year of cutting, even if done aggressively, is not likely to control its growth, but mowing can improve late-season forage quality.

Acknowledgements

We thank darleen masiak for technical help with this project. This research was supported in part by a grant from the Alaska Science and Technology Foundation.

References

Aamodt, O.S. and Savage, D.A. 1949. Cereal, forage, and range problems and possibilities in Alaska. pp. 87–124 *in* Report of exploratory investigations of agricultural problems in Alaska. USDA Misc. Rep. 700. Washington, DC.

Alberts, H.W. 1928. Report of the Alaska Agr. Exp. Sta., 1927. USDA Office of Exp. Sta. Washington, DC. 40 pp.

Conn, J.S. 1987. Effects of tillage and straw management on Alaskan weed vegetation: a study of newly cleared land. *Soil and Tillage Res.* 9:275–285.

Conn, J.S. and Deck, R.E., 1991. Bluejoint reedgrass (*Calamagrostis canadensis*) control with glyphosate and additives. *Weed Tech.* 5:521–524.

Corns, W.G. and Schraa, R.J. 1962. Seasonal productivity and chemical composition of marsh reed grass (*Calamagrostis canadensis*) (Michx.) Beauv.) harvested periodically from fertilized and unfertilized native sod. *Can. J. Plant Sci.* 42:651–659.

Gainer, R.S. 1987. Livestock raising in the Northwest Territories. *Can. Vet. J.* 28:103–104.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research*, 2nd edition. John A. Wiley and Sons, New York, NY. 680 pp.

Hitchcock, A.S. 1950. *Manual of the grasses of the United States*, 2nd ed.. USDA Misc. Pub. 200. U.S. Government Printing Office, Washington, DC. 1051 pp.

Hogg, E.H. and Lieffers, V.J. 1991. The relationship between seasonal changes in rhizome carbohydrate reserves and recovery following disturbance in *Calamagrostis canadensis*. *Can. J. Bot.* 69:641–646.

Hultén, E. 1968. *Flora of Alaska and neighboring territories*. Stanford Univ. Press. Stanford, CA. 1004 pp.

Klebesadel, L.J. 1965. Response of native bluejoint grass (*Calamagrostis canadensis*) in subarctic Alaska to harvest schedules and fertilizers. pp. 1309–1314 *in* Proc. Ninth Int. Grassl. Conf., Vol. 2. Sao Paulo, Brazil.

Klebesadel, L.J. 1983. Forage crops in Alaska. Univ. Alaska Agr. and Forest. Exp. Sta. Bull. 63. Fairbanks, AK.

Klebesadel, L.J. 1994. 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. Univ. Alaska Fairbanks Agr. and Forest. Exp. Sta. Bull. 99. Fairbanks, AK.

Klebesadel, L.J. and Helm, D. 1986. Food reserve storage, low-temperature injury, winter survival, and forage yields of timothy in subarctic Alaska as related to latitude-of-origin. *Crop Sci.* 26:325–334.

Klebesadel, L.J. and Laughlin, W.M. 1964. Utilization of native bluejoint grass in Alaska. Univ. Alaska Agr. and Forest. Exp. Sta. Forage Res. Rep. 2. Fairbanks, AK.

Komarek, A.R., Manson, H., and Thiex, N. 1996. Crude fiber determinations using the ANKOM System. ANKOM Tech. Corp., Pub. 102. Fairport, NY. 3 pp.

Komarek, A.R., Robertson, J.B., and Van Soest, P.J. 1994. A comparison of methods for determining ADF using the filter bag technique versus conventional filtration. *J. Dairy Sci.* 77 (Supplement 1).

Laughlin, W.M., Smith, G.A., and Peters, M.A. 1984. Influence of N, P, and K fertilization on yield and mineral composition of native bluejoint grass on the Lower Kenai Peninsula, Alaska. *Agron. J.* 76:389–397.

Lieffers, V.J., MacDonald, S.E., and Hogg, E.H. 1993. Ecology of and control strategies for *Calamagrostis canadensis* in boreal forest sites. *Can. J. For. Res.* 23:2070–2077.

Mitchell, W.W. 1979. Managing bluejoint reedgrass for forage production. *Agroborealis* 11:15–19.

