Revegetation Research on Coal Mine Overburden Materials in Interior To Southcentral Alaska

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ABSTRACT

Plant material, and planting and fertilizer scheduling studies were conducted on coal mine overburden materials in the Nenana coal field at the Usibelli coal mine near Healy, in the Matanuska coal field at the Jonesville mine north of Anchorage, and at two test pits in the Beluga coal field west of Anchorage. With proper fertilization a number of grasses were found to maintain adequate cover for soil stabilization purposes over the five- to seven-years of the various trials. The consistently good performers were entries of tufted hairgrass, Bering hairgrass, red fescue, hard fescue, polargrass, and Kentucky bluegrass. Most were native to Alaska. Some northern-selected materials of alfalfa did well on sites below timberline with near neutral soils. Fertilizer responses and indicated nutrient requirements indicated a preferred schedule of fertilizer applications in the first and third, and possibly the fifth or sixth growing years. Seedings conducted from Spring, in late May, into summer, in late July, produced equally satisfactory results.

INTRODUCTION

The primary, short-term objective of revegetating coal mine disturbances is to provide a stabilizing cover to prevent erosion. Over the long-term, it is to constitute a self-sustaining community that, nevertheless, permits recolonization by native plants of the local area. For regulatory purposes, ten years is the target date for judging a stand to meet bonding requirements, at which time, the stand must have been self sustaining for five years. Thus, it must not have received man-supplied amendments, such as fertilizer, if the operator is to receive the final payment on his posted bond. Furthermore, efforts are to be made in the planting to achieve stand diversity.

The ultimate, desired goal is for native plants of the area to invade and become an increasingly important fraction of the stand. A critical issue here is the level of expectation for this in a particular time frame, and the need to maintain an adequate cover per the regulations and for soil stabilization purposes. Personal observations have demonstrated that native reinvasion can happen rapidly or can be a slow process, depending on the circumstances. Strip mining exposes extensive areas of overburden and drastically reworked soils. To ensure maintaining adequate cover over the initial ten years, I think it will be necessary to rely mainly on the plant materials that are seeded in the original mix. Thus, these materials must be selected with care.

This paper concerns research that has been conducted since 1980 at mine sites in three different coal fields of central interior and southcentral regions of Alaska. The purpose of the research was to determine which grasses, among a number of native and introduced entries, were adapted for use on mine soils of overburden origin. A few legumes also were included in the trials. Some effects of planting and fertilizer scheduling were studied, as well.

MATERIALS AND METHODS

Commencing in 1980, revegetation trials were established in the Nenana coal field at the Usibelli coal mine south of Fairbanks, in the Matanuska coal field at the abandoned Jonesville mine north of Anchorage, and in the Beluga coal field at two Placer Amex, Inc. test pits west of Anchorage.

Mine soils on which seedings were conducted were coal-seam overburden materials, moderately alkaline to strongly acidic in nature. They were low in fertility and contained various amounts of coal fragments. Fertility and textural measurements are detailed in Table 1 for the three trial sites at the Usibelli coal mine, the single trial site at Jonesville, and two trial sites in the Beluga coal field.

Trial sites at the Usibelli coal mine were tilled with a hand-operated rototiller before seeding, but no tilling was conducted at the other sites. Seedings were conducted in plots generally measuring 4 ft x 8 ft. Seed and fertilizer were broadcast and raked into the surface followed by tamping. Trial entries were randomly arranged in each of three replicated blocks. Evaluations were conducted by visually estimating percent live coverage for each plot. The values were averaged for the three replications for each entry.

Nenana Coal Field - Usibelli Coal Mine

The Usibelli coal mine is located in central interior Alaska with mining activities occurring from below timberline at about 1500 ft elevation, to a subalpine region at the edge of timberline, about 2500 ft elevation. The area is subject to occasional strong winds. Revegetation trials were located at three sites: at Poker Flat in the area of current mining activity at about 1500 ft elevation, at Vitro, an abandoned mining area at about 2000 ft elevation, and at Gold Run Pass, near 2500 ft elevation. Soils were sandy loam at Poker Flat and Vitro and clay loam at Gold Run Pass (Table 1).

Fertilizer containing nitrogen, phosphorus, and potassium were applied to the trials established at the Usibelli mine according to the following schedules:

Poker Flat, 1980 planting - fertilized in 1980 and in 1981.

Vitro, 1981 planting - fertilized in 1981, and a 3-foot portion of 8-foot plots fertilized again in 1984.

Vitro, 1982 time-of-planting trial - fertilized in 1981, and a 3-foot portion of 8-foot plots fertilized again in 1984.

Gold Run Pass, 1983 planting - fertilized in 1983, and a 3-foot portion of 8-foot plots fertilized again in 1984.

Thus, a 3-foot portion of the Vitro site and Gold Run Pass plantings received two fertilizer applications and a 5-foot portion only one application.

Since 1971 the Usibelli coal mine has engaged in a reclamation program that has seeded almost 2,000 acres. These seedings have provided a valuable reference on the performance of a number of plants over a variety of conditions.

Matanuska Coal Field - Jonesville Mine

The trial location at the abandoned Jonesville mine site in the Matanuska coal field is well below timberline at about 1000 - 1100 ft elevation. The minesoil is of a coarse nature, interspersed with embedded rocks, which leads to rapid drying of the surface material.

The trial planting established in 1980 was fertilized when seeded and was refertilized in 1981.

Beluga Coal Field

Trials were established in the Beluga coal field at test pits opened by Placer Amex, Inc. to extract coal for testing in the oriental market. Access to these sites was by airplane. The Capps test pit was located in the alpine region at about 2300 feet elevation, adjacent to Capps glacier which flows from Mt. Spurr of the Alaska Range. Snow cover can remain well into June at this site, dictating a growing season that commences in late June to early July, and generally terminates with freezing temperatures in September.

