ESTABLISHMENT OF TREES AND SHRUBS ON MINED LAND IN THE FOOTHILLS/MOUNTAINS REGION OF ALBERTA, CANADA[1]

Terry M. Macyk and Zdenek W. Widtman[2]

Abstract.--The Alberta Research Council has conducted a reclamation research program near Grande Cache, Alberta, Canada on behalf of Smoky River Coal Limited since 1972. The overall objective of this study is to develop cost-effective methods of establishing and maintaining a vegetative cover that is in harmony with adjacent undisturbed areas. An initial erosion control cover was established with introduced grasses and legumes. Container and bare root conifer seedlings and cuttings of deciduous species were utilized initially to establish trees and shrubs in the area. Results indicate that a significantly higher survival rate was achieved for trees planted in areas where a grass and legume cover was present as compared to areas where no cover was present. Survival rate was higher for container than for bare root seedlings. Shrub cuttings rooted prior to planting had higher survival and growth rates than direct planted cuttings. Long term results indicate that trees and shrubs will become established in significant numbers by natural processes. Direct seeding has also proven to be a viable method for establishment of trees and shrubs in the area. Results obtained from the research program to date indicate that there are a number of methods that exist for the establishment of trees and shrubs on mined land. The method or combination of methods utilized is dependent upon end land use desired, time frame allowed and specific site conditions.

INTRODUCTION

The Terrain Sciences Department of the Alberta Research Council (ARC) has been conducting a reclamation research Program in the Grande Cache area in conjunction with the operations of Smoky River Coal Limited since May 1972. At the time the program was initiated reclamation research was truly in its infancy in Alberta. Techniques employed elsewhere at the time, primarily in the United States, were not applicable to the Alberta situation. Furthermore, legislation pertinent to reclamation in Alberta was not formally in place until the Land Surface Conservation and Reclamation Act of 1973 and the Coal Policy of 1976. This paper provides a summary of the work undertaken and an assessment of the results obtained relative to the establishment of trees and shrubs in the area (Macyk 1972 to 1982; Macyk and Widtman 1983 to 1986).

Setting

The operations of Smoky River Coal Limited are located in the Rocky Mountain Foothills approximately 150 km north of Jasper. Elevations range from 1600 to 1800 m and the topography is steeply sloping. Treeline in the area occurs at about 2050 m. Climate can be considered one of the major limiting factors to revegetation success. For example, the frost-free period (>0°C) was 45 days in 1984 and 64 days in 1985. Snow can occur in any month of the year and wind is a common phenomenon.

---

[1]Paper presented at the combined Fourth Biennial Billings Symposium on Mining and Reclamation in the West and The National Meeting of the American Society for Surface Mining and Reclamation. March 17-19, 1987. Billings, MT.

[2]Terry M. Macyk and Zdenek W. Widtman are Senior Research Officer and Research Technologist respectively in Terrain Sciences Department, Alberta Research Council, Edmonton, Alberta, Canada.

Proceedings America Society of Mining and Reclamation, 1987 pp 239-244
DOI: 10.21000/JASMR87010239
https://doi.org/10.21000/JASMR87010239

Objective

The overall objective of the program is to develop cost-effective methods for the establishment of a long-term self-sustaining vegetative cover that is in harmony with the adjacent undisturbed area. A specific end land use for the area was not spelled out at the time the project was initiated, however, erosion control was one of the initial considerations along with the re-establishment of a forest cover with some capability for wildlife use.

MATERIALS AND METHODS

Coal production from the No. 8 Mine surface operations commenced in June 1971. The research program that placed emphasis on soils and vegetation concerns began in May 1972. The research program was subsequently extended to the No. 9 Mine area in 1976.

Pre-Mining Soils

Soil surveys were conducted in each of the mine areas to determine the characteristics of the soils and their suitability for revegetation purposes as well as the volume of material that could be salvaged and ultimately replaced (Macyk 1973; Macyk and Widtman 1985; Macyk and Widtman 1986). The data obtained indicate that, in general, the unmined soils are moderately to slightly acid, medium textured and have low levels of available plant nutrients (Macyk 1985).

