

ESTABLISHMENT OF TREES AND SHRUBS ON MINED LAND IN THE SUBALPINE REGION OF ALBERTA

Terry M. Macyk¹ and Vernon G. Belts²

¹ Alberta Research Council, Box 8330, Edmonton, Alberta T6H 5X2

² Smoky River Coal Limited, Box 2000, Grande Cache, Alberta T0E 0Y0

ABSTRACT

The Alberta Research Council has conducted a surface mine reclamation research program at the operations of Smoky River Coal Limited near Grande Cache, Alberta since 1972. The overall objective of this study is to develop and refine cost-effective methods of establishing and maintaining a vegetative cover that is in harmony with adjacent undisturbed areas.

A program to introduce trees and shrubs to the area was undertaken concurrently with the establishment of grasses and legumes. Due to the lack of seedlings available at the time for planting above an elevation of 1100 m, a cone collection program was undertaken to obtain seed for production of lodgepole pine (*Pinus contorta* var. *latifolia*), white spruce (*Picea glauca*), and engelmann spruce (*Picea engelmannii*). Cuttings of willow (*Salix* spp.), balsam poplar (*Populus balsamifera*), and root cuttings of aspen (*Populus tremuloides*) were rooted in the greenhouse prior to planting. Willow cuttings were also collected and directly planted in the field.

Most of the trees and shrubs produced were planted in areas having an established grass, or grass and legume cover. Container grown conifer seedlings were superior to bare root stock in terms of survival and growth rate. Survival rate increased with increasing size of container. Mean annual growth measurements of lodgepole pine and engelmann spruce seedlings in the reclaimed areas and adjacent undisturbed forest indicated that the reconstructed soils will support tree growth that is equivalent to the growth achieved on the natural or undisturbed soils. The willow and alder provided excellent protection for the conifers when the conifers exceeded the height of the grass and legume cover.

Frost heaving of container seedlings and limited egress were the major causes of mortality for the conifers. Direct seeding was initiated in the fall of 1983 using seed of pine, spruce, and alder. The results obtained showed that direct seeding is a viable alternative to the use of container or bare root materials for specific locations in a mined area.

The research conducted to date indicates that trees and shrubs can become established in reclaimed areas in the subalpine. The methods that are utilized for any given location are dependent on the end land use desired, the time frame allowed, and specific site conditions.

INTRODUCTION

The Alberta Research Council 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.

The overall objective of the program is to develop and refine cost-effective methods for the establishment of a self-sustaining vegetative cover that is in harmony with the adjacent undisturbed area. A specific end land use for the area was not defined 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.

The major activities included soil and spoil characterization and management, vegetation establishment and maintenance, revegetation of areas affected by fly ash disposal, detailed climate monitoring, equipment design for operational reclamation, and technology transfer. The results of this long term research are reported in annual progress reports as well as in conference proceedings (Macyk and Widtman, 1987; Macyk et al., 1991).

The establishment of trees and shrubs was considered essential in the overall reclamation scheme because they provide floristic and structural diversity and aid in slope stabilization. They are important in ungulate nutrition especially in areas that have the potential for use as winter range. Shrubs such as alder, despite having low palatability for ungulates, are good for reconstructed soil improvement through nitrogen fixation and addition of organic matter through leaf fall.

MATERIALS AND METHODS

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 and climate is the most limiting factor to revegetation success.

Soils and Soil Handling Procedures

The characteristics of the soils and their suitability for revegetation, as well as the volume of material available for salvage and replacement, was determined for each of the mined areas (Macyk, 1973; Macyk and Widtman, 1985; Macyk and Widtman, 1986a). The pre-mining soils were generally moderately to slightly acid, medium textured and low in levels of available plant nutrients (Macyk, 1985).

Salvage operations involve the removal of soil overlying consolidated bedrock in one lift and stockpiling for future use. Segregation or selective handling of soil materials is not considered because the surface or organo-mineral horizons are very thin or nonexistent, and the sola are quite variable in thickness (Macyk and Widtman, 1987). Soil material is replaced on the graded surface by truck/caterpillar operations. The resulting soils are generally coarser textured, higher in pH, and lower in available nutrients than unmined soils (Macyk, 1985).

Tree and Shrub Establishment

The revegetation work was initiated in May 1972 with the establishment of plot areas to assess the suitability of a variety of introduced grasses and legumes (Macyk, 1985). The program to introduce trees and shrubs in the area was undertaken concurrently with the grass and legume establishment program. Initially, seedlings suitable for planting above an elevation of 1100 m were unavailable which necessitated the use of the best material that could be obtained including bare root and container stock of lodgepole pine (*Pinus contorta* var. *latifolia*) and white spruce (*Picea glauca*). To develop a source of suitable material, 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 the reconstructed soils of this area, and to evaluate the relative costs associated with seedling production. Details regarding container size and type used are described in Macyk and Widtman (1987).

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 planted in areas with no other vegetation cover. Planting techniques are described in Macyk and Widtman (1987).