The Lone Ridge test pit in the Beluga coal field was at the edge of timberline, at about 1600 ft elevation. The growing season is longer than at the Capps site.

The minesoils at these two Beluga sites were overburden material from above shallow coal seams. The soils are of volcanic origin (C.L. Ping, personal communication) and

TABLE 1
Analyses of top 4 to 6 inches of minesoils at test sites.

Trial Sites	pH	N	P	K	Sand	Silt	Clay	o.m.
		--------ppm-------			---------------%---------------			
Nenana Coal Field								
Usibelli coal mine								
Poker Flat	6.7	3	5	30	60	22	18	1.0
Vitro	5.9	31	5	53	68	15	17	2.3
Gold Run Pass	5.8	37	19	92	19	38	43	4.7
Matanuska Coal Field								
Jonesville mine	8.3	16	9	105	6[1]	17	17	---
Beluga Coal Field								
Capps Glacier	5.5	13	1	48	--	--	--	---
Lone Ridge	5.6	30	3	58	41	42	17	6.0

1 50% of Jonesville minesoil consisted of particles greater than 2 mm in size.

texturally, a loam, according to the Lone Ridge soil determination.

The trial planting at Capps glacier was fertilized when seeded in 1980 and refertilized in September 1982.

The trial planting at Lone Ridge was fertilized when seeded in 1982 and was not subsequently refertilized.

Plant Materials

The grasses and legumes for which data are presented in this paper are listed in Table 2 along with their geographic origin, where known. Varieties are names, or referred to by number from the University of Alaska Institute of Agricultural Science (IAS). Future references will use the number only, omitting the "IAS".

RESULTS

Nenana Coal Field

The different schedules employed at the three Usibelli mine sites provided information on the effects of timing of fertilizer applications.

At Poker Flat, fertilizing in each of the first two years of growth provided for a lush growth in the initial years and a consequent buildup of a thick layer of litter by some of the better performing grasses (Figure 1). By the sixth and last year of growth, the grasses providing the most live coverage were some red fescues, hard fescues, tufted hairgrasses, and the very short-growing Kentucky bluegrass (Table 3). The red fescues and hard fescues produced the most litter, from 2 to 7 inches thick over 90 to 100% of the plot. The tufted hairgrasses also produced about 100% litter cover of similar thickness, but not as dense as that of the fescues. These grasses showed the ability to produce live growth through this litter. Litter cover generally was less extensive or less thick for the other grasses. Two alfalfas maintained vigorous growth at this site (Figure 2).

The effects of fertilizer scheduling were readily apparent at the Vitro site. Without fertilization in the second year of growth (1982), most of the grasses afforded less than 40% coverage (Table 4). Though no additional fertilizer was applied in 1983, many of the grasses showed little decline in coverage. Climatic conditions for growth seemed more favorable in 1983 than in 1982. However, the effects of nutrient depletion became obvious in 1984. Only some fescues provided 40% or better coverage without additional fertilization, and their growth in leaf height was only 2 to 3 inches. Applying fertilizer increased coverage over two-fold, and growth in height from two to four-fold (Figure 3). With the second fertilizer application, only eight of the 32 grasses provided less than 40% coverage in 1984. By 1986, without another fertilizer application, 14 of the grasses provided less than 40% coverage. Entries of red fescue, hard fescue, tufted hairgrass, Bering hairgrass, and purple reedgrass afforded well over 50% coverage. The once-fertilized portion had declined to less than 20% and in many cases less than 10% coverage for most of the grasses. Growth was extremely short. Litter accumulation was much less at this site than at Poker Flat probably owing in part to the longer time interval between fertilizer treatments.

The Gold Run Pass trial was on clay loam overburden, thus had higher water and nutrient retention capacity than the sandy loam of the other two sites. However, its subalpine location at about 2500 ft subjected it to a more severe climate, characterized by a shorter growing season, colder temperatures, and stronger and possibly more frequent winds. The area had been seeded about six to seven years prior to the 1982 trial seeding, but it sustained a scant cover of about 10% or less of the seeded grasses. Possibly, this was due in part to poor establishment initially.

Good establishment was obtained of most of the entries in the seeded trial. By 1984 most were still providing 40% or better coverage without receiving additional fertilization beyond the initial application (Table 5). By the fifth year (1986) a number of grasses had declined below 40% in coverage. Arctared fescue, the hard fescues, Bering and tufted hairgrass, and Nugget bluegrass maintained the highest coverage values. Applying fertilizer in 1984 increased average coverage 80% over that for the once-fertilized portion (Figure 4). In 1986, the twice-fertilized portion provided 71% greater coverage than the once-fertilized portion. Most grasses were still providing over 40% coverage on the twice-fertilized portion in 1986. Only a few plants of Anik alfalfa survived, and these were low in vigor.

Some plants of green alder (Alnus crispa) and willow (Salix sp.) had established in the grass plantings at the trial sites. These are important woody invaders of the reclamation seedings at the mine.

Time-of-Planting Trial

Three plantings conducted about one month apart, commencing May 27, 1982 at Vitro provided information on the effect of planting date on performance in subsequent years. The later plantings survived the first winter equally as well as the earliest planting and provided as much or more coverage (Table 6). After being fertilized again in 1984, by 1986 the twice-fertilized portion averaged over 50% coverage for five of the seven grasses. The test indicated no advantage for the early planting date.

Other trial plantings that were conducted in mid July at

TABLE 2
Plant-material entries included in minesoil plantings at various sites.

