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No-till Forage Establishment in Alaska

Stephen D. Sparrow, Michael T. Panciera, Beth A. Hall, darleen t. masiak, Raymond G. Gavlak

Summary

We assessed the effectiveness of no-till forage establishment at six Alaska locations: Anchor Point, Sterling, Point MacKenzie, Palmer, Delta Junction, and Fairbanks. Directly seeding grass into established grass stands generally did not improve forage yields or quality. Seeding rate had little effect on establishment of newly seeded forages in no-till. Grass yields were depressed when companion crop yields were high, and they typically did not recover in subsequent years. Red clover established well, producing high yields of good quality forage under no-till at Point MacKenzie, but established poorly at Anchor Point and Delta Junction. These results indicated that no-till seeding of most forage crops into declining grass stands is not likely to be successful in Alaska with current available technology.

Introduction

Grass stands in Alaska periodically require renovation because of occasional winterkill or stand depletion over time. Current practices for reestablishing forage grasses in Alaska usually involve reseeding into well-tilled seedbeds. However, dry and often windy spring conditions prevail in much of Alaska, making establishment of small-seeded crops difficult. This project was designed to test the effectiveness of no-till seeding of forage crops as a means of renovating existing grass stands in Alaska. The objectives of this project were:

1. Nitrogen rate experiment. Evaluate the efficacy of no-till planting into existing sod compared to planting into tilled soil under various N fertilizer rates for establishing perennial forage grasses in Alaska.

2. Companion crop experiment. Evaluate annual companion crops for forage production during perennial grass establishment in no-till and conventionally tilled planting systems.

3. Seeding rate experiment. For sod renovation, determine the effectiveness of no-till establishment of perennial grasses and clover at various seeding rates.

Materials and Methods

Site Descriptions

We established experiments on farmers' fields at four locations in southcentral Alaska and two locations in interior Alaska. The southcentral Alaska sites were near Anchor Point (59°45'N, 151°39'W) on Edna Anderson's farm, near Sterling (60°32'N, 150°39'W) on Paul Rumley's farm, at Point Mackenzie (61°24'N, 150°04'W) on the Trytten Farm, and at Palmer (61°39'N, 150°04'W) on Peter Scorup's farm (Figure 1). The interior Alaska sites were near Delta Junction (63°55'N, 145°44'W) on Schultz Farms and near Fairbanks (64°55'N, 147°43'W) on Columbia Creek Farm. Climate at the different sites varies from moderately maritime to strongly continental (Table 1). The Anchor Point area experiences wetter and cooler growing seasons than the other sites (figures 2 and 3). April and May are typically the driest months, so spring moisture is often limited, especially if snow cover is inadequate to supply enough melt water to sufficiently wet the soil. The Delta Junction and Palmer areas experience strong winter and spring winds that tend to remove much of the snow cover and dry the soil surface in spring. During the

Table 1. Climate at six locations in Alaska.

Location	MAT†	MAP‡	Climate Classification
Anchor Point	37	25.4	Moderately maritime
Sterling	34	19.0	Moderately continental
Point MacKenzie	36	15.9	Moderately continental
Palmer	35	15.5	Moderately continental
Delta Junction	28	10.9	Strongly continental
Fairbanks	27	12.0	Strongly continental

†Mean annual temperature (°F)
‡Mean annual precipitation (inches)
Sources: National Climatic Data Center, 2001, Stahler, 1969.