The activities relative to tree and shrub establishment described above occurred from 1972 to 1977 inclusive. A direct seeding program was initiated in 1983 to evaluate the potential for establishing spruce, pine, and alder by seeding techniques. The research assessed the effectiveness of spring and fall seeding as well as the use of soil surface scarification techniques.

Other experimental work included a comparison of the growth of conifers on unmined and reconstructed soil including a comparison of rooting depth and pattern. One hundred conifer seedlings were tagged at each of two sites referred to as Area 1 and the Highwall Site and the respective adjacent unmined areas.

RESULTS AND DISCUSSION

The different propagation and planting techniques resulted in successful establishment of trees and shrubs. The results clearly 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 planting the overall survival rate for conifers planted in areas with no other cover was 8%, and in areas with a grass and legume cover was 58%.

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 (Macyk et al., 1989). Subsequent cold spells, especially if accompanied by strong winds, can be particularly detrimental to young seedlings. Winds averaging 60 to 70 km/hr for 6 to 8 hours per day are not unusual during the winter months. 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 can reach levels in excess of 45 °C to 50 °C for several consecutive hours on several consecutive days in July and August (Macyk and Widtman, 1986b). Temperatures at the same depth under a more dense vegetative cover were about 10 °C lower.

Conifer Establishment

Container grown seedlings were superior to bare root stock in terms of survival and growth rate (Table 1). Survival rate also increased with increasing size of container. The coarse fragment content and the potential for

Table 1. Survival and Growth Rate of Bare Root and Container Conifer Stock.

	Survival (%) ^a		MAHG (cm) ^b	
	Spruce	Pine	Spruce	Pine
Bare root ^c	46	35	2.9	6.4
Container ^d	58	52	3.8	7.6

- ^a - Survival assessed five years after planting.
- ^b - Mean annual height gain (cm).
- ^c - Bare root stock three years old at time of planting.
- ^d - Container stock one year old at time of planting.

periods of low moisture content in the replaced coversoils are limiting factors in the use of bare root stock. Container seedlings allow the seedling to develop a more effective root mass initially in the more desirable rooting material. One of the disadvantages of the larger size container seedlings is the difficulty in preparation of planting holes at least 18 to 20 cm deep in the reconstructed soils.

The growth data obtained for the eleven year period at Area 1 (Figure 1) and ten years at the Highwall Site (Figures 2 and 3) indicate that mean annual growth was comparable for the natural and reconstructed soils with the largest difference occurring for pine on reconstructed soil at Area 1. The data illustrated in the three figures indicates that during initial establishment or the first five years of measurement, the trees in the unmined locations generally had marginally better annual growth than the trees in the reconstructed areas. The trend was reversed in subsequent years. Below average precipitation levels reported for four of the five years from 1983 to 1988 followed by above average levels in 1989, 1990, and 1991 could be a partial reason for the growth trends observed (Macyk et al., 1995).

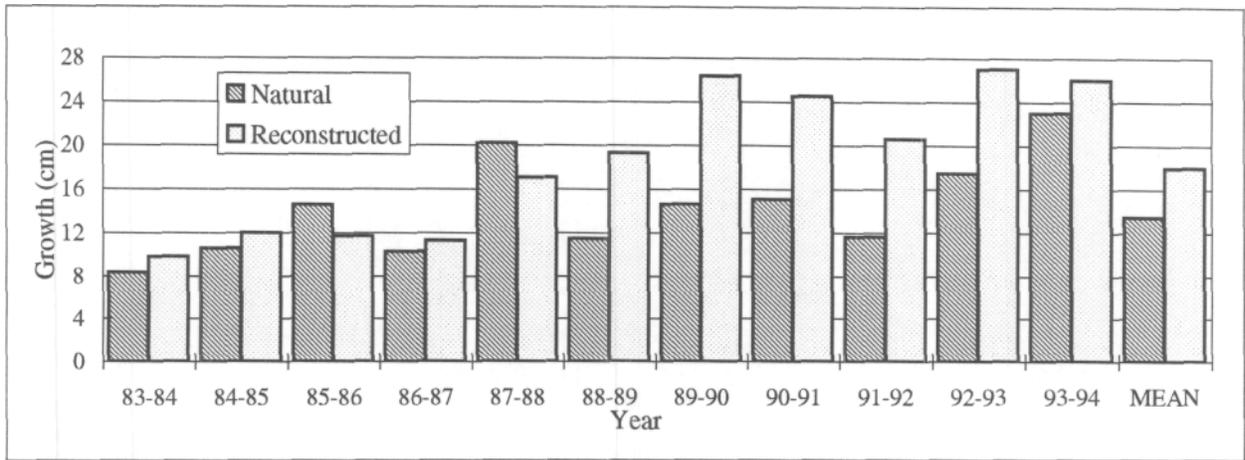


Figure 1. Annual and Mean Annual Tree Growth of Pine on Reconstructed and Natural Soils at Area 1.