Materials Handling Procedures

Soil salvage is an integral part of the materials handling program associated with the surface mining operations. Following the removal of tree and shrub cover, the soil overlying consolidated bedrock is removed in one lift and stockpiled for future use. Because the surface or organo-mineral horizons are very thin or nonexistent and the sola quite variable in thickness, segregation or selective handling of soil materials is not considered.

Following the removal of the overburden and coal and subsequent backfilling and grading, soil material is replaced on the graded surface by scrapers or truck/caterpillar operations.

Reconstructed Soils

The soils that are reconstructed do not duplicate the soils that existed prior to disturbance. The physical properties of the soils are the ones most drastically altered by the mining process. Analytical data indicate that reconstructed soils are generally coarser textured, higher in pH and lower in available nutrients than unmined soils (Macyk 1985).

These reconstructed soils have some limitations, however, with proper management they are invaluable in achieving reclamation success.

Tree and Shrub Establisment

A specific end land use was not designated for the mined area at the time the project was initiated because there was no precedent set or knowledge of what could be achieved in terms of reclamation. Erosion control was one of the major concerns relative to the establishment of a plant cover.

The revegetation work was initiated in May 1972 with the establishment of three plot areas to assess the suitability of several different grasses and legumes (Macyk 1985). Fertilizer trials were included to determine the most appropriate fertilizer types and analyses to be used, as well as timing and rate of application.

A program to introduce trees and shrubs to the area was undertaken concurrently with the grass and legume establishment program. Initially, a major problem was encountered in that seedlings suitable for planting above an elevation of 1100 m were unavailable. For the first year the best material available including bare root and container stock of lodgepole pine (*Pinus contorta* var. *latifolia*) and white spruce (*Picea glauca*) were planted. In addition a cone collection program was undertaken and greenhouse space acquired to rear lodgepole pine, white spruce and engelmann spruce (*Picea engelmannii*). Different types and sizes of containers were utilized to determine those most suitable for use in reconstructed soils and to get an appreciation of the relative costs associated with seedling production.

Initially the "peat sausage" container which was developed by the Alberta Research Council was utilized. This container is produced by extruding a peat-water mixture into a continuous thin, tubular, flexible plastic casing which is then sliced into short uniform cylinders or "sausages" which are 2.5 cm in diameter and 7.5 cm long (Mitchell et al. 1972).

The other container type utilized was the "Spencer Lemaire" with four different cavity sizes: 1) Ferdinand - 39 cm^3; 2) Five - 82 cm^3; 3) Hillson - 164 cm^3 and; 4) Tinus - 328 cm^3. In terms of production one square metre of greenhouse space would allow for the production of approximately 1150, 850, 350 and 250 seedlings, respectively. Bare root stock of the three conifer types was also produced.

Cuttings of willow (*Salix* spp.), balsam poplar (*Populus balsamifera*) and root cuttings of aspen (*Populus tremuloides*) were rooted in the greenhouse. Direct planting methods were also utilized for willow cuttings. Most of the trees and shrubs produced were planted in areas having an established grass or grass and legume cover with the remainder being planted in areas with no other vegetation cover present.

In the first year of the program the trees and shrubs were planted on an 2 m x 2 m grid basis. In subsequent plantings no specific grid dimensions were utilized since planting was done more on the basis of selecting appropriate microsites.

During the early stages of the program planting sites were determined on the basis of site availability and planting was undertaken where areas were available. This involved planting on crown, south and west facing slopes as well as the north and east facing slopes.

The activities relative to tree and shrub establishment described above occurred from 1972 to 1977 inclusive. During 1983 a direct seeding program to establish spruce and pine was undertaken to determine whether this procedure might be appropriate for operational reclamation. This involved the establishment of two 3 m x 3 m plots where pine seed was broadcast into the existing grass, legume and accompanying plant litter cover.

In 1984 six individual 10 m x 10 m plots were established to assess the fate of spruce and pine seeded into a surface disturbed to a depth of 1 to 2 cm. Within these plots half of the rows (0.5 m spacing) were seeded in May and the remainder in August to allow for a comparison of spring and fall seeding. Approximately 200 seeds per row were utilized.

In the fall of 1985 the plot seeding program was expanded and the seeding methods modified. The scarification process was much more extensive in that a rototiller was used and 800 seeds of pine or spruce was planted in each row. The rows of spruce or pine were alternated with rows of alder where 2000 seeds per row were utilized.