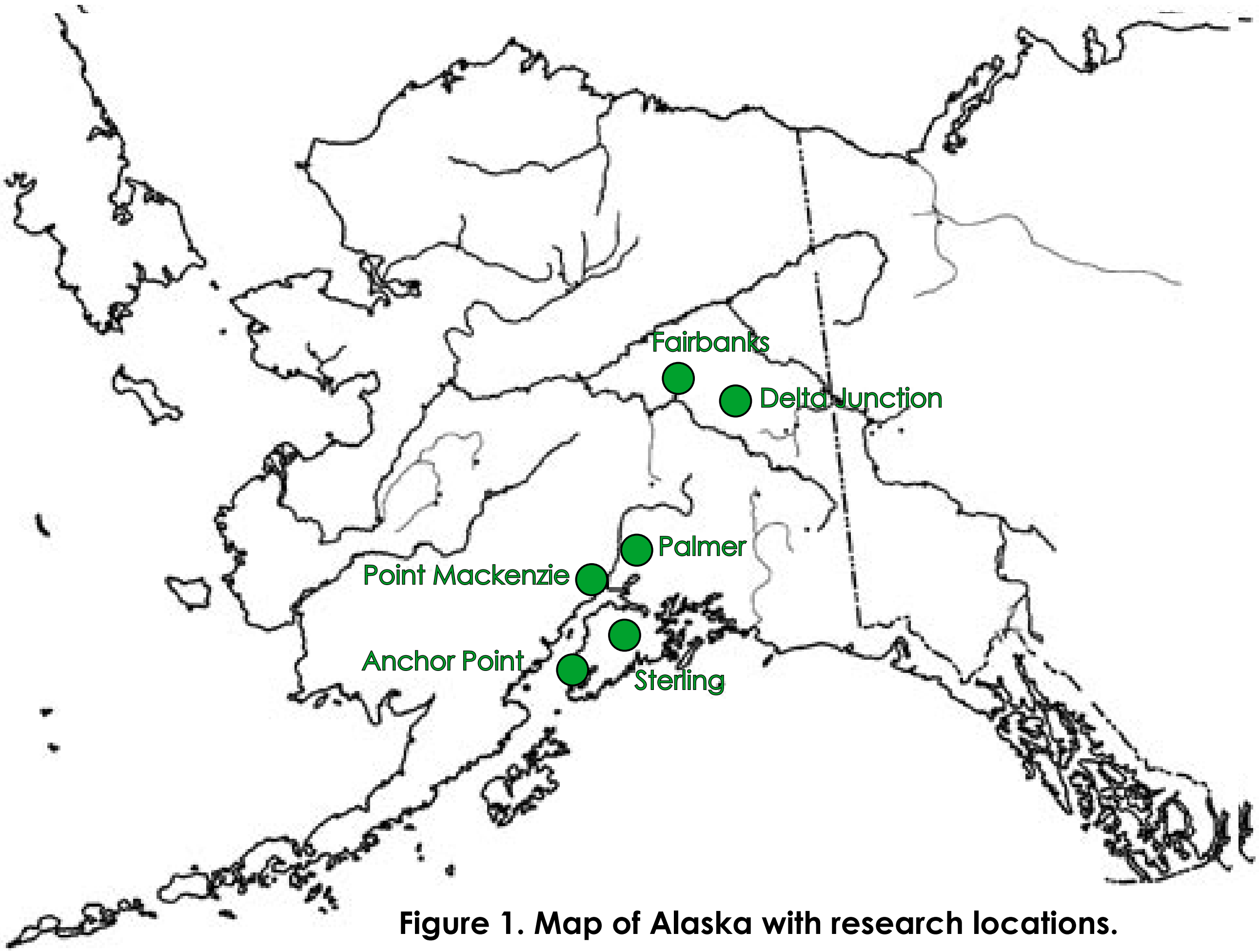


Figure 1. Map of Alaska with research locations.

years of the study (1998–2001), snow cover usually remained at Anchor Point until early to mid-May. Snow usually disappeared in early or mid-April at Kenai (near Sterling) and at the Anchorage airport (near Point MacKenzie), and by late April at Fairbanks. At Palmer and Delta Junction, most of the snow had disappeared by early to mid-March.

Soils at the sites are moderately to strongly acidic silt loams (Table 2). Field composition and stands in farmers' fields varied considerably. At Anchor Point, the field was a mixture of several native grasses, forbs, and sedges, with a fair stand of timothy (*Phleum pratense* L.). At Sterling, we used a field consisting of a mixture of Kentucky bluegrass (*Poa pratensis* L.) and red fescue (*Festuca rubra* L.) with a fair stand. At Point MacKenzie, we used a timothy hayfield with a good stand. We placed the Palmer plots on a smooth bromegrass field with a good stand. At Delta Junction, the plots were

Table 2. Soil characteristics at six locations in Alaska.

Location	Soil Series	Soil Classification	Soil Texture	Slope	Aspect	Soil pH	Soil C (%)
Anchor Point	Kachemak	Typic Vitricryands	silt loam	moderately sloping	NW	4.7	10.6
Sterling	Tustumena	Typic Cryorthods	silt loam	nearly level	S	5.4	7.0
Point MacKenzie	Kashwitna	Andic Haplocryods	silt loam	level	-	5.2	3.7
Palmer	Bodenburg	Typic Eutrocryepts	silt loam	nearly level	NNE	5.8	4.3
Delta Junction	Volkmar	Aquic Eutrocryepts	silt loam	level	-	5.6	1.3
Fairbanks	Fairbanks	Typic Eutrocryepts	silt loam	moderately sloping	S	5.6	1.7

Source: Natural Resources Conservation Service, 2002 established on an abandoned Kentucky bluegrass seed field with a poor stand. We placed the Fairbanks trials on a smooth bromegrass (*Bromus inermis* Leyss.) hayfield with a fair stand and weedy grasses present (mainly quackgrass, *Elytrigia repens* L.; bluejoint reedgrass, *Calamagrostis canadensis* {Michx} Beauv.; and Kentucky bluegrass).