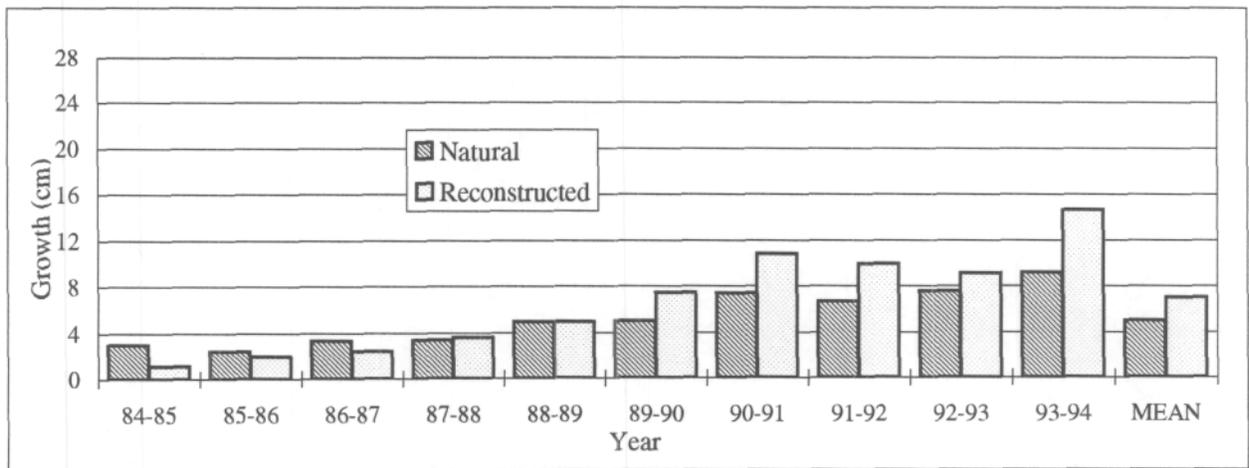


Figure 2. Annual and Mean Annual Growth of Spruce on Reconstructed and Natural Soils at Highwall Site.

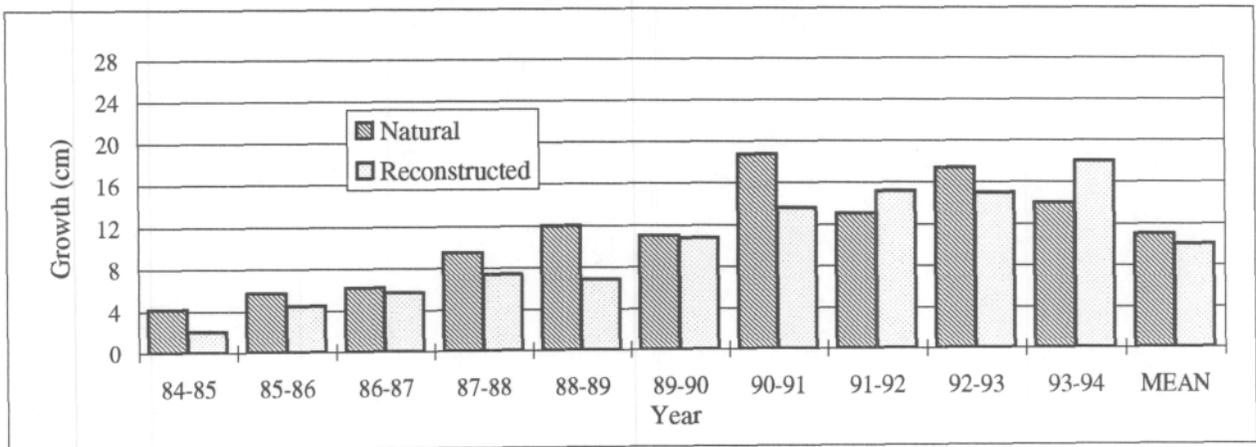


Figure 3. Annual and Mean Annual Growth of Pine on Reconstructed and Natural Soils at Highwall Site.

Shrub Establishment

Willow was successfully established by utilizing cuttings that were rooted in containers in the greenhouse and by directly planting 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 (%) ^a	Height (cm) ^b
Rooted cuttings	65	127
Directly planted	40	83

^a Survival rate assessed five years after planting.

^b 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 directly planted cuttings. Cuttings rooted prior to planting appeared to adapt to a wider range of site conditions than the directly planted cuttings. It should be noted however, that direct planting of cuttings is much less costly than use of cuttings rooted prior to planting.

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. Investigations relative to seedling survival and growth indicated 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 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 consideration of alternative methods for tree and shrub establishment (Macyk and Widtman, 1987).

Observations in the reclaimed area indicated that spruce, pine, alder, willow and buffaloberry were becoming established in significant numbers by natural means. This implied that direct seeding might be a viable technique for tree and shrub establishment.

The spring and fall seeding program undertaken in 1984 involved 10 m x 10 m plots with surface soil scarification to about the 5 cm depth. The following observations were reported:

- 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 alder. The "physical" characteristics or condition of the soil appeared to be one of the major influences on germination and growth.

CONCLUSIONS

This long term reclamation research program demonstrates that trees and shrubs can be established in surface mined areas in the subalpine. The methods that are utilized for a given location are dependent upon the end land use desired, the time frame allowed, and specific site conditions. The options available include the use of container and bare root stock, rooted and directly planted cuttings, direct seeding, and natural invasion.

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