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RECLAMATION RESEARCH IN THE ALPINE REGION NEAR GRANDE CACHE, ALBERTA

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ABSTRACT

In 1992 the Alberta Research Council initiated a reclamation study at the Smoky River Coal Limited No. 12 Mine South area located northwest of Grande Cache, Alberta. The objective of the research is to assess the potential for revegetation of land affected by surface coal mining in this alpine area. Two plot areas approximately 300 m apart were established on a south-west facing slope to evaluate the suitability of two different "soil materials". These included "coversoil" or the indigenous soil material and "rock spoil" material. A total of 18 plots were established at each of the two locations to evaluate the suitability of Highlander slender wheatgrass *(Agropyron trachycaulum),* alpine bluegrass *(Poa alpina),* broadglumed wheatgrass *(Agropyron violaceum),* and sheep fescue *(Festuca ovina)* for revegetation in this area.

Plot seeding was completed in September, 1992 and selected plots were fertilized with the equivalent of 125 kg/ha of 35-15-0 in June 1993. Automated climate monitoring stations were installed at the two plot areas to measure air temperature, soil temperature, soil moisture, precipitation, solar radiation, relative humidity, wind speed, and wind direction. From 1993 to 1997 the frost-free period ranged from 16 to 68 days, and growing season precipitation from 250 mm to 502 mm.

Plant cover is less dense at the rock spoil plots because of the higher coarse fragment content and smaller number of potential germination sites. The overall mean percent cover at the coversoil plots in 1997 was 89% compared to 74% for the adjacent undisturbed area. The overall mean at the rock spoil plots was 78% compared to 56% for the adjacent undisturbed area. Invasion or encroachment of native species from the surrounding undisturbed area has been documented since plot establishment.

The coversoil and rock spoil materials both offer attributes that enhance the potential for reclamation success. The low level of fertilizer applied after seeding improved initial vegetation establishment, however it appears that no additional fertilizer application will be required. On the basis of the five years of results to date it is evident that these disturbed alpine areas can be successfully reclaimed by combining the use of available native seed and the process of indigenous species invasion or encroachment.

INTRODUCTION

Industrial development and recreational use are rapidly expanding in the subalpine and alpine regions of North America (Macyk 1998). In light of this expanding pressure for development, the major challenge is not to withdraw these areas from reasonable use, but to develop and refine the techniques to return these ecosystems to a natural self-sustaining state (Brown et al. 1978).

In 1992 the Alberta Research Council (ARC) initiated a reclamation study at the Smoky River Coal Limited No. 12 Mine South area located northwest of Grande Cache, Alberta. The objective of the research is to assess the potential for revegetation of land affected by surface coal mining in this alpine area. The ARC has been conducting reclamation research in the adjacent subalpine area at the No. 8 and No. 9 Mines since 1971.

MATERIALS AND METHODS

Site

The experimental site established in July 1992 was located outside the boundary of the area to be mined to preserve the integrity of the site and allow for an adequate record of data to provide a basis for conclusive recommendations. The two plot areas are located on a gentle southwest facing slope which represents the most difficult slope position to reclaim in this region.

Plot Construction

Two different surface or growth medium materials including "coversoil" or the surface soil material and the "rock spoil" material were used. The coversoil plot area was constructed by first removing the surface soil layer (12 to 18 cm) and then excavating and mixing the underlying spoil material to a depth of about 1.5 m. The mixed spoil was levelled and the coversoil replaced on the spoil surface (Macyk and Widtman 1993).

The rock spoil plot area was constructed by excavating and mixing the weathered rock material to a depth of about 1.2 m. There was no surface soil present in the area prior to disturbance resulting in a growth medium comprised of fragmented rock and the associated fines. Both the "coversoil" and "rock spoil" materials are typical of the area and are representative of the reconstructed surface that occurs following surface mining activities. A total of 18 plots (4 m x 8 m) was established at each of the two locations. The rock spoil plot treatment group is located about 300 m north of the coversoil plot treatment group. A wire mesh fence approximately 2 m in height was constructed at each of the two plot areas to protect the plots from all terrain vehicle traffic (Macyk and Widtman 1993).

Plot Treatments

In addition to the effect of the different surface material characteristics, species type was the other major variable included in the experiment. Grass seed was obtained from native plant researchers at the Alberta Environmental Centre and a commercial seed supplier. The species included alpine bluegrass *(Poa alpina)* seeded at 110 g/plot, Highlander slender wheatgrass *(Agropyron trachycaulum),* Mountaineer broadglumed wheatgrass *(Agropyron violaceum),* and sheep fescue *(Festuca ovina)* each seeded at 175 g/plot.