Procedures

We planted trials in 1998, 1999, and 2000 and maintained and harvested them through the 2001 growing season. The farmer fertilized the entire plot area at Palmer in spring 1999, so for that year only, seeding was done at the nearby Matanuska Experiment Farm. We used an ALMACO plot drill at the interior Alaska sites in 1998 and 1999. For all other sites and for 2000 seedings at all sites, we used a no-till plot drill designed and built by Dan Hall at the Matanuska Experiment Farm. Both drills were equipped with Yetter no-till coulters and heavy duty John Deere double disk openers to allow for cutting slots into the existing sod to facilitate seed and fertilizer placement. Fertilizer was placed in the same opening as the seed. Seeds were planted at ¼ to ½ inch depth. We used four replications for each experiment at each site.

Nitrogen rate experiment

We established the N rate experiment at all six sites. We planted Engmo timothy at a seeding rate of 8 lb/acre at Anchor Point, Sterling, and Point MacKenzie. Manchar smooth bromegrass was planted at Delta Junction, Fairbanks, and Palmer at a rate of 20 lb viable seeds per acre. We planted seeds into both tilled and untilled soil at all locations except Anchor Point and Sterling where only no-till treatments were used. Also, only no-till treatments were planted at Fairbanks in 2000 because of lack of plot space. For tilled plots, we seeded within one day of tilling. Each site received P and K fertilizer applied in bands at 26 lb P/acre (60 lb P_2O_5/acre) as triple superphosphate and 50 lb K/acre (60 lb K_2O/acre) and 22 lb S/acre as potassium sulfate. Nitrogen, as ammonium nitrate, was banded with the seed at 0, 15, 30, and 60 lb N/acre. In 1999 and 2000 we included an unseeded control treatment at all sites, at two N fertilizer rates (0 and 30 lb N/acre).

Companion crop experiment

Toral oats (*Avena sativa* L.), Gulf Westerwold ryegrass (*Lolium multiflorum* Lam.), and Dwarf Essex fodder rape (*Brassica napus* L.) were planted as companion crops with Engmo timothy at Anchor Point and Point MacKenzie and with Manchar smooth bromegrass at Delta Junction. We seeded oats at 80 lb viable seed per acre, ryegrass at 10 lb/acre, and fodder rape at 4 lb/acre. We planted bromegrass at 20 lb viable seed/acre and timothy at 8 lb/acre. At Anchor Point, only no-till seeding was done; at the other two sites, seed was drilled into tilled and untilled soil. Fertilizer rates for P and K were the same as for the N rate experiment; N fertilizer was banded as ammonium nitrate at 30 lb N/acre at planting.

Plot drill, built by Dan Hall at the Matanuska Experiment Farm, used to compare seeding forage crop into untilled and tilled soil.