Mitchell, W.W. 1982. Forage yield and quality of indigenous and introduced grasses at Palmer, Alaska. *Agron. J.* 74:899–905.

Mitchell, W.W. 1986. Perennial grass trials for forage purposes in three areas of southcentral Alaska. Univ. Alaska Agr. and Forest. Exp. Sta. Bull. 73. Fairbanks, AK.

Mitchell, W.W. 1987. Grasses indigenous to Alaska and Iceland compared with introduced grasses for forage quality. *Can. J. Plant Sci.* 67:193–201.

Mitchell, W.W. and Evans, J. 1966. Composition of two disclimax bluejoint stands in southcentral Alaska. *J. Range Manage.* 19:65–68.

Mitchell, W.W., Laughlin, W.M., and Mitchell, G.A. 1983. Fertilizing bluejoint hay meadows on the Lower Kenai Peninsula. Univ. Alaska Agr. and Forest. Exp. Sta. Circ. 45. Fairbanks, AK.

Petersen, R.G. 1994. *Agricultural field experiments, design and analysis.* Marcel Dekker, New York. 409 pp.

About the Agricultural and Forestry Experiment Station

The federal Hatch Act of 1887 authorized establishment of agricultural experiment stations in the U.S. and its territories to provide sicence-based research information to farmers. There are agricultural experiment stations in each of the 50 states, Puerto Rico, and Guam. All are part of the land-grant college system. The Morrill Act established the land-grant colleges in 1862. While the experiment stations perform agricultural research, the land-grant colleges provide education in the science and economics of agriculture.

The first experiment station in Alaska was established in Sitka in 1898. Subsequent stations were opened at Kodiak, Kenai, Rampart, Copper Center, Fairbanks, and Matanuska. The latter two remain. None were originally part of the Alaska land-grant college system. The Alaska Agricultural College and School of Mines was established by the Morrill Act in 1922. It became the University of Alaska in 1935. The Fairbanks and Matanuska stations now form the Agricultural and Forestry Experiment Station of the University of Alaska Fairbanks, which also includes the Palmer Research Center.

Early experiment station researchers developed adapted cultivars of grains, grasses, potatoes, and berries, and introduced many vegetable cultivars appropriate to Alaska. Animal and poultry management was also important. This work continues, as does research in soils and revegetation, forest ecology and management, and rural and economic development. Change has been constant as the Agricultural and Forestry Experiment Station continues to bring state-of-the-art research information to its clientele.

Reynolds, H.W., Hansen, R.M., and Peden D.G. 1978. Diets of the Slave River Lowland Bison Herd, Northwest Territories, Canada. *J. Wildl. Manage.* 42: 581–589.

Schoephorster, D.B. 1973. Soil Survey of Salcha-Big Delta Area, Alaska. USDA, Soil Conservation Service, Washington, DC. 51 pp.

Van Soest, P.J. 1967. Development of a comprehensive system of feed analyses and its application to forages. *J. Anim. Sci.* 26:119–120.

Van Soest, P.J. 1994. *Nutritional ecology of the ruminant*, 2nd ed. Comstock Publ. Assoc. New York. 476 pp.

Van Veldhuizen, R.M. and Knight, C.W. 2004. Performance of Agronomic Crop Varieties in Alaska, 1978 – 2002. Univ. Alaska Fairbanks Agr. and Forest. Exp. Sta. Bull. 111. Fairbanks, AK. 130 pp.

Viereck, L.A., Dyrness, C.T., Batten, A.R., and Wenzlick, K.J. 1992. The Alaska vegetation classification. USDA Forest Service General Tech. Rep. PNW-GTR-286. USDA Pacific Northwest Res. Sta., Portland, OR. 277 pp.

Agricultural and Forestry Experiment Station

University of Alaska Fairbanks
AFES Publications Office
P.O. Box 757200
Fairbanks, AK 99775-7200
fynrpub@uaf.edu • www.uaf.edu/snras
907.474.6923 or 907.474.5042
fax: 907.474.6184

NOTE: Bulletins are published by the Alaska Agricultural and Forestry Experiment Station to provide information and final interpretations of data obtained over several years. Bulletins present results, analyses, and conclusions arising from formal studies or experiments and are scientific or technical reports of substance and significance. They represent final conclusions.