Plot seeding was completed September 1 and 2, 1992. Raking was completed immediately after seeding of each plot. Selected plots were fertilized with the equivalent of 125 kg/ha of 35-15-0 in June 1993. The plot treatments were replicated three times at each of the two locations with the exception of the control and Sheep fescue treatments. Emphasis was placed on including as many seed treatments as possible therefore only one control plot per location was established and fertilizer treatments were not a high priority (Macyk and Widtman 1993).

Soil Characterization

Soil samples were collected from the 0 to 15 cm and 15 to 30 cm depths in the rock spoil and coversoil plot areas prior to disturbance and from a total of six plots; following completion of site construction. Suitability of the soil materials for revegetation purposes was assessed by comparing the data to the soil quality criteria established for root zone material in the Eastern Slopes Region (Alberta Soils Advisory Committee 1987). The materials were rated "good" on the basis of pH, texture, and $CaCO_3$ equivalent.

Climate Monitoring

Automated climate monitoring stations were installed at the two plot areas. Measurements include air temperature, soil temperature (O, 2, 5, and 10 cm depth), soil moisture (5 and 15 cm depths), precipitation (tipping bucket rain gauge), solar radiation, relative humidity, wind speed, and wind direction. A rain gauge to measure total precipitation was also installed at the rock spoil plot area.

RESULTS AND DISCUSSION

Climate Data

An overview of some of the climatic parameters are provided. Table 1 provides growing season (monthly) air temperature (°C) in 1993 to 1997.

Table 1. Average growing season air temperatures (^{0}C) at No. 12 Mine from 1993 to 1997.

Month	Mean Monthly Air Temperature (°C)				
	1993	1994	1995	1996	1997
June	-	5.9	7.6	4.7	5.2
July	3.4	9.7	7.1	8.8	7.8
August	7.1	9.2	4.4	9.6	8.5
Average	5.3	8.3	6.4	7.7	7.2

The frost-free (>0°C) and killing frost-free (>-2.2°C) periods for 1993 to 1997 inclusive are provided in Table 2. In 1993 there was a one day difference between the frost-free and killing frost-free period, however the difference was substantial in subsequent years.

Table 2. Length of Frost-Free (>0°C) and Killing Frost-Free (>-2.2 °C) Period at No. 12 Mine in 1993 to 1997.

Year	Last Frost *	First Frost**	Length (days)
1993	8-July	9-August	32
1994	16-June	23-August	68
1995	26-June	8-August	43
1996	20-July	5-August	16
1997	29-June	8-August	40

Year	Last Killing Frost	First Killing Frost	Length (days)
1993	8-July	10-August	33
1994	15-June	28-September	105
1995	25-May	17-September	115
1996	5-July	3-September	60
1997	28-June	17-September	81

* Last Frost - Last frost in spring.
** First Frost - First frost in fall.

The wind speed data indicate that the winds are predominantly from the south and west. Table 3 provides monthly average wind speeds for 1993 to 1997 and the average number of hours per month that wind speeds exceeded 40 km/hr during that period.

Distribution of rainfall throughout the growing sea.son and intensity of rainfall events are critical for plant establishment and growth. For the five year period of 1993 to 1997, growing season precipitation averaged 357 mm and varied from a low of 250 mm in 1996 to a high of 502 mm in 1997. Data recorded to date indicate several precipitation events with 1 mm of rain occurring per minute over a five to 10 minute period. Also 50% of a monthly rainfall total has been recorded in one day.

Table 3. Average Monthly Wind Speed and Duration (Hours) of Wind Exceeding 40 km/hr for 1993 to 1997.

Month	Average	
	Monthly Average Speed (km/hr)*	Duration of Wind Exceeding 40 km/hr (hours)**
January	24	150
February	29	136
March	31	217
April	21	101
May	17	46
June	22	64
July	21	73
August	21	94
September	23	111
October	30	211
November	30	216
December	30	204

* Average speed - Average wind speed for the month.
** Duration - Hours of wind with average speed >40 km/hr.

Vegetation Establishment

Following plot seeding in September, 1992, germination and emergence were well underway in both the rock spoil and coversoil plot areas by mid-June, 1993. Substantial growth was achieved in 1994 and continued through 1997. The alpine bluegrass, sheep fescue, and broadglumed wheatgrass dropped mature seed in 1995, 1996, and 1997.