—photo by Stephen Sparrow

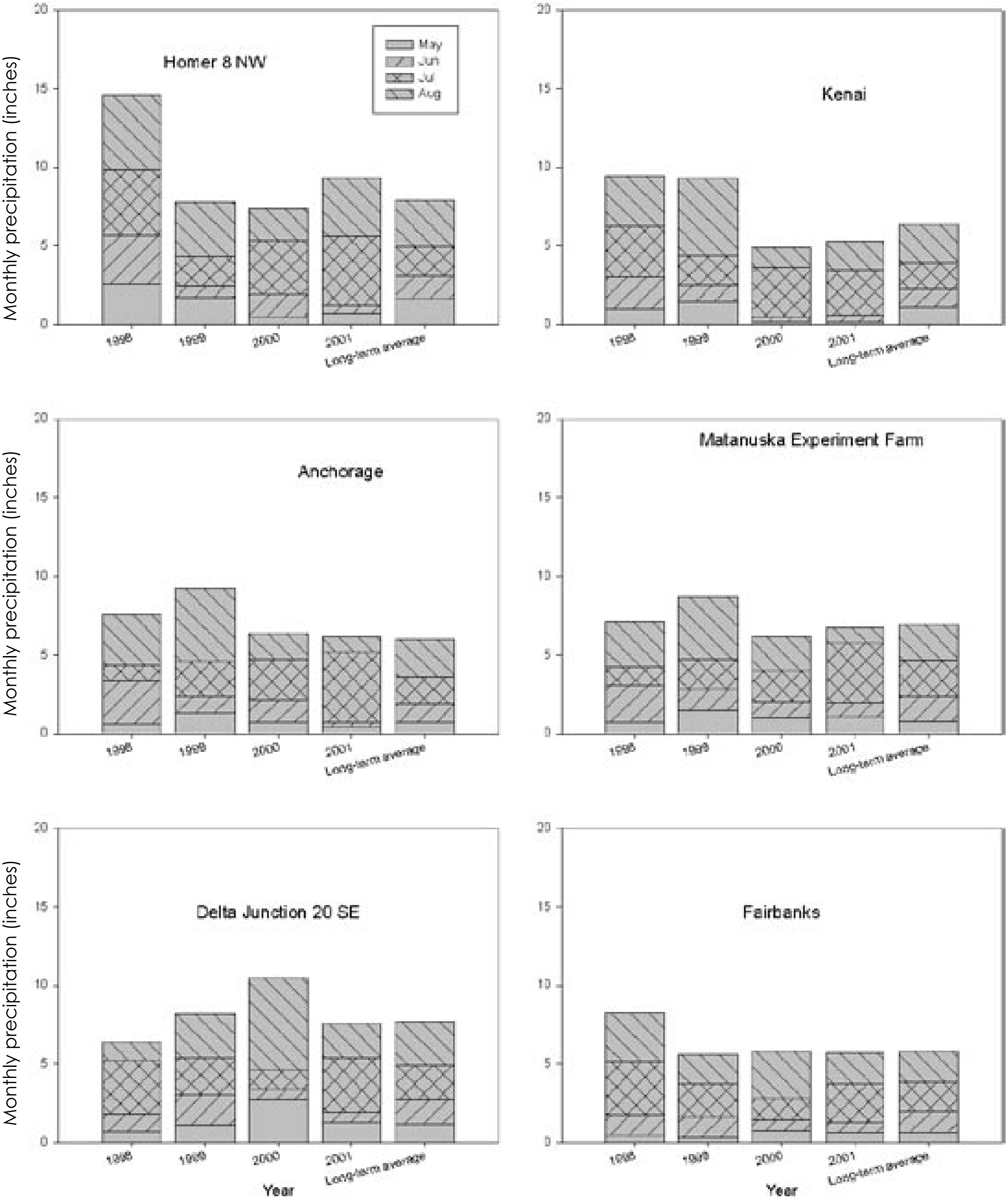
Seeding rate experiment

We planted Engmo timothy at Anchor Point and Point MacKenzie, Manchar smooth bromegrass at Delta Junction, and Altaswede red clover at all three sites at three seeding rates (0.5, 1, and 2 times the normal rates). All seeds were direct drilled into existing grass stands. The normal seeding rate for red clover was 12 lb viable seeds/acre, for timothy it was 8 lb/acre, and for smooth bromegrass it was 20 lb/acre. Phosphorus and potassium fertilizer was applied the same as for the N rate experiment. We banded nitrogen fertilizer as ammonium nitrate at 30 lb N/acre in the grass plots. Nitrogen fertilizer was not applied to the red clover plots; but powdered rhizobia inoculant was applied with the seed.

