Progress Report
for Research on

REVEGETATION OF ALASKAN
COAL MINE SPOILS

To

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INTRODUCTION

Activities initiated after the start of the revegetation project on Alaskan coal mine spoils on September 1, 1979, have consisted mainly of some fall plantings (dormant seedings) and soil and coal spoil samplings and analyses. Some related work having an important bearing on the project will be summarized briefly. Results of a project on the use of green alder for coal spoil reclamation, commenced in 1977, also will be summarized. As funding for that project was terminated in 1979, it will be continued under the current project.

PLANT MATERIAL STUDIES

Because of the late summer start for the project, only a limited amount of field work could be initiated in plant material studies. This consisted of a fall planting at the Usibelli mine site at Healy in interior Alaska. The planting was intended to test the efficacy of seeding in the frost period following the growing season, requiring the seed to remain dormant over winter and to germinate when conditions become favorable in late spring. It also was intended as a comparison of a number of different grasses. Thirty entries were seeded in three replications. Fifteen species of grasses and a clover were included in the trial. The site provided for the trial was on overburden material along a streambed. Among the entries were eight cultivars of introduced grasses, five cultivars of native Alaskan germplasm, one introduced clover cultivar, and sixteen experimental grasses mainly of Alaskan origin.

RELATED ACTIVITIES

Turf Trials

Information is being gained on the adaptability of a number of turf grasses of north temperate to boreal origin. The turf-type grasses consist mainly of Kentucky bluegrasses (Poa pratensis L.) and red fescues (Festuca rubra L.). Nineteen cultivars are currently on trial in comparison with numerous experimental entries. These trials can serve as a preliminary screening of a wide array of cultivars and experimental entries. Current results have provided sufficient information to eliminate some from further consideration while indicating others that should be entered into the coal-spoil, mine-site trials.

Forage Trials

Experimental trials and agricultural experiences with forages are providing information on those materials adapted for use in Alaska and their possible range of adaption in the state. Certain varieties of brome grass (Bromus inermis) have performed well in forested areas with soils above pH 5.5. Select varieties of timothy (Phleum pratense) have been the preferred choice on the more acid soils. Others also receiving attention are meadow foxtail (Alopecurus pratensis), creeping foxtail (A. arundinaceus), reed canarygrass (Phalaris arundinacea), and native entries of polargrass (Arctagrostis latifolia), bluejoint reedgrass (Calamagrostis canadensis), hairgrass (Deschampsia caespitosa complex), wheatgrasses (Agropyron sp.), and Siberian wildrye (Elymus sibiricus). Some of these show a potential for areas in which the standard forages grow with difficulty.

Some current work on seeding mixtures of grasses indicates that in areas favorable to brome grass and timothy, the seedling vigor of these

forage cultivars suppress the development of native grasses included in the mix. These results are leading to further trials with adjustments of seeding rates to permit better expression of the natives while benefiting from the vigor of the forage cultivars. These may have application in reclamation work.

Seed Increase Efforts

Evaluations and seed increase were conducted on a number of experimental entries in spaced and row plantings. The seed increase efforts provide seed with which to conduct revegetation and other trials.

Currently breeding stock is being maintained of the following three varieties of native grasses recently released for revegetation purposes: 'Tundra' bluegrass (Poa glauca), 'Alyeska' polargrass, and 'Sourdough' bluejoint reedgrass. These populations must be renewed periodically. Breeding populations of the varieties 'Arctared' fescue, 'Nugget' bluegrass, and 'Polar' brome grass also are being maintained at the Palmer Research Center.

Species for which evaluation plantings are currently underway include: Deschampsia caespitosa, D. beringensis, Festuca rubra, F. ovina, Poa glauca, Poa pratensis, Calamagrostis canadensis, and Arctagrostis latifolia. Other species have been included in previous evaluations and seed stocks developed of the more promising entries.

ALDER STUDIES

Studies have been conducted on the use of the indigenous shrub green alder (Alnus crispa), a nitrogen fixer, for coal mine reclamation. Requirements necessary for germination have been established. Untreated

seed generally has germinated at 15 - 20%; stratification at 5° C raised germination to 65 - 75%. Stratification at 1° C did not significantly increase germination over that at 5° C, but treating at 9° C was inferior to the 5-degree treatment.

