

RECLAMATION RESEARCH AT THE SURFACE MINE OPERATION OF
SMOKY RIVER COAL LIMITED

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ABSTRACT

Commissioned in 1971, an on-going reclamation study has been conducted by the Soils Department of the Alberta Research Council on behalf of Smoky River Coal Ltd. at their open-pit mine operations near Grande Cache, Alberta. The main objective of the project was to determine methods of establishing long-term cover that would be in harmony with adjacent, undisturbed areas.

The soils occurring in the pre-mining state as well as the soils reconstructed after mining, were characterized.

Plot studies to determine the suitability and adaptability of various agronomic and native grasses and legumes were established. Fertilization trials were included. Conifer seedlings and rooted cuttings of deciduous species were planted in the disturbed areas following establishment of a grass and legume cover. Long term results indicated that agronomic species, including alfalfa, will thrive and reproduce, and that tree seedlings will co-exist with the initially established grass and legume cover. The results obtained from the research effort have been successfully transferred to the operational scale.

INTRODUCTION

When the Alberta Research Council was approached by McIntyre Mines Ltd. (presently known as Smoky River Coal Ltd.) in 1971 to undertake a reclamation research study in the Grande Cache area, reclamation research was truly in its infancy in Alberta. Techniques developed elsewhere, primarily in the United States were not applicable to the situation at hand. This paper will provide a summary of some of the research conducted for, and funded by Smoky River Coal Ltd. during the past eleven years. In addition to providing some of the technical details associated with the research some of the challenges associated with doing environmental research in the early 1970's will be explored. Specifics relating to any aspect of the study may be obtained by contacting the author.

Setting

The operations of Smoky River Coal Ltd. are located approximately 13 km north of Grande Cache in the Rocky Mountain Foothills of West Central Alberta. The two major surface mining operations are referred to as the No. 8 and No. 9 Mine areas. Elevations range from 1600 to 1800 m and the topography is steeply sloping. The climate is characterized as cold continental with short, cool summers and long, cold winters. In fact, frost and/or snow can occur in any month of the year.

Objectives

The original objectives of the project were defined as follows> new ones were added as additional needs were identified;

- 1) to determine the properties of the undisturbed and reconstructed soils in the mine area and evaluate their suitability for reclamation purposes;
- 2) to determine, by field testing, suitable species of grasses and legumes for establishing a protective vegetative cover on the reclaimed areas to minimize erosion;
- 3) to determine, by field and laboratory testing, the nutrient requirements for maintaining a viable vegetative cover; and
- 4) to determine methods of establishing a long-term cover in harmony with the adjacent, undisturbed areas.

MATERIALS AND METHODS

Preproduction development of the No. 8 Mine began early in 1971, and coal production commenced in June of that year. Reclamation research which emphasized soils and vegetation concerns, began in May of 1972 (Macyk, 1972-1982).

Pre-Mining Soils

A soil survey of that portion of the No. 8 Mine area that had not yet been disturbed by mining indicated that the soils were dominantly Luvisolic and Brunisolic (CSSC, 1978) with 10 cm to 1 m of salvageable material overlying bedrock. It was established that an average thickness of about 50 cm of salvageable soil material was available in the mine area. Analyses indicated that these soils were medium to slightly acid (pH 5.5 to 6.5), medium (silt loam) textured and had low levels of available macronutrients, especially nitrogen and phosphorus.

Materials Handling Procedures

Soil salvage became an integral part of the materials handling program associated with the overall mining operation. Following the harvesting of merchantable timber, the soil overlying consolidated bedrock is removed in one lift in a manner whereby a minimum amount of coarse fragments are incorporated. Segregation or selective handling of soil materials is not considered because the surface or organo-mineral horizons are minimal or nonexistent. The soil materials are stockpiled for future use. Following the removal of overburden and coal, and the backfilling and grading, soil material is replaced on the spoil surface by scrapers or truck/caterpillar operations. Scrapers tend to allow for a more uniform depth of soil placement but they are limited by slope angle and they cause more severe compaction under moist conditions. Caterpillars are not as versatile, however, their tracks provide excellent seed germination sites.