Treatments in years following seeding year

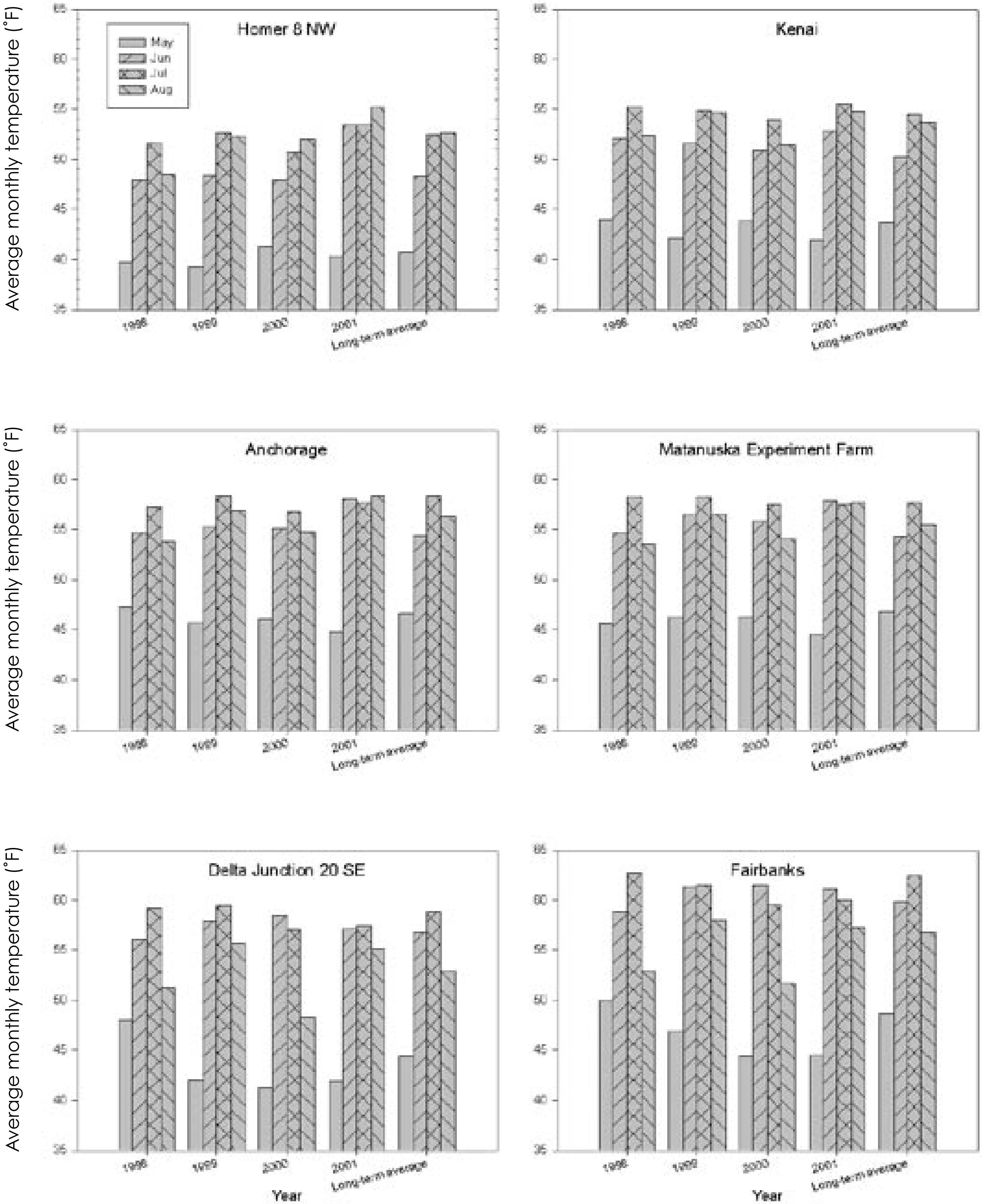
In years subsequent to the seeding year, we broadcast N fertilizer, as ammonium nitrate, to all plots except the red clover

Figure 2. Monthly growing season precipitation at six locations in Alaska.[1]



1 These data were obtained from National Weather Service records for stations near each of the sites used for this study. We selected stations which were near the research sites and for which there were complete, and, where possible, long-term records available. Homer 8 NW (located 8 mile NW of Homer) serves as a proxy for the Anchor Point site, Kenai (Kenai Airport) for Sterling, Anchorage (Anchorage Airport) for

Figure 3. Monthly growing season temperatures at six locations in Alaska.[1]



Point MacKenzie, Matanuska Experiment Farm for Palmer, Delta Junction 20 SE (located on Schultz Farm) for Delta Junction, and Fairbanks (Fairbanks Airport) for the Columbia Creek Farm site. Long-term averages are based on 7 years of data at Delta Junction and more than 20 years' data at all other sites.

Table 3. Herbage yields in the establishment year for forage grasses seeded at various N rates into tilled soil or established perennial grass stands at four locations in Alaska. Values are averages of two years' results except at Anchor Point values are from the 1999 establishment year only.