The application of fertilizer in 1993 resulted in enhanced growth at both plot areas with a more visible impact at the rock spoil site than the coversoil site. The cover in the fertilized plots had greener, larger, and generally more lush plants. In comparison, the plants in the unfertilized plots were shorter, more spindly (thinner), and slightly chlorotic in appearance. This was expected since the coversoil material had higher natural fertility levels than the rock spoil. In addition to the more enhanced growth at the rock spoil plots, the fertilizer also had a direct bearing on plant maturity. This indicated an earlier start to plant function and growth in the spring and/or more rapid progression of plant development during the growing season. The enhanced growth was quite evident in 1993 with lesser impact in 1994 and in subsequent years. This was expected as the initial application rates were relatively low and plant uptake and losses due to leaching would eventually deplete the nutrients added. Observations in 1997 indicated that there was no real visual difference in plant vigor or cover density between the fertilized and not fertilized treatments suggesting that the initial effects of fertilization had diminished over the five seasons since it was initially applied. In fact, it appeared that some of the not fertilized treatments, for example the alpine bluegrass at the rock spoil site, were showing more vigor than the fertilized treatments. These results suggest that an initial fertilizer application will enhance initial vegetation establishment and that subsequent applications will not likely be required.

Plant Cover

The plant cover established varied with the different species in both the rock spoil and coversoil plot areas. The obvious difference in growth of the various species between the two areas related particularly to the height, and to a lesser extent the density of the cover. Cover was generally less dense at the rock spoil plots because of the higher course fragment content and smaller number of potential germination sites. Table 4 provides an ocular estimate of ground cover completed in August, 1997 for the different treatments at both plot areas. The values represent a mean of three random quadrats in each of three replicates. In addition, three random measurements were made at four different locations (north, south, east, west) adjacent to but outside the plot areas.

The data reported in Table 4 indicates that the ground cover was greater at the coversoil than the rock spoil sites. The overall mean for the percent cover at the coversoil plots was 89% compared to 74% for the adjacent undisturbed area. The control plot which had no seed applied had developed a plant cover of 83%.

Table 4. Ocular Estimate of Ground Cover (Mean Values) for the Different Treatments in 1997.

Coversoil Plots

Plant Species	% Cover	Plant Species	%Cover
Slender Wheatgrass	90	Alpine Bluegrass	89
Broadglumed Wheatgrass	87	Alpine Bluegrass (F)*	87
Sheep Fescue	99	Sheep Fescue (F)*	82
Control	83	Undisturbed **	74

Rock Spoil Plots

Plant Species	% Cover	Plant Species	%Cover
Slender Wheatgrass	62	Alpine Bluegrass	77
Broadglumed Wheatgrass	70	Alpine Bluegrass (F)*	79
Sheep Fescue	93	Sheep Fescue (F)*	89
Control	44	Undisturbed**	56

* Fertilized in 1993
** Undisturbed adjacent area

The overall mean for the percent cover at the rock spoil plots was 78% compared to 56% for the adjacent undisturbed area. The control plot which had no seed applied had developed a plant cover of 44% which was dominated by native species (Macyk and Pojasok 1998).

Invasion or encroachment of native species into the plot areas has been documented since the time of plot establishment. Native species identified in the plots included:

Common Name	Scientific Name
Bracted Lousewort	*Pedicularis bracteosa*
Mountain Sorrel	*Oxyria digyna*
Moss Campion	*Silene acaulis*
Alpine Hawkweed	*Hieracium gracile*
Yellow Dryad	*Dryas drummondii*
Late Yellow Locoweed	*Oxytropis campestris, Oxytropis monticola*
Yellow Mountain Heather	*Phyllodoce glanuliflora*
Alpine Forget-Me-Not	*Myostis alpestris, Myostis sylvatica*
White Mountain Avens	*Dryas octopetala*
Mountain Monkshood	*Aconitum delphinifolium*

CONCLUSIONS

Results to date indicate that the four grass species utilized in the experiment are suitable for revegetation in the area. They provide excellent erosion control and achieve maturity despite the relatively short growing season.

The coversoil and rock spoil materials both offer attributes that enhance the potential for reclamation success. The ground cover established was generally greater at the coversoil than the rock spoil plots. The coversoil material offers more potential germination sites, has higher natural soil fertility, and provides a better medium for nutrient retention and availability to plants.

The rock spoil material provides much needed protection from the wind and has the greater potential to reduce both wind and water erosion than does the coversoil material. The potential for excessive runoff or erosion is a concern because much of the rainfall occurring in the area can come in short and intense precipitation events. The rock spoil material also traps and holds more snow during winter thus providing some protection for the vegetation established.

Based on the results to date it is evident that these areas can be successfully reclaimed by combining the use of available native seed and the natural process of indigenous species invasion or encroachment.

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