RESULTS AND DISCUSSION

Initial Cover Establishment

Most of the agronomics that were planted initially survived and continue to thrive. Time and annual monitoring of growth resulted in the development of an appreciation of species suitability and desirability, stand composition and fertilizer requirement (Macyk 1985).

Tree and Shrub Establishment

Good success was achieved in terms of tree and shrub establishment utilizing the different propagation and planting techniques. It was demonstrated that trees and shrubs will thrive when planted in areas having a grass and legume cover. This practice was questioned initially because of an anticipated competition for moisture. It became apparent that the protection afforded the seedlings by the grass and legume cover, especially in holding snow in the winter, far outweighed the negative aspects of moisture competition during the growing season. Two years after initial planting the overall survival rate for conifers planted in areas with no other cover was 8 percent and in areas with a grass and legume cover was 58 percent.

Climatic limitations dictate that some form of protection for the young seedlings is critical in this area. During the winter it is not unusual to have the snow cover blown off by strong winds or melted down during periods of warm weather. Subsequent cold spells, especially if accompanied by strong winds, can be particularly detrimental to young seedlings. During the summer, surface and near surface soil temperatures can reach relatively high values especially in areas where the soil material is dark in colour. For example, near surface (2 cm depth) soil temperatures in sparsely vegetated areas reached levels in excess of 46°C for six consecutive hours on three consecutive days in the latter part of July 1985 (Macyk and Widtman 1986). Temperatures at the same depth under a more dense vegetative cover were 10°C lower.

A specific experiment to assess the impact of aspect on conifer establishment was not undertaken, however, it is apparent from field observations that east and north facing slopes are superior to the other aspects. East facing slopes are particularly suitable because of the protection from wind and temperature extremes. Furthermore, snow accumulation also tends to be greatest on these slopes.

Container and Bare Root Conifer Stock

Container grown conifer seedlings are superior to bare root stock in terms of survival and growth rate (table 1).

Table 1.--Survival and growth rate of bare root and container stock

	Survival (%)*		MAHG (cm)**	
	spruce	pine	spruce	pine
Bare root***	46	35	2.9	6.4
Container****	58	52	3.8	7.6

* Survival assessed five years after planting.
** Mean annual height gain.
*** Bare root stock three years old at time of planting.
**** Container stock one year old at time of planting.

Spruce has the higher survival rate but also the lower growth rate.

In considering container stock only, it became apparent that survival rate increased with increasing size of container. For example, the largest size of container utilized provides approximately eight times the volume of rooting medium than does the smallest size utilized. This allows the seedling more opportunity to develop a more effective root mass in the more desirable rooting material. One of the disadvantages of the larger size container seedlings is the requirement for planting holes at least 18 to 20 cm deep.

Recently, emphasis was placed on assessing some of the characteristics of trees planted in the reclaimed area and relating this to trees found in the adjacent forest and in areas reforested after harvesting operations (Macyk 1985). Trees were excavated to allow for examination of rooting habit and depth. Stem diameter at the base, as well as age and height of each individual tree were determined. The data obtained indicated that the trees planted and growing in the reclaimed area are comparable to those growing in the reforested and natural forest settings.

Shrub Establishment

Willow was successfully established by utilizing cuttings that were rooted in containers in the greenhouse and by direct planting of cuttings. A summary of survival rate five years after planting and height achieved ten years after planting is presented in table 2.

Table 2.--Survival and growth of willow

	Survival rate (%)*	Height (cm)**
Rooted cuttings	65	126.5
Direct planted	40	83.2

* Survival rate assessed five years after planting.

** Height based on a mean value for 25 shrubs 10 years after planting.

The results indicate a higher survival rate and height growth for cuttings rooted prior to planting as compared to direct planted cuttings. Cuttings rooted prior to planting will also adapt to a wider range of site conditions than will direct planted cuttings. It should be noted however, that direct planting of cuttings is much less costly than prior rooting.

Direct Seeding Trials

A number of factors led to the initiation of direct seeding trials as a means of tree and shrub establishment in the area. First of all, during investigations relative to seedling survival and growth it became apparent that some of the seedlings demonstrating poor growth had limited root egress. Furthermore, frost heaving of some of the container seedlings resulted in the exposure of the upper root mass surrounded by peat from the original container above the soil surface. As a result the seedlings eventually died.