N rate	Seeded	Tillage	Anchor Point	Sterling	Point MacKenzie	Palmer	Delta Junction	Fairbanks
lb/acre			----------------------------------tons/acre----------------------------------					
0	No	No-till	0.70	0.31	0.63	0.94	0	0.11
30	No	No-till	0.94	0.60	1.19	1.39	0	0.12
0	Yes	No-till	0.78	0.32	0.63	1.12	0.01	0.29
15	Yes	No-till	0.80	0.53	0.95	1.31	0.04	0.27
30	Yes	No-till	0.81	0.62	1.41	1.38	0.02	0.20
60	Yes	No-till	0.94	0.97	1.57	1.58	0.04	0.39
0	No	Tilled	NP†	NP	NP	NP	0	0
30	No	Tilled	NP	NP	NP	NP	0.02	0
0	Yes	Tilled	NP	NP	0.04	0.68	0.46	0.17
15	Yes	Tilled	NP	NP	0.08	0.86	0.57	0.39
30	Yes	Tilled	NP	NP	0.28	1.07	0.60	0.26
60	Yes	Tilled	NP	NP	0.56	1.65	0.89	1.01

†Not Planted

plots. At Anchor Point and Sterling, we applied 80 lb N/acre in spring. At Point MacKenzie, Palmer, and the interior Alaska sites, we applied 60 lb N/acre in spring and 40 lb N/acre after the first harvest. Phosphorus fertilizer as triple superphosphate (26 lb P/acre, 60 lb P_2O_5/acre) and potassium fertilizer as potassium sulfate (50 lb K/acre, 60 lb K_2O/acre, 22 lb S/acre) were uniformly broadcast to all plots each spring. We harvested plots by either hand-clipping biomass from four-square-foot areas in each plot or by harvesting a two-foot-wide swath from each plot with a flail type forage harvester. Our aim was to harvest when stands at each location reached the early heading stage, but this was not always possible because of logistical constraints. We made two harvests in some years at Delta Junction, Fairbanks, Palmer, and Point MacKenzie; other sites were harvested once each year. When we harvested by hand, we separated weeds from crop biomass (crop included all grasses at southcentral Alaska sites). We dried the harvested herbage at 140°F (60°C) and analyzed selected samples for forage quality (crude protein, neutral detergent fiber, and acid detergent fiber). Crude protein was estimated as tissue N concentration x 6.25. We used the van Soest method (van Soest, 1967) or a modified van Soest method (Komarek et al., 1994, 1996) for neutral detergent fiber (NDF) and acid detergent fiber (ADF).

At Anchor Point in 2000, farmhands harvested the entire plot area before sample collection, thus no yield or forage quality data were available for that site in that year. At Fairbanks in 2001, a farmer mowed one replication of the first harvest of the 2000 N rate experiment before sampling. We lost two replications from the 2000 nitrogen rate plots in 2001 at Point MacKenzie because the farmer excavated the area.

Results and Discussion

Nitrogen rate experiment under till and no-till

Establishment year results

Forage crop yields were low (<1.0 tons/acre) in the establishment year at most locations (Table 3). Yields were similar in unseeded and seeded no-till plots, indicating poor seed germination or high seedling mortality in no-till treatments. Thus, most of the biomass in no-till plots resulted from grass in the existing stands, rather than from the seeded crop. The low yields at the Anchor Point, Sterling, and Fairbanks probably resulted from poor quality of the initial stands and high weed populations. Crop yields at Delta Junction, where a previous bromegrass stand did not exist, were higher in tilled soil than in no-till, but were still quite low. At Point MacKenzie, Palmer, and, Fairbanks yields under tillage were similar to or lower than yields under no-till, although at Fairbanks at the high N rate, yields under tillage were much higher than all other treatments. Yields in tilled plots were usually highest with highest N rate, indicating no damage to emerging seedlings when N fertilizer was applied with the seeds.

Forage quality at Delta Junction, where no previous bromegrass stand existed, was generally higher in no-till than in tilled soil. Crude protein averaged 17.4% in no-till compared to 12.2% in tilled soil, NDF averaged 50.0% in no-till and 52.6% in tilled soil, and ADF averaged 29.3% in no-till and 30.5% in tilled soil. These differences probably reflect slower germination, hence less mature plants at harvest, in the no-till. The opposite was true at Palmer, where crude protein averaged 7.9% in no-till compared to 14.6% in tilled soil. NDF averaged 49.3% in no-till compared to 47.2% in tilled soil. ADF averaged 26.5% under both tillage treatments. These results probably reflect the difference between established stands (in the no-till) and newly established stands (under tillage). The established stands would be expected to begin growth earlier and hence reach maturity earlier than would newly established stands. Thus, forage quality at a given time would be lower in the no-till. Results at Point MacKenzie were similar to those at Palmer, probably reflecting effects of seeding into existing stands without any sod suppression for the no-till treatments. At Fairbanks, tillage had little effect on forage quality. Protein concentrations in forage tissue usually increased with increase in N fertilizer rate at all sites; tissue fiber was little affected by N rate.