Seeding trials on mine spoils at Sutton were unsuccessful, attributable, most likely, to the excessive dryness of the study sites. Growth chamber studies indicated that seeding depths greater than 8 mm and spoil moisture contents less than 8% were detrimental to germination and emergence.

Alder plants started in small peat pots in the greenhouse were successfully transplanted to the Sutton mine site and to the Usibelli mine at Healy. Although showing N deficiency symptoms, over 90% survived the first growing season. In fertility studies of transplants involving N, P, and K additions, N application was the primary factor responsible for increasing plant size and uptake of N, P, and K. Symbiotic N-fixation was limited in the vermiculite/peat medium employed for the transplants.

Analyses of soil characteristics under and adjacent to alder thickets demonstrate that alder growth increases organic content, organic N, and exchangeable K while decreasing pH and exchangeable Ca and Mg.

SOILS CHARACTERIZATION AND AMENDMENTS RESEARCH

Reclamation of surface mined lands requires close attention to spoil manipulation for optimizing the establishment of vegetation. Approaches include topsoiling, mulching, and surface manipulation aimed at increasing moisture status, water infiltration, tilth, and nutrient availability and retention. Topsoiling is highly desirable but is not feasible or practical in all situations, thus requiring plant establishment in spoils resulting from a wide range of mixtures of coal and overburden materials.

CHEMICAL CHARACTERISTICS

Characterization of coal spoils and overburden materials elsewhere has indicated problems ranging from general nutrient deficiencies to severe toxicities as well as soil physical problems due to dispersive effects of high exchangeable sodium concentrations. In the eastern part of the U.S., spoils from high sulfur coal are acidic and often result in aluminum and heavy metal toxicity to plants. In the arid west, saline and/or sodic spoil materials are observed and, without some method of amelioration, can result in specific ion toxicity or general salt (osmotic) effects on plant growth. Nutrient deficiencies frequently include N and P and sometimes K. Secondary nutrients (Ca, Mg, and S) and micronutrient deficiencies are less common in revegetation trials.

Very little information is available on the physical or chemical properties of Alaskan coal spoils and overburden materials. Alaskan coal is generally low in S content; therefore, S oxidation and resultant acidification of spoil material should not be a major problem. Climatic conditions at locations of immediate interest would not generally be

considered conducive to accumulations of excess soluble salts. However, local incidence of salt accumulation and high sodium in substratum materials cannot be ruled out.

Preliminary sampling of spoil and overburden materials was initiated at the Usibelli Mine at Healy, the Capps lease in the Beluga field, an abandoned strip mine northeast of Palmer at Sutton, and an abandoned site at Meade River in the fall of 1979. Samples were analyzed for various chemical constituents to characterize soil fertility status and to evaluate potential toxicity problems.

Extractable nutrient concentrations in surface spoil material at five sites are given in Table 1. The Healy A site was exposed substratum material overlying a coal seam but containing no coal, while the Healy B site was from a spoil bank containing significant amounts of coal and shale material. The Sutton site was a relatively old (perhaps 15 years) spoil bank containing appreciable amounts of both coal and shale material. The Beluga site represented recently disturbed and shallow overburden material containing no coal or shale. The Meade River sampling was from an abandoned disturbance of unknown age and had a high shale content. Spoil pH ranged from 5.5 at Beluga to 8.3 at Sutton. The lower end of this range would not be indicative of a serious acidity problem, and S content of the coal in the Beluga field (approximately 0.2%) should not adversely affect pH. The high pH at Sutton could adversely affect availability of P and certain micronutrients; studies planned for the coming growing season should confirm or deny this possibility. Nutrient concentrations would indicate probable response to N, P, and K fertilizer application at most of the sites tested. High Mg levels at the Healy A site could aggravate the already

low K levels in that area. Overall, the Beluga site was the least fertile and, in addition to NPK response, might well benefit from Mg additions.