Entry Scientific Name: Common Name ( )[1]	Possible Origin[2]
Bromus inermis: Smooth bromegrass (r)	
'Manchar'[3]	Manchuria in origin
'Polar'	Native x introduced material
Phleum pratense: Timothy (t)	
'Engmo'	Norwegian cultivar
'Climax'	Canadian cultivar
Festuca rubra: Red fescue (r)	
'Boreal'	Canadian cultivar
'Pennlawn'	Pennsylvania cultivar
'Arctared'	Alaska cultivar, indigenous
IAS 374[4]	Experimental, Alaska native
Festuca longifolia: Hard fescue (t)	
'Scaldis'	Introduced cultivar, Netherlands
'Tournament'	Introduced cultivar, Netherlands
'Durar'	Introduced cultivar, Holland
IAS 517	Experimental, Alaska collection, probable introduction
IAS 650	Experimental, Alaska collection, probable introduction
Poa pratensis: Kentucky bluegrass (r)	
'Nugget'	Alaska cultivar, probable introduction
'Sydsport'	Swedish cultivar
'Merion'	Pennsylvania cultivar
Poa compressa: Canada bluegrass (r)	
'Reubens'	Introduced cultivar
Poa glauca: Glaucous bluegrass (t)	
'Tundra'	Alaska cultivar, arctic native
IAS 254	Experimental, Alaska native
IAS 253	Experimental, Alaska native
IAS 252	Experimental, Alaska native
Alopecurus pratensis: Meadow foxtail (r)	
Common commercial	Oregon grown
Alopecurus arundinaceus: Creeping foxtail (r)	
'Garrison'	North Dakota cultivar
Phalaris arundinacea: Reed canarygrass (r)	
Common commercial	Native to Minnesota

TABLE 2 (Cont.)

Entry Scientific Name: Common Name ( )[1]	Possible Origin[2]
Deschampsia beringensis: Bering hairgrass (t)	
'Norcoast'	Alaska cultivar, indigenous
IAS 73	Experimental, Alaska native
Deschampsia caespitosa: Tufted hairgrass (t)	
IAS 243	Experimental, Alaska native
IAS 239	Experimental, Alaska native
IAS 458	Experimental, Alaska native
IAS 371	Iceland native
IAS 560	Iceland native
IAS 389	Iceland native
Arctagrostis latifolia: Polargrass (r)	
'Alyeska'	Alaska cultivar, indigenous
IAS 571	Experimental, Alaska native
IAS 572	Experimental, Alaska native
Calamagrostis canadensis: Bluejoint reedgrass (r)	
'Sourdough'	Alaska cultivar, indigenous
IAS 477	Experimental, Alaska native
Calamagrostis purpurascens: Purple reedgrass (t)	
IAS 625	Experimental, Alaska native
Elymus sibiricus: Siberian wildrye (t)	
IAS 626	Experimental, Alaska native
Agropyron desertorum: crested wheatgrass (t)	
'Nordan'	North Dakota cultivar
Agropyron riparium: Streambank wheatgrass (r)	
'Sodar'	Idaho/Washington cultivar
Agropyron subsecundum: Bearded wheatgrass (t)	
IAS 623	Experimental, Alaska native
Agropyron spicatum: Bluebunch wheatgrass (t)	
IAS 627	Experimental, Alaska native
Agropyron trachycaulum: Slender wheatgrass (t)	
'Revenue'	Canadian cultivar
IAS 267	Experimental, Alaska native
Puccinellia sp.: Alkaligrass (t)	
IAS 215	Experimental, Alaska native
Panicum clandestinum: Deer tongue (r)	
Common	Introduction

TABLE 2 (Cont.)

Entry Scientific Name: Common Name ( )[1]	Possible Origin[2]
Trifolium repens: White clover (s)	
Commercial	Introduction
Trifolium hybridum: Alsike clover (t)	
Common commercial	Introduction
Medicago sativa: Alfalfa (t)	
AsynB	Experimental, introduced
Medicago falcata: Yellow-flowered alfalfa (t)	
IAS 628	Experimental, introduced
Medicago media (sativa x falcata): Variegated alfalfa (t)	
'Anik'	Canada cultivar

1 Growth form: (t) - tufted plants, producing new tillers from the base of the stem; (r) or (s)-spreading plants producing new tillers from a laterally growing, below ground rhizome (r) or above ground stolon (s).

2 Hanson (1972) was a source of information on origins of a number of introduced cultivars.

3 Names enclosed in single quotes are cultivar (variety) names.

4 Numbering system for experimental entries in research program.

Vitro and at Poker Flat, for which data are not presented here, also produced good results.

Matanuska Coal Field - Jonesville Mine

Despite the very coarse nature of the Jonesville mine site, excellent stands were obtained for the grass plantings there. Applying fertilizer in consecutive years provided good to dense coverage for most of the grasses in the second year of growth (Table 7). However, without additional fertilization after the 1981 application, most grasses declined severely in coverage (Figure 5). Only Arctared fescue, Scaldis hard fescue, and tufted hairgrass 371 provided coverage of 40% or better by 1986. Nugget bluegrass approached 40% in coverage. The coarse nature of the site obviously resulted in excessive leaching with serious loss of nutrients.

The alfalfas, on the other hand, showed an increase in vigor over that of the initial years on this alkaline soil (Table I). Though the number of plants persisting in each plot were few, their tall, bushy growth provided excellent coverage. Doubtlessly this resulted from the development of their nitrogen fixing capacity. This indicates that nitrogen deficiency was an important limiting factor to the grasses.

Green alder and balsam poplar (Populus balsamifera) were woody invaders on this site (Figure 5). The spread of balsam poplar was assisted by vegetative propagation (suckering) from laterally-growing roots. This characteristic appears worthy of exploiting for the use of balsam poplar in reclamation plantings.