Subsequent year results

Herbage yields in years subsequent to the establishment years averaged 1.2 tons/acre at Anchor Point and 1.5 tons/acre at Sterling, with no effects of establishment year seeding or N fertilizer rate. At Palmer, yields averaged 2.5 tons/acre by the third year and were similar in no-till and tilled soil. Yields were much higher in tilled soil than in no-till at Point MacKenzie (1.7 tons/acre in tilled soil compared to 0.9 tons/acre in no-till) and at Fairbanks (2.1 tons/acre in tilled soil compared to 1.43 tons dry matter/acre in no-till). No-till yields remained low throughout the study at Delta Junction, with seeded no-till plots averaging only 0.25 tons/acre in the third cropping year compared to 0.7 tons/acre for tilled plots. This was the result of poor initial establishment. Yields for seeded and unseeded plots were generally similar, however, indicating that most of the biomass resulted from existing stands rather than from the seeded grass. Seeding year fertilizer rates did not affect subsequent year yields, except that plots that received zero N sometimes did not recover to provide yields equal to the other fertilizer treatments. In subsequent years, forage quality was not affected by establishment year tillage or fertilizer treatment.

Companion crop experiment under till and no-till

Seeding year results

Companion crop and grass yields were low at Anchor Point (Table 4). Companion crops produced higher yields under tillage than under no-till at Point MacKenzie and Delta Junction. Yields for forage rape and ryegrass were considerably lower than those reported in other trials in Alaska. For example, Panciera and Gavlak (1991) reported yields of almost 3 tons/acre for forage rape seeded into tilled soil in southcentral Alaska, and we have obtained herbage yields of up to 1.5 tons/acre for annual ryegrass in interior Alaska (unpublished data). Seeding rates and depth in our study were similar to those used in other trials in Alaska. We did not determine plant population densities, but stands were typically poor, apparently because of poor seed germination. Oats were the only

Table 4. Herbage yields of grass and companion crops in the establishment year at Anchor Point, Delta Junction, and Point MacKenzie, Alaska. Yields are averages of three years' results except at Anchor Point where values are averages of two years' results.

		Anchor Point		Point MacKenzie		Delta Junction	
Companion crop	Tillage treatment	Companion crop yield	Grass yield	Companion crop yield	Timothy yield	Companion crop yield	Bromegrass yield
		tons/acre					
None	No-till	-	0.87	-	NH	-	0.07
Annual ryegrass	No-till	0.02	0.95	NH†	NH	0.27	0.12
Forage rape	No-till	0.07	0.74	NH	NH	0.38	0.02
Oats	No-till	0.24	0.86	NH	NH	1.56	0.05
None	Tilled	NP‡	NP	-	0.33	-	0.66
Annual ryegrass	Tilled	NP	NP	0.90	0.25	1.08	0.14
Forage rape	Tilled	NP	NP	0.40	0.33	0.87	0.03
Oats	Tilled	NP	NP	1.61	0.15	1.95	0.30

†No harvest due to little growth

‡Not planted

Dan Hall drives a tractor, pulling the no-till plot drill, as Beth Hall feeds forage crop seed into the planter. The no-till area is in the background, while the tilled plots are in the foreground.

—photo by Stephen Sparrow

companion crop showing promise under no-till. Grass yields were depressed by high- yielding companion crops.

Tillage regime had little effect on companion crop forage quality. Crude protein concentrations in both companion crops and grasses were low (<10%) at Delta Junction and Point MacKenzie, with forage rape usually having higher crude protein than other species. At Anchor Point, crude protein values were higher, with forage rape exceeding 20% in both years for which data are available. Values for NDF and ADF were comparable for the perennial grasses and all companion crops except forage rape. Values for NDF were usually near 50% to 55% and values for ADF were usually near 30%. Forage rape, however, had NDF values of <20% and ADF values of <15%. Thus, forage rape has potential for producing high quality forage in Alaska. However, other problems, such as difficulty in establishment and high tissue moisture content make rape problematic as a forage crop candidate for Alaska; especially in no-till planting.

Subsequent year results

If the previous companion crops had high yields, perennial grass yields were generally low in the year following the establishment year. At Anchor Point, where all companion crop yields were low, grass yields averaged 1.2 tons/acre in years subsequent to the establishment years, with no effect from the previous companion crop. At Point MacKenzie, timothy had recovered by the third year to the point that yield differences following different companion crops were undetectable. At Delta Junction, yields remained low in the third cropping year following oats. Through the third cropping year, grass herbage yields remained lower following all companion crops in no-till than in tilled soil at both Delta Junction and Point MacKenzie. At Delta Junction, third year yields in no-till averaged only 0.38 tons/acre as compared to 0.98 tons/acre in tilled soil. At Point Mackenzie, third year dry matter yields for direct seeded timothy were 1.08 tons/acre compared to 1.47 tons/acre following seeding into tilled soil. Forage quality was not affected by previous companion crop or tillage treatment.