Saturation extract analysis (Table 2) showed a range in E.C. values (soluble salts) from 0.05 to 2.90 mmhos/cm. While the upper value would be considered high for surface soils in Alaska, it should not affect plant establishment or growth. Sodium levels ranged from 0.21 to 6.13 meq/l; however, as Na increased, concomitant increases in Ca and Mg resulted in sodium adsorption ratios (SAR) well below levels that would cause serious soil physical problems. High pH values at Meade River are explained by relatively high CO_3^{2-} levels, indicating the presence of free Ca and Mg carbonates. The even higher pH at Sutton would appear to be controlled by a HCO_3^- system. The Sutton site, in particular, offers the possibility of reduced availability of micronutrients. The extremely low soluble salt level at Beluga reinforces the earlier data which predicted soil infertility.

Diethylenetriaminepentaacetic acid (DTPA) extractable Zn, Mn, Cu, and Fe are summarized in Table 3. Generally, the values reported are equal to or greater than those obtained on a wide range of agricultural soils in Alaska. In view of this and the fact that micronutrient deficiencies have not been documented for forage grasses in Alaska, it is unlikely that micronutrient deficiency will be a major problem in mine spoil revegetation. Additionally, these preliminary results would not indicate problems of metal phytotoxicity or accumulation of metals in plant tissue that might be toxic to wildlife.

The preliminary sampling was restricted to sites (with the exception of Meade River) where revegetation studies have been or will be

initiated. In addition to providing background information, these data will be used to determine initial amendment treatments in the revegetation studies. Additional samplings will be made during the summer and fall of 1980. Field trials initiated in 1979 or planned for 1980 include:

1. Fertilizer field trials to measure N, P, and K response for selected grass species at three locations.
2. Field trials to measure effects of fall vs spring application of fertilizer.
3. A combination NPK-flyash trial using annual ryegrass as an indicator crop (Healy only).
4. Mineral uptake trial to monitor nutrient deficiencies and/or toxicities in barley grown at 3 mine locations vs on an agricultural soil.

PHYSICAL CHARACTERISTICS

Primary physical characteristics that indicate potential problems to plant establishment and sustained growth include: low moisture holding capacity, poor soil struction, formation of high strength surface crusts, and compaction. The common contributors to these problems are coarse spoil texture and low organic matter content. Unpublished data by the authors has shown excessive dryness as the primary factor in the failure of field seedings of alder at the Sutton mine site. Results of preliminary analysis would indicate that the Sutton mine has the most severe soil physical conditions and the greatest potential for moisture stress.

Preparatory to the establishment of an irrigation and mulching trial at Sutton, soil moisture monitoring was initiated on three distinctly different textured spoil materials (Table 4). Site one showed

relatively heavy natural revegetation by poplar and alder shrubs, fireweed, and horsetail; site two was more sparsely vegetated, and site three was essentially devoid of vegetation. Particle size analysis showed an approximate 55% increase in coarse (> 2 mm) particles and concomitant 50% decrease in clay content in going from site one to site three. The implication is strong that moisture holding capacity had a direct influence on natural revegetation. This is further substantiated by moisture content measurements made in the spring of 1980 at the three sites (Figures 1 and 2). Moisture content measurements were made before and subsequent to the first rainfall episode of the 1980 growing season. Relative moisture holding capacity in the 0-1 inch (0-2.5 cm) and 1-2 inch (2.5-5.0 cm) depths was directly related to spoil texture at the three sites and is likely, at least in part, responsible for the observed differences in natural revegetation. The very rapid drying in the surface 5 cm during the first three days following precipitation is apparently critical to germination and seedling survival at sites one and two. Unpublished growth chambers studies by the authors using spoil material from site three showed significantly reduced emergence and survival of alder seedlings at moisture contents less than 8% and no emergence at 4%. Surface drying at sites one and two resulted in moisture contents in this range within three days of the rainfall episode. Moisture contents remained at greater than 8% for longer periods at the 2.5 to 5.0 cm depth, however, this exceeds the seeding depth of most revegetation grasses but may be an important factor in successful establishment of transplants.

While coarse texture and low organic matter contents are largely responsible for rapid surface drying, relatively high soil temperatures

and their effects on evaporative losses are apparent contributors.