Beluga Coal Field

Trial results obtained at the alpine site adjacent to Capps glacier indicate it was the most severe of the test sites. Without fertilization in 1981, relatively low coverage was obtained by most of the grasses in their second year of growth (Table 8). A number of grasses experienced an increase in coverage in 1983 owing to the fertilizer that was applied in the fall of 1982. However, some grasses continued in a pattern of declining growth. By 1986, without any further fertilization, only the tufted hairgrasses still provided

TABLE 3

Poker Flat trial. Coverage estimates for three different years for entries seeded in Spring, 1980 at Poker Flat mining area, Usibelli coal mine, Nenana coal field, central interior Alaska[1].

Entries	1981	1983	1985
Grasses			
Arctared red fescue	98	58	57
Boreal red fescue	93	53	23
Pennlawn red fescue	95	53	38
Red fescue 374	83	72	55
Scaldis hard fescue	93	82	40
Tournament hard fescue	89	85	38
Durar hard fescue	98	38	14
Hard fescue 517	80	58	30
Manchar bromegrass	57	40	27
Polar bromegrass	77	54	38
Engmo timothy	73	50	7
Nugget bluegrass	87	70	52
Merion bluegrass	80	42	28
Sydsport bluegrass	89	40	25
Glaucous bluegrass 252	70	30	22
Tundra glaucous bluegrass	77	18	0
Meadow foxtail	89	47	0
Garrison creeping foxtail	87	27	0
Nordan crested wheatgrass	63	22	4
Sodar streambank wheatgrass	73	30	12
Bluebunch wheatgrass 627	80	28	0
Siberian wildrye 626	77	27	8
Sourdough bluejoint reedgrass	63	37	30
Bluejoint reedgrass 477	53	37	37
Purple reedgrass 625	47	37	18
Alyeska polargrass	77	57	35
Tufted hairgrass 371	83	80	45
Tufted hairgrass 243	92	60	33
Tufted hairgrass 239	93	80	55
Average	80	49	27
Legumes			
Anik alfalfa	47	57	43
AsynB alfalfa	68	30	27
Yellow alfalfa	63	67	63
White clover	5	0	0
Average	46	39	33

[1] Fertilized when seeded in 1980, 49-105-49 lbs/acre of N - P_2O_5 - K_2O and fertilized again in the spring of 1981, 70-70-53 lbs/acre of N - P_2O_5 - K_2O.

over 40% coverage. The polargrasses were the next best performers (Figure 6). The alfalfas failed at this site.

The Lone Ridge site at the edge of timberline afforded more favorable growing conditions than the Capps site. However, portions of the trial area were subject to excessive moisture accumulation. Furthermore, by 1986 native bluejoint reedgrass had invaded and taken over a portion of the trial with vigorous growth. Thus, the number of plots that could be evaluated were reduced.

Grasses that demonstrated fair to good adaptability for the site included the tufted hairgrasses, polargrass, reed canarygrass, and red fescue (Table 9 and Figure 7). Norcoast Bering hairgrass did well in some plots. Alfalfa failed at this strongly acidic site. The seeded bluejoint did not do as well as the invading bluejoint. Other plants that were invading the trial included willow and green alder. The moist condition of the site favors invasion by willows.

Both of the Beluga sites are characterized by a deep accumulation of snow that does not thaw until well into spring or early summer. This is a condition that is propitious for the development of snow mold (Sclerotinia borealis, possibly others). Though the trials have not been observed early in the growing season when direct evidence of snow mold damage can readily be seen, it would seem that susceptible grasses have been subject to snow mold effects at these sites, particularly at the Capps site, appears warranted.

Soil-Building Effects

Soil samples taken at the Poker Flat site at the Usibelli coal mine in 1985 provided some information on soil-building by established grasses. The soil under Arctared fescue in its sixth year of growth was compared with soil under bare plots, and with soil under bare ground adjacent to the plots. The bare plots had been seeded but the plantings had failed; they were fertilized the same as the Arctared plots. The bare ground had not been seeded or fertilized. The soil was analyzed for pH nitrogen (N), phosphorus (P), potassium (K), and organic matter (o.m.). The results for the N content were so erratic for the three samples from the Arctared plots that this measurement was not included in the analysis.

The bare-soil plots reflected the effects of the fertilizer treatments applied in 1980 and 1981, having significantly greater amounts of P and K than the bare-ground soil, but were similar in o.m. content (Table 10). Soil from the Arctared fescue plots showed the effects of retention recycling of nutrients, containing more P (not statisti significant, however) and significantly more K and o.m the bare-plot soil.

TABLE 4
Vitro trial. Coverage estimates for three different years for entries seeded spring 1981 at Vitro lining area, Usibelli coal mine, Nenana coal field[1].

Entries Grasses	1982	1983	1984[2]	1986[3]
Arctared red fescue	40	44	83 - 35	58
Pennlawn red fescue	37	46	80 - 24	47
Red fescue 427	40	41	72 - 43	57
Scaldis hard fescue	43	48	78 - 47	58
Tournament hard fescue	40	46	82 - 40	57
Durar hard fescue	40	41	60 - 30	27
Hard fescue 517	47	51	78 - 45	55
Manchar bromegrass	33	32	48 - 17	32
Polar bromegrass	30	32	50 - 20	38
Engmo timothy	27	37	40 - 3	13
Climax timothy	14	6	13 - 0	0
Nugget bluegrass	30	31	65 - 19	43
Merion bluegrass	27	28	56 - 10	25
Glaucous bluegrass 254	30	25	60 - 14	7
Tundra glaucous bluegrass	33	26	51 - 15	0
Meadow foxtail	37	23	27 - 2	4
Garrison creeping foxtail	37	28	22 - 6	3
Nordan crested wheatgrass	23	23	22 - 7	0
Sodar streambank wheatgrass	30	34	15 - 4	33
Bearded wheatgrass 623	13	4	2 - 0	0
Sourdough bluejoint reedgrass	27	27	47 - 20	35
Bluejoint reedgrass 477	27	31	55 - 18	37
Purple reedgrass 625	37	35	70 - 27	67
Alyeska polargrass	23	25	60 - 15	43
Polargrass 571	37	41	52 - 21	43
Norcoast Bering hairgrass	40	38	68 - 28	67
Tufted hairgrass 371	30	36	62 - 28	40
Tufted hairgrass 560	43	38	68 - 32	53
Tufted hairgrass 239	40	40	80 - 28	57
Tufted hairgrass 458	30	37	77 - 24	62
Alkaligrass sp. 215	27	23	13 - 0	6
Deer tongue	0	0	0 - 0	0
Average	32	32	52 19	33