Seeding rate experiment under no-till

Red clover establishment was poor at Anchor Point, with yields never exceeding 0.3 tons/acre. Grass yields at Anchor Point averaged 0.8 tons/acre, with no effect of seeding rate (including the 0 rate). At Delta Junction, yields for both

darleen masiak packs tilled soil prior to seeding.

—photo by Stephen Sparrow

smooth bromegrass and red clover were very low (usually <0.25 tons/acre) in the establishment year. Increasing seeding rate at Delta Junction increased bromegrass yields somewhat, with the 2x seeding rate producing average yields of 0.5 tons/acre. Red clover yields at Delta Junction were not affected by seeding rate. Smooth bromegrass yields did not improve over time and red clover had completely died out by the second cropping year.

For the seeding rate experiment at Point MacKenzie, harvests were not done in any of the establishment years. Average grass yields for years subsequent to establishment year averaged 2.15 tons/acre for grass alone and 0.38 tons/acre when red clover was seeded in the plots, apparently due to competition with the clover. Red clover yields averaged 1.65 tons/acre in the second cropping year, 0.62 in the third cropping year, and decreased to <0.05 tons/acre by the fourth cropping year at Point MacKenzie. We were surprised by these results because previous trials at Point MacKenzie have shown good survival of red clover there (Panciera, 1995). The low yields in the last year may be due to severe winterkill resulting from unusually low accumulations of snow cover that winter. Inadequate snow cover can dramatically decrease plant survival in Alaska, especially for plant species or varieties that originated in more moderate climates (Panciera, 1995).

These results indicate that direct seeding of red clover into untilled sod can be successful in some situations in Alaska, but not others. We do not yet fully understand why red clover was able to establish under no-till at Point MacKenzie but not at Anchor Point or Delta Junction. We expect that it was due to a combination of soil moisture, soil pH, and competition factors. Spring soil moisture is usually higher at Point MacKenzie than at Delta Junction, where snow cover is usually removed by winter winds. Extreme acidity coupled with competition from existing plants likely limited red clover germination and seedling growth and survival at Anchor Point.

Poor establishment of grass forage crops under no-till in the study was likely attributable to several factors, including low moisture near the soil surface, poor closure of the seed slots made by the drill openers preventing good seed to soil contact, and competition from existing vegetation. Soil moisture would be expected to be low, because most of the areas experience dry spring weather, and the surface of the soil can dry rapidly, even when there is moisture deeper within the profile. However, low moisture may not have been a major limiting factor at some sites, because establishment was poor, even at sites or years with high spring moisture, such as at Delta Junction in 2000, when precipitation was more than double the normal amount (Figure 1), or at Anchor Point, where soils were usually quite moist at planting. Better designed drills to effect better closure of the seed slots in sod may have helped. Also, suppression of existing vegetation, especially at sites where good stands existed, would likely have improved germination and seedling survival in the no-till seedings.

Conclusions

• No-till seeding of perennial grasses into declining grass stands is not likely to be successful in Alaska with current technology.

• Direct seeding of red clover and oats into existing sod may be successful under some situations in Alaska, but further research is needed to determine under which conditions they are likely to be productive.

• Companion crops can increase total forage yields in the establishment year, but may depress perennial forage grass yields to the point that recovery is unlikely in subsequent years. Most companion crops are not likely to be successful under no-till.

Future Recommendations or New Hypotheses

The main impact of this work was to show which practices are not likely to work for establishing forage crops in depleting grass stands in Alaska. Future research should emphasize finding out why these practices did not work, developing better techniques to improve results, and finding alternative forage crops which will work in no-till, thus providing more choices for farmers. Suppression of or killing of existing sod, through management practices such as use of herbicides to kill the existing grasses, or heavy grazing or cutting timed to suppress the stand, may be potential ways to improve the success of no-till forage crops in Alaska.

Grass stands in no-till plots were usually poor and resulted from existing stands rather than from grass we seeded.

—photo by Steve Sparrow

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The first experiment station in Alsaska 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 cultuvars 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.

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University of Alaska Fairbanks
AFES Publications Office
P.O. Box 757200
Fairbanks, AK 99775-7200
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907.474.6923 or 907.474.5042
fax: 907.474.6184

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