Post-Mining (Reconstructed) Soils

The "reconstructed" soils that are developed do not duplicate the soils that existed under virgin conditions. The physical properties of the soils are the most drastically altered by the mining process. Soil structure is completely destroyed. Compaction by heavy equipment reduces pore space and makes the soils somewhat less pervious to water, roots and air. The silt loam texture combined with very low levels of organic matter results in a crusting problem which has a direct bearing on infiltration capacity and processes such as runoff and erosion. Infiltration tests indicated that the undisturbed or virgin

soils had considerably higher infiltration rates than the reconstructed soils.

The chemical properties of the soil are affected somewhat by the manipulation. The pH values increased by about one unit and the available macronutrient levels decreased as compared to the virgin soils. The reason for these changes is that during the soil salvage process it is inevitable that some of the parent material is incorporated with the soil material during salvage operations. The parent materials are generally higher in pH and have lower macronutrient levels than the soil sola.

The soils that are "reconstructed" following mining have some limitations but they are still the vital link to successful revegetation.

Vegetation Studies

The vegetation aspect of the study was initiated in May 1972 with the establishment of three study locations involving 60 individual 6 x 9 m plots to determine the suitability of 30 different agronomic grasses and legumes. Slopes ranged from 0 to 40 degrees. The grasses and legumes were utilized to provide an initial quick cover to minimize erosion. 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 concern relative to utilization of native species was addressed early in the study. It had been suggested that native species be utilized because animals prefer them, that less maintenance is required after establishment and that natives are more aesthetically pleasing. Realistically, however, in 1972 there was very little "native" seed available. Consequently, seed from loco-weed (*Oxytropis* spp.), Alpine hedysarum (*Hedysarum alpinum*), lupine (*Lupinus* spp.) and Hairŷ wildrye (*Elymus innovatus*) was collected in the undisturbed portions of the mine area and subsequently cleaned and planted.

The native species issue was also approached from the standpoint of introducing trees and shrubs relative to meeting the objective of establishing a long term cover that is in harmony with the surrounding area. A major problem was encountered in that seedlings appropriate for planting above an elevation of 1100 m were unavailable. Consequently, a cone collection program was undertaken and greenhouse space acquired to rear lodgepole pine (*Pinus contorta* var. *lotifolia*), engelmann spruce (*Picea engelmannii*) and white spruce (*Picea glauca*). Different sizes and types 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.

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 the cuttings of willow.

During the first five years of the study approximately 16000 conifer seedlings and 2000 shrub and deciduous tree cuttings were planted in areas that had an established cover of agronomic grasses and legumes.

Experimental work relative to establishment of vegetation on steep slopes involved the use of surface amendments such as burlap, leno-mesh and liquid plastic sprays.

RESULTS AND DISCUSSION

Suitability of Agronomics

Most of the agronomics that were planted initially, survived and continue to thrive. Many of the species produced and dropped viable seed. There was some concern at the outset that legumes, and in particular alfalfa, would not adapt or survive at the elevations involved in this study. It was observed that with time, and the withholding of fertilizers, alfalfa increased its share of the ground cover while the grasses, which comprised a major portion of the initial cover, declined in vigor. Annual observations and assessment of growth resulted in the development of a number of recommended seed mixtures and seeding rates appropriate for different slope aspects (moisture regimes) and time of year of planting. It was determined that spring seeding is superior to fall seeding for a number of reasons, the major one being that legumes, which should be included in the cover established, perform much better when seeded in the spring.

Utilization of Fertilizers

As indicated previously, the available nutrient levels of the undisturbed and reconstructed soils was quite low. The grasses and legumes showed a marked response to the application of fertilizers to the extent that fertilized plots produced 10 to 20 times more dry matter than the unfertilized plots.

In response to the initial results obtained, fears were expressed that large applications of fertilizer would be required annually to maintain the established cover. Furthermore, it was suggested that the vegetation cover established was too lush and would preclude invasion by natives and that resultant dead plant material would create a fire hazard in spring. The dead plant material probably does present

a fire hazard but it is also useful from the standpoint of improving the organic matter status of the reconstructed soil.