[1] Fertilized when seeded in 1981, 80-80-60 lbs/acre of N - P_2O_5 - K_2O. Three-foot portion of each plot fertilized again in spring 1984, 63-63-63 lbs/acre of N - P_2O_5 - K_2O.

[2] Left-hand column for twice-fertilized portion, right-hand column for once-fertilized portion.

[3] For twice-fertilized portion only.

TABLE 5

Gold Run Pass trial. Coverage estimates for entries seeded in 1980 at Gold Run Pass mining area, Usibelli coal mine, Nenana coal field[1].

Entries	Once Fertilized		Twice Fertilized	
	1984	1986	1984	1986
Grasses	------ % coverage -----			
Arctared red fescue	67	52	92	72
Boreal red fescue	40	33	88	48
Scaldis hard fescue	42	43	72	78
Hard fescue 560	50	48	88	83
Manchar bromegrass	27	17	50	33
Nugget bluegrass	40	40	87	70
Reubens Canada bluegrass	4	0	11	0
Glaucous bluegrass 254	37	27	78	52
Meadow foxtail	32	6	81	28
Sodar streambank wheatgrass	47	27	73	47
Slender wheatgrass 267	40	22	63	45
Revenue slender wheatgrass	38	27	58	40
Slender wheatgrass 267	40	22	63	45
Bluejoint reedgrass 477	43	37	75	62
Norcoast Bering hairgrass	43	45	93	63
Tufted hairgrass 371	43	42	82	77
Average	40	31	72	53
Legume-				
Anik alfalfa	8	9	10	5

[1] Fertilized when seeded in early summer 1980, 54-54-54 lb/acre of N - P_2O_5 - K_2O, and a 3-foot portion of each plot fertilized again in 1984, 63-63-63 lb/acre of N - P_2O_5 - K_2O. Coverage of 3-foot, twice fertilized portion is compared with coverage on remaining 5-foot, once-fertilized portion.

DISCUSSION

Revegetation of mine soils, consisting of coal-seam overburden material, involves working with soil materials very low in nutrient and organic matter contents. However, these overburden soils of the Nenana, Matanuska, and Beluga coal fields have not demonstrated the presence of harmful substances in toxic amounts (Mitchell et al. 1980); futhermore, while the pH range of about 5.5 to 8.3 has effects on plant performance, these effects are not extreme.

To succeed, plants must be adapted to the soil and to the aerial environment, as affected by temperature, wind, and length of growing season.The soil can be amended using fertilizers and other additions. But little can feasibly be done about the aerial environment over extensive areas, except for some modifications to surface features.

It can be difficult to assess why plants fail or do poorly. Some plants in these trials, however, obviously lacked sufficient winterhardiness. These included Reubens Canada bluegrass, Climax timothy, deer tongue, and white clover. With others, it was probably a combination of factors, including marginal hardiness.

Indigenous Alaska origin, which presumably would confer sufficient winterhardiness upon the entry, did not necessarily mean superior performance. Bluebunch wheatgrass, bearded wheatgrass, and Siberian wildrye, all native tufted grasses of a related group, did poorly, some after establishing good stands in their early years. A native slender wheatgrass performed comparably to the introduced Revenue slender wheatgrass in the Gold Run Pass trial. The rhizomatous Sodar streambank wheatgrass originating in Oregon did as well or sometimes better than the native wheatgrasses.

The tufted glaucous bluegrasses of native origin, in general, were poor performers. The variety Tundra glaucous bluegrass native to the Arctic and recommended for arctic use (Mitchell 1979), failed to persist at these northern sites.

Grasses such as glaucous bluegrass, wildrye, and some of the wheat grasses are often found in open stands where each individual plant has ample room in which to grow. Forcing establishment in dense stands, with a consequent buildup of litter, appears to be detrimental to their maintaining sufficiently healthy growth. Some, by nature, may be short-lived perennials that depend on reseeding themselves to perpetuate a stand, as has been suggested for Siberian wildrye (Weintraub, 1953), and slender and bearded wheatgrass (Hafenrichter et al. 1968).

It is more difficult to assess the poor performance of some of the other grasses. Hardy varieties of bromegrass and timothy are important forage grasses in Alaska (Klebesadel 1983). Meadow foxtail has been used for forage and revegetation purposes, mainly on acidic soils. The evidence indicates that these grasses require the maintenance of higher fertility levels than were used on the overburden materials in these trials. Without repeated fertilizer applications, drastic reduction in coverage occurred.

Bromegrass, timothy, and meadow foxtail were components of seed mixes used over the last 14 years for reclaiming mined land and other disturbed areas at the Usibelli coal mine. None has persisted well on the extensive areas overburden material. In one instance meadow foxtail has persisted as the dominant grass over a large area that

TABLE 6

Time-of-planting trial, Vitro site. Coverage estimates for entries seeded in 1982 on three different dates at Vitro mining area, Usibelli coal mine, Healy coal field[1].