Measurements taken on 29 April, 1980 at site three showed soil temperatures of 17 and 13° C at 2.5 and 10 cm depths, respectively. Measurements made the same day on agricultural soils nearby were 12 and 8° C, respectively. The reasons for a difference of this magnitude have not been fully determined but may include increased adsorption of solar energy by the dark colored shale and coal material, differences in slope and aspect, and absence of vegetative cover at the mine site. Regardless of the mechanisms of water loss, management practices must be determined which will reduce losses and/or replenish the losses through artificial means.

A field trial involving variables of mulching and irrigation was initiated at site three on 21 May, 1980. Plant materials being tested in this trial include barley, ryegrass, brome grass, arctared fescue, and alder. This trial will be evaluated in the fall and should provide important information on moisture requirements for revegetation of particularly harsh sites. Time of planting studies are underway which, among other things, will provide information on the importance of seasonal rainfall patterns on plant establishment.

TABLE 1. Soil fertility status of selected overburden materials in Alaska.

<u>Location</u>	<u>Extractable Nutrients</u>						
	<u>pH</u>	<u>NH₄-N</u>	<u>NO₃-N</u>	<u>P</u>	<u>K</u>	<u>Ca</u>	<u>Mg</u>
		-----ppm-----					
Healy A	5.9	5.4	7.3	2.7	56	710	1725
Healy B	6.0	27.1	8.3	6.4	68	140	391
Sutton	8.3	9.9	5.8	9.0	105	825	650
Beluga	5.5	7.2	5.9	0.8	48	319	14
Meade River	7.6	29.1	8.2	15.0	195	2140	950

TABLE 2. Chemical properties of selected overburden materials in Alaska.

<u>Location</u>	<u>pH</u>	<u>E.C.</u>	<u>Saturation Extract Analysis</u>						
			<u>K</u>	<u>Ca</u>	<u>Mg</u>	<u>Na</u>	<u>CO₃⁼</u>	<u>HCO₃⁻</u>	<u>SAR</u>
		mmhos/cm							
Healy A	5.9	0.16	Tr.	0.8	0.31	1.55	--	0.74	2.13
Healy B	6.0	2.90	0.54	19.7	17.9	6.13	--	0.44	1.41
Sutton	8.3	0.43	0.21	1.2	2.18	2.20	0.17	2.73	1.67
Beluga	5.5	0.05	Tr.	0.2	0.05	0.21	--	0.01	0.60
Meade River	7.6	1.84	1.12	5.0	10.7	2.75	2.05	4.31	0.98

TABLE 3. Availability of selected micronutrients in overburden materials in Alaska.

<u>Location</u>	<u>DTPA Extractable</u>			
	<u>Zn</u>	<u>Mn</u>	<u>Cu</u>	<u>Fe</u>
	-----ppm-----			
Healy A	0.7	2.7	2.2	112
Healy B	7.8	8.6	7.4	57
Sutton	3.5	4.0	5.7	28
Beluga	1.2	3.1	3.6	130
Meade River	1.9	9.0	2.8	88
	-----ppm-----			
	<u>Deficient</u>	<u>Marginal</u>	<u>Adequate</u>	
Zn	<0.8	0.8-1.5	>1.5	
Mn	<1.0		>1.0	
Cu	<0.2		>0.2	
Fe	<2.5	2.5-4.5	>4.5	

TABLE 4. Relationship between natural vegetative cover and spoil texture.
Sutton, 1980.

<u>Site</u>	<u>Particle Size Analysis</u>			
	<u>>2 mm</u>	<u>Sand</u>	<u>Silt</u>	<u>Clay</u>
	-----%			
1 Heavily vegetated	32	11	26	31
2 Sparsely vegetated	45	7	27	21
3 No vegetation	50	6	27	17

FIGURE 1. Effects of spoil type on moisture content of the surface 1 inch (2.5 cm) before and subsequent to a rainfall event. Sutton, 1980.

FIGURE 2. Effects of spoil type on moisture content of the 1-2 inch (2.5-5.0 cm) depth before and subsequent to a rainfall event. Sutton, 1980.