In response to these concerns, recommendations relative to the fertilization and refertilization including timing, type of fertilizer and rate were developed on the basis of 10 years of observations. For example, areas that are seeded to grass mixtures are likely to require refertilization every three years after establishment. Areas where legumes such as alfalfa are included in the vegetation cover can be left for five years and longer without refertilization.

Success with Native Species

Results indicated that some of the native grasses and legumes had relatively low germination rates. For example, the germination rate for loco-weed was 70 percent, whereas that of alpine hedysarum was 15 percent. It was observed that establishment of a viable erosion control cover utilizing natives took at least two years longer than it did when agronomics were used. Despite some of the limitations associated with utilizing natives, the species used in this study are considered appropriate for large scale use. The major concern relates to the acquisition of an adequate seed supply.

It was noted also, that native species such as lupine and oxytropis naturally invaded the areas initially seeded to agronomics. The encroachment by natives is the result of seed spreading from adjacent undisturbed areas and/or the result of incorporation of seed during the soil salvage operation and the resultant germination after soil replacement.

Relatively good success was achieved in terms of tree and shrub establishment. It was shown that trees and shrubs will thrive in areas initially seeded to grasses and legumes. This practice was questioned initially because of the anticipated competition for moisture. It was found 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.

Since seedlings of different ages and methods of propagation were planted during five different years a general summary of survival rates is presented:

- 1) engelmann spruce survival rate - 65%;
- 2) lodgepole pine survival rate - 50%;

- 3) rooted willow and balsam cutting survival rate - 65%;
- 4) direct planted willow cutting survival rate - 40%.

It was noted that container grown conifer seedlings are superior to bare root stock in terms of survival and growth rate and that the larger size containers promoted higher survival rates.

Unfortunately some problems were encountered relative to seedling mortality. Upon investigation of some of the seedlings that had expired, it became apparent that the upper root mass surrounded by the peat from the original container was exposed at the soil surface. This exposure is likely the result of frost heaving.

Utilization of Reclaimed Areas by Wildlife

During the initial stages of the study it was suggested that most wild-life species would not utilize reclaimed areas especially those where agronomic grasses and legumes were utilized. Bighorn sheep initially inhabited the experimental areas only in spring because the plots greened up earlier than their native range. Presently, they stay within the reclaimed area throughout the growing season, selectively grazing particular species such as alpine bluegrass, creeping foxtail, hard fescue and to some extent the tender shoots of alfalfa.

Revegetation of Steeply Sloping Areas

Surface amending materials including burlap, leno-mesh, and liquid plastics all produced positive results despite some problems encountered during plot establishment. The major drawback regarding their use is that they are too costly to implement on a large scale.

It was observed that slopes of approximately 30 degrees could be revegetated and maintained without surface amending materials if appropriate engineering techniques were employed during spoil dump development and grading. Severe erosion can and will occur if runoff is allowed to collect or build up at the top of a slope. A solution to the problem is to install adequate drainage to handle the runoff which reaches the top of long downward sloping areas.

Transfer of Research Results to Operational Scale

The results of the experimental work were applied on a large scale early in the project; revegetation of major areas began in the fall of 1973, 16 months after the inception of experimental work. Seed mixtures and fertilizer applications were based on results available at that time

and have been upgraded annually as more information became available. It was determined that hand broadcast of seed and fertilizer was more effective and had a higher cost-benefit ratio when compared to hydro-seeding and helicopter seeding. One troublesome aspect of going to the large scale involved that of incorporating the seed by roughening or scarifying the surface following the broadcast application. On a plot scale this was accomplished by hand raking, whereas for the large scale, several designs of a "drag" were prepared before one was built which was both suitable and adequately sturdy.

CONCLUSIONS

Time is a major consideration when one conducts any facet of research and assesses the results thereof. This is particularly true for reclamation research. It takes time to re-establish diverse vegetation communities just as it takes time for soil processes to become functional again in the reconstructed soils. One must also remember that nature works more slowly in the type of area described by this study.

It seems appropriate to suggest, however, that with a good research effort and some patience, most reclamation problems can be successfully resolved.

REFERENCES

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