Planting Dates:	May 27	Jun 24	Jul 22	May 27	Jun 24	Jul 22	
Entries	% coverage						
	1983			1986			Avg.
Arctared fescue	50	56	58	63	65	65	64
Boreal red fescue	47	55	57	52	53	58	54
Manchar brome	37	28	41	32	22	33	29
Bluejoint rg.	34	50	35	57	63	43	54
Norcoast B. hg.	40	52	56	53	72	78	68
Tufted hairgrass	51	61	57	63	60	68	64
Meadow foxtail	41	43	47	17	17	18	17
Avg. % covg.	43	49	50	48	50	52	
Avg. ht., cm	12	13	14	NA	NA	NA	

[1] Fertilized when seeded in 1982, 76-60-60 lb/acre of N - P_2O_5 - K_2O, and a 3-foot portion of each plot fertilized again in 1984, 63-63-63 lb/acre of N - P_2O_5 - K_2O.

resulted from a mud flow that incorporated subsurface and surface soil materials. It also has persisted in some low sheltered areas. Bromegrass has persisted as a dominant on some disturbances involving surface soil materials. Timothy is probably marginally-adapted to areas subject to the drying and other stressful effects of winter winds.

The soils of the Beluga coal field were too acidic for bromegrass and Garrison creeping foxtail, which also performed poorly in forage trials on strongly acidic soils (below pH 5.5) of southcentral Alaska (Mitchell, 1986A). The poor showing of timothy and meadow foxtail on these acid soils must have been due to other reasons, however, as these grasses have tolerated strongly acidic soils of southcentral Alaska (Mitchell 1986A).

The introduced or exotic grasses that tended to do the best in the various trials included the red fescues and hard fescues followed by Kentucky bluegrass. The variety Arctared, based on an Alaskan collection (Hodgson et al. 1978), generally outperformed the introduced varieties Boreal and Pennlawn. Boreal outperformed Arctared at the Beluga Capps site, however. The hard fescues were stronger performers in the Nenana and Matanuska coal fields than in the Beluga coal field. The varieties Scaldis and Tournament hard fescue were far superior to Durar, which is the variety that has been used in some revegetation seedings in Alaska.

Introduced reed canarygrass was one of the best performers at the Beluga Lone Ridge site at the edge of timberline, but failed at the Beluga Capps site in the alpine region. Reed canarygrass was a component of the reclamation seedings at the Usibelli coal mine, but it has persisted only on sites that have been protected from the wind and favored with snow accumulation in the winter because of drifting or snow plowing.

Bluejoint reedgrass, a native grass expected to do well in the revegetation trials, was a disappointing performer. Bluejoint is one of the most abundant native grasses in Alaska and is one of the principal native invaders on reclamation seedings at the Usibelli coal mine, often forming conspicuous, vigorously growing clumps (Figure 8), and was a strong invader at the Lone Ridge test site. In most of the trials, however, seeded bluejoint did not develop vigorously growing stands. A relative of bluejoint, purple reedgrass, did particularly well at the Vitro site.

Grasses providing the most consistently good performance over all of the trials were the tufted hairgrasses, native to Alaska and Iceland, and red fescue. Bering hairgrass, native to Alaska, also did well at many of the sites as did the indigenous polargrass, particularly in the Beluga coal field.

TABLE 7
Jonesville trial. Coverage estimates for three different years for entries seeded in 1980 at the Jonesville coal mine, Matanuska coal field, southcentral Alaska[1].

Entries			
Grasses	1981	1984	1986
Arctared red fescue	98	50	42
Boreal red fescue	95	47	25
Scaldis hard fescue	83	57	50
Hard fescue 517	90	52	35
Manchar bromegrass	80	20	13
Polar bromegrass	93	23	18
Nugget bluegrass	87	40	38
Merion bluegrass	90	47	30
Sydsport bluegrass	86	42	30
Glaucous bluegrass 254	70	28	0
Meadow foxtail	93	35	15
Garrison creeping foxtail	95	28	16
Nordan crested wheatgrass	80	22	12
Sodar streambank wheatgrass	67	23	15
Sourdough bluejoint reedgrass	57	32	32
Norcoast Bering hairgrass	77	25	8
Tufted hairgrass 371	90	50	47
Tufted hairgrass 243	83	28	24
Tufted hairgrass 239	83	40	33
Siberian wildrye	57	15	9
Average	83	35	25
Legumes			
Anik alfalfa	53	80	91
AsynB alfalfa	57	57	73
White clover	0	0	0

1 Fertilized when seeded in 1980, 54-54-54 lb/acre of N - P_2O_5 - K_2O, and fertilized again in 1981, 63-63-63 lb/acre of N - P_2O_5 - K_2O.

On the northern plains, the introduced crested wheatgrass and, to a lesser extent, smooth bromegrass have proved to be too competitive in mixtures with native grass species (Schuman et al. 1982; Holechek et al. 1981; Laycock 1980). At Usibelli mine, the predominant survivor of a number of seed mixtures used in their reclamation program has been the Canadian variety Boreal red fescue (Figure 8). In the research trials at Usibelli, however, the Alaskan variety Arctared generally outperformed Boreal. Observations of reclamation seedings along the trans Alaska pipeline route have shown Arctared fescue to be the dominant survivor at a number of sites where it was included in mixes with introduced grasses. The success of some native entries relative to that of the introduced entries in the trials reported on here indicates that, at these north latitudes, the use of properly identified native materials can be expected to produce a stand with substantial native plant representation. Experience with growing grasses in Alaska has shown, however, that some qualifications to this statement are necessary. Under favorable circumstances, the introduced grasses such as bromegrass, meadow foxtail, reed canarygrass, and timothy often grow more vigorously in their seeding year than do the native entries. Thus, initial year competition from heavy seedings of introduced grasses

TABLE 8
Beluga Capps trial. Coverage estimates for entries seeded in early summer 1980 at Capps Glacier test pit, Beluga coal field[1].