The problems described above combined with the difficulty in planting bare root and container seedlings in the reconstructed soils at the site and the cost of production and planting resulted in a desire to consider alternative methods for tree and shrub establishment.

Observations in the area indicated that spruce, pine, alder, willow and buffaloberry are becoming established in significant numbers by natural means in the area. This implied that direct seeding might be a viable technique for tree and shrub establishment. Seedlings up to 7 cm in height in October 1986 are the product of the initial seeding undertaken in the fall of 1983.

The spring and fall seeding program undertaken in 1984 resulted in the following observations:

- pine germinants outnumbered the spruce for both spring and fall seeding;
- spruce seeded in spring resulted in virtually no germinants;
- fall seeded pine resulted in a four to ten fold increase in germinants when compared to spring seeded pine.

In 1985, seeding was done in the fall only and included alternating rows of alder. Some of the results obtained from observations made in the fall of 1986 are presented in table 3.

Table 3.--Spruce and pine germinants at four plot* locations

Row	Plot 7		Plot 8		Plot 9		Plot 10	
	spruce	pine	spruce	pine	spruce	pine	spruce	pine
1	2	52	1	8	3	60	6	79
2	0	55	2	7	11	87	7	94
3	10	56	0	6	17	88	11	41
4	11	91	2	11	14	133	9	33
5	4	129	2	7	9	124	3	26
6	6	82	2	19	7	137	4	70
7	8	46	1	12	2	111	6	32
8	11	51	3	21	8	78	2	27
9	10	50	0	13	12	67	3	48
Total	62	612	13	104	83	885	51	450

* Each plot is 10 m x 10 m in size.

The alder germinants were not counted because the plants were extremely small. The data in table 3 indicate that pine resulted in approximately ten times as many germinants as spruce. Furthermore, the pine germinants appeared more healthy or vigorous than the spruce at the time of assessment.

The "physical" characteristics or condition of the "soil" appear to be one of the major influences on germination and growth and is one of the reasons for the variation in number of germinants per row. Plot 8, for example, is characterized by the highest coarse fragment content of all the sites.

The results obtained to date suggest that direct seeding can be a viable alternative to planting seedlings in certain locations.

CONCLUSIONS

This reclamation research program in the Grande Cache area demonstrates that trees and shrubs can be returned to a reconstructed soil setting in the region. The methods that are utilized for any specific location are dependent upon the end land use desired, the time frame allowed and specific site conditions. The options available in terms of techniques for establishment are:

Trees
- container and bare root seedlings
- direct seeding
- natural invasion
- transplanting

Shrubs
- rooted cuttings
- direct planted cuttings
- natural invasion
- transplanting

LITERATURE CITED

Macyk, T.M., and Z.W. Widtman. 1983 to 1986. Progress report, surface mine reclamation project, No. 8 and No. 9 Mines, Grande Cache, Alberta. Alberta Research Council, Terrain Sciences Department Reports prepared annually.

Macyk, T.M., and Z.W. Widtman. 1986. Soil survey and soil suitability evaluation for the No. 12 Mine area. Alberta Research Council, Terrain Sciences Department Report.

Macyk, T.M. 1985. Reclamation research in the foothills/mountains region of Alberta; a case study. In Proceedings of the Second Annual Meeting of the American Society for Surface Mining and Reclamation, Denver, Colorado, October 8-10, 1985.
http://dx.doi.org/10.21000/JASMR85010153

Macyk, T.M. 1972 to 1982. Progress report, surface mine reclamation project, No. 8 Mine, Grande Cache, Alberta. Alberta Research Council, Soils Department Reports prepared annually.

Mitchell, D.L., D. Hocking, and W.C. Kay. 1972. Reforestation with seedlings grown in extruded peat cylinders. Part I. The production process and preliminary growth data. Proc. Am. Soc. Agric. Eng. 15. 36-39.
http://dx.doi.org/10.13031/2013.37824

Macyk, T.M. 1973. Soil survey of the No. 9 Mine area, Grande Cache, Alberta. Soils Division, Alberta Research Council Report.