Entries			
Grasses	1981	1983	1986
Arctared red fescue	37	55	16
Boreal red fescue	30	63	28
Scaldis hard fescue	43	55	23
Hard fescue 517	47	50	1
Manchar bromegrass	10	3	0
Polar bromegrass	17	14	0
Nugget bluegrass	43	57	23
Merion bluegrass	33	38	0
Sydsport bluegrass	47	57	10
Glaucous bluegrass 254	33	40	0
Tundra glaucous bluegrass	17	2	0
Meadow foxtail	33	22	11
Garrison creeping foxtail	0	0	0
Engmo timothy	27	28	4
Reed canarygrass	11	2	2
Sourdough bluejoint reedgrass	20	18	17
Bluejoint reedgrass 477	30	23	8
Alyeska polargrass	33	38	33
Polargrass 572	37	47	30
Norcoast Bering hairgrass	43	55	8
Bering hairgrass 73	50	58	5
Tufted hairgrass 371	57	77	47
Tufted hairgrass 243	57	68	45
Tufted hairgrass 389	53	75	42
Tufted hairgrass 239	47	68	52
Average	34	41	16
Legumes			
Anik alfalfa	0	0	0
AsynB alfalfa	0	0	0
White clover	0	0	0

1 Fertilized when seeded in 1980, 70-150-70 lb/acre of N - P_2O_5 - K_2O, and fertilized again in September 1982, 70-70-53 of N - P_2O_5 - K_2O.

TABLE 9
Beluga Lone Ridge trial. Coverage estimates for entries seeded 1982 at Lone Ridge test pit, Beluga coal field, southcentral Alaska[1].

Entries	1983	1986
Grasses	- -% coverage- -	
Arctared red fescue	68	48
Pennlawn red fescue	70	45
Scaldis hard fescue	72	20
Durar hard fescue	65	10
Polar bromegrass	7	0
Nugget bluegrass	62	23
Glaucous bluegrass 253	57	0
Engmo timothy	50	0
Meadow foxtail	55	13
Garrison creeping foxtail	58	7
Reed canarygrass	73	60
Sourdough bluejoint reedgrass	52	32
Bluejoint reedgrass 477	57	27
Alyeska polargrass	58	43
Polargrass 572	72	65
Norcoast Bering hairgrass	65	38
Tufted hairgrass 371	72	63
Tufted hairgrass 243	70	70
Average	60	31
Legumes		
Anik alfalfa	2	0
Alsike clover	48	0
Average	25	0

[1] Fertilized when seeded in early summer 1982, 87-195-87 lb/acre of N - P_2O_5 - K_2O.

TABLE 10
Analysis of soils sampled from Poker Flat trial and adjoining bare ground in 1985.

Treatment	pH	P	K	o.m.
		----lb/acre---		%
Arctared-plot soil	6.5	84 a	154 a	1.58 a
Bare-plot soil	6.8	68 a	2 b	1.03 b
Bare-ground soil	6.7	6 b	66 c	1.07 b

Soils sampled from 0-4 inch depth; three samples taken of each. Figures within a column not followed by the same letter differ significantly at the 5% level of probability according to Duncan's multiple range.

could be a barrier to adequate establishment of some of the slower growing native grasses. Of the more successful native grasses, polargrass, bluejoint reedgrass, and tufted hairgrass show less seedling vigor than red fescue and Bering hairgrass.

Exposure has been a critical factor for the survival of a number of plants in the Usibelli reclamation seedings. Among these are the alfalfa varieties used in these seedings, which have required the protection of sheltered positions with good snow cover for their survival. The alfalfas used in the research trials, however, displayed good hardiness at two locations, although failing at others. The results indicated a limitation in their use to sites below timberline with soil acidities above pH 6.0.

In some of their reclamation seedings, the Usibelli coal mine has produced some microrelief by gouging furrows with rippers on a bulldozer before seeding. This has benefited the seedings by providing some protection and concentrating moisture and nutrients in the furrows.

Snow mold infection may be a factor at some sites with snow cover of long duration in the Beluga field. This could affect entries of timothy, red fescue, Kentucky bluegrass, Bering hairgrass, meadow foxtail, and possibly others. Snow mold infestations vary in intensity, permitting different degrees of recovery.

Recommendations

The results of the trials indicated the following grass and alfalfa varieties most suited for use in seeding on minesoil overburden material in southcentral to central interior Alaska.

Red fescue - variety (var.) Arctared (Boreal or Pennlawn second choice)

Hard fescues - var. Scaldis or Tournament

Tufted hairgrass - var. Nortran (Mitchell 1986B)

Bering hairgrass - var. Norcoast (Mitchell 1985)

Polargrass - var. Kenai (Mitchell, In press) or var. Alyeska (1980)

Kentucky bluegrass - var. Nugget (Hodgson et al. 1971)

Reed canarygrass (below timberline in Beluga field)

Alfalfa - Anik or Denali (below timberline on soils above pH 6.0)

Though not performing as well as the above grasses in

Figure 1. Lush, third-year growth of trial at Poker Flat, Usibelli coal mine. Trial had been fertilized in previous two years.

Figure 2. Sixth-year growth of trial at Poker Flat, showing accumulation of litter in grass plots and vigorous growth of alfalfas, var. Anik on left and accession AsynB on right.

Figure 3. Fourth-year growth of trial at Vitro, Usibelli coal mine, showing effect of once-fertilized treatment on the left and twice-fertilized treatment on the right in each plot. Fertilizer was applied overall when seeded in 1981 and to portion on right in 1984.

Figure 4. Fifth-year growth of Norcoast Bering hairgrass in foreground and Boreal red fescue in background, with mostly barren bromegrass plot in between at Gold Run Pass, Usibelli coal mine. Right hand portion of plot was fertilized in 1982 and again in 1984, left hand portion in 1982 only. Willow plants have established in the grass plots.

Figure 5. Seventh-year growth of trial at Jonesville mine, Matanuska coal field. After making good growth with aid of fertilization in the first two years, grasses declined severely in coverage in later years owing to leaching of nutrients in coarse overburden material. Nitrogen-fixing alfalfas, however, grew vigorously.

Figure 6. Best performing grasses at alpine site in Beluga coal field were tufted hairgrass, in foreground, and polargrass, the tall grass visible in various plots, as shown in seventh year of growth.

Figure 7. Fifth-year growth of trial at Lone Ridge, Beluga coal field. Red fescue, polargrass, tufted hairgrass, Bering hairgrass, and bluejoint reedgrass are visible here providing fair to good coverage. A number of plants of willow and green alder have established in the plots.

Figure 8. A reclamation seeding at the Usibelli coal mine, Poker Flat area, in its eighth year of growth. Boreal red fescue, low green growth, is the predominant survivor of the seeding mix. The large, vigorously growing clumps are invading plants of bluejoint reedgrass. The reddish stalks are invading plants of tall fireweed (Epilobium angustifolium) which, once established, spread by rhizomes. Also invading are plants of willow and green alder.


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most of the trials, previous experience with bluejoint reedgrass has shown it to be a durable grass.

Plantings conducted from late May to late July indicated that seedings can be conducted successfully into the third week of July. Precipitation patterns are such as to favor July plantings for a more certain moisture supply.

Results further indicated that to sustain an adequate cover on these overburden soils fertilization is necessary beyond the initial year. Fertilizing consecutively in the first two years at Poker Flat stimulated vigorous growth in the early years and the buildup of considerable litter, possibly to the detriment of some plants. At Vitro most grasses declined to an inadequate level of vigor by the fourth year without a second fertilizer application. Two fertilizer applications were inadequate to maintain good stands on the coarse textured site at Jonesville and the alpine site in the Beluga field.

The results recommend a schedule of applying fertilizer in the first and third growing years. Another application in the fifth or sixth growing year also is recommended to help establish the threshold of fertility necessary for a self-sustaining community providing adequate cover. A fertilizer containing nitrogen, phosphate, and potash in percentages of 20, 20, and 15, respectively, applied at 350 to 400 lb/acre in each treatment should be adequate.

With the identification and use of plants adapted to the climatic conditions of the region, the fertility level of a site becomes the most critical question for the development of a self sustaining community at an adequate growth level. The addition of small amounts of fertilizer, as signalled by declining vigor, would ensure the development of a healthy community and further promote soil building. Regulations prohibiting the use of fertilizer beyond the five-year limit should be reviewed. Encouraging good grass growth, with legumes where possible, improves the site for the future development of a diverse community including invading woody species.

LITERATURE CITED

1. Hafenrichter, A.L., J.L. Schwendiman, H.L. Harris, R.S. MacLauchlan, and H.W. Miller. 1968.Grasses and legumes for soil conservation in the Pacific Northwest and Great Basin states. U.S.D.A., Soil Conser. Serv., Agric. Handbook 339. 69 pp.

2. Hanson, A.A. 1972 (rev. ed.). Grass varieties in the United States. U.S.D.A. Agric. res. Serv., Agric. Handbook 170. 124 pp.

3. Holechek, J.L., E.J. Depuit, J.G. Coenenberg, and R. Valdez. 1981. Fertilizer effects on establishment of two seed mixtures on mined land in southeastern Montana. J. Soil and Water Conserv. July-Aug:241-244.

4. Hodgson, H.J., R.L. Taylor, A.C. Wilton, and L.J. Klebesadel. 1971. Registration of Nugget Kentucky Bluegrass. Crop Science 11:938.

5. Hodgson, H.J., R.L. Taylor, L.J. Klebesadel, and A.C. Wilton. 1978. Registration of Arctared red fescue. Crop Science 18:524.

6. Klebesadel, L.J. 1983. Forage crops in Alaska. Univ. of Alaska. Agric. Exp. Sta. Bull. 63. 16 pp.

7. Laycock, W.A. 1980. What is successful reclamation? A look at the concepts of adaptability, productivity, cover, and diversity of seeded species. Northwest Colo. Land Reclam. Seminar II Proceed., Steamboat Springs, Colo. p. 1 - 17.

8. Mitchell, G.A., W.W. Mitchell, and J.D. McKendrick. 1980. Soil characterization of Alaskan coal mine spoils. p. 412-417. In: Focus on Alaska's Coal '80. P.D. Rao and E.N. Wolff, ed. Univ. of Alaska MIRL Report 50, Proceed. of Conf., Fairbanks.

9. Mitchell, W.W. 1979. Three varieties of native grasses for revegetation purposes. Univ. of Alaska Agric. Exp. Sta. Circular 32. 9 pp.

10. Mitchell, W.W. 1980. Registration of Alyeska polargrass. Crop Sci. 20:671.

11. Mitchell, W.W. 1985. Registration of Norcoast Bering hairgrass. Crop Sci. 25:708-709.

12. Mitchell, W.W. 1986A. Perennial grass trials for forage purposes in three areas of southcentral Alaska. Univ. of Alaska-Fairbanks Agric. and For. Exp. Sta., Bull. 73. 30 pp.

13. Mitchell, W.W. 1986B. Notice of release of 'Nortran' tufted hairgrass. Agroborealis 18:6-7.

14. Mitchell, W.W. In press. Notice of release of Kenai polargrass. Agroborealis 19.

15. Schuman, G.E., F. Rauze, and D.T. Booth. 1982. Production and competition of crested wheatgrass-native grass mixture. Agron. J. 74:23-26.

16. Weintraub, F.C. 1953. Grasses introduced into the United States. U.S.D.A., Forest Service, Agric. Handbook 58. 79 pp.

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