ABSTRACT

"OVER TWENTY YEARS OF RECLAMATION AT THE FORDING RIVERMINE"

The reclamation research accomplished at the Fording River minesite over the previous twenty years has made a substantial contribution to the development of mine reclamation technology in the province of British Columbia. This paper presents the evolution of this research from the pre-production studies to the present land use objective studies and also describes how this technology is successfully applied at our mine where waste dumps and disturbed land are restored to productive commercial forest and wildlife habitat.

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Proceedings of the 16th Annual British Columbia Mine Reclamation Symposium in Smithers, BC, 1992.
The Technical and Research Committee on Reclamation

OVER TWENTY YEARS OF RECLAMATION AT THE FORDING RIVER MINE

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Mining disturbs the land temporarily: Reclamation returns the land back to productive forests and wildlife range while reclamation research provides the tools to do the job.

INTRODUCTION

When plans to mine coal in the Fording River valley became public, little was known about surface mine reclamation in mountainous terrain typical of south-east British Columbia. Important environmental issues were raised by a concerned public. The mining company's inexperience with reclamation under the difficult conditions encountered in the Fording Valley increased the fear of serious environmental damage. The need to develop cost-effective measures to stabilize waste dumps, protect local watercourses and restore the forest resource and critical wildlife habitat was evident. Fording Coal Limited was committed to meet the challenge and has! Research conducted at the Fording River mine over the past 20 years (1969 - 1990) has made a substantial contribution to the development of mine reclamation technology in British Columbia. This technology is successfully applied at our mine where waste dumps and disturbed land are restored to productive commercial forest and wildlife habitat.

ENVIRONMENTAL CONCERNS AND RECLAMATION ISSUES

During the mine planning stage, waste dump stability, acid mine drainage, sedimentation of watercourses, loss of fish and wildlife habitat (in particular winter range), and loss of the forest resource were important environmental concerns. Measures proposed to protect local water and land resources include design and construction of diversion ditches and sediment ponds and establishment of vegetation to stabilize waste dump slopes and provide forage and browse to sustain wildlife. Reestablishing commercial forest and both summer and winter wildlife range were long term reclamation objectives.

Surface mine reclamation experience specific to developing coal mines in the region was non-existent in 1969. The type of vegetation and cultural practices required to achieve immediate and long term reclamation objectives were unknown. Indigenous "colonizing" plants were recommended, but seed and planting stock were not available commercially. Use of commercially available "agronomic" plants was widely criticized because of perceived high nutrient requirements and dependence on fertilizer to sustain growth. To increase waste dump stability and improve conditions for vegetation establishment, the regrading of slopes to the "biological" angle of repose and covering them with "soil" saved during pit and spoil area development were strongly

recommended. Such site preparation measures added substantially to the cost of mining and were considered impractical due to scarcity of soil material and limited space available for spoil disposal.

EVOLUTION OF RECLAMATION RESEARCH

The evolution of reclamation research was influenced, not only by immediate and long term reclamation objectives, but also by the availability of waste dumps with appropriate physiographic features and of sufficient "life expectancy" to enable assessment of the effects of time. The program evolved through four phases including:

- Pre-production: 1969 to 1973
- Short-term waste dump studies: 1973 to 1977
- Long-term waste dump studies: 1977 to present
- Specific land use studies: 1980 to present

PREPRODUCTION STUDIES

During the pre-production phase, research addressed the most immediate concerns related to the use of vegetation to:

- control erosion on waste dump slopes and land disturbed by exploration and construction
- provide forage and browse for wildlife, and
- maintain the aesthetics of the Fording River valley.

Laboratory, growth room and field study techniques were used to:

- characterize the chemical and physical properties of waste dumps and tailings
- identify plant growth limiting factors and develop appropriate mitigative measures
- identify plants capable of sustaining growth over the range of elevations and aspects encountered within the mine area
- develop effective cultural practices for establishing and sustaining vegetation on waste dumps and disturbed land -
- monitor vegetation diversity, productivity and quality, as impacted by discontinuation of maintenance fertilizer and time.

Investigations were initiated in 1969, three years before mine production would begin and before waste dumps were available for on site assessment. The suitability of waste dumps as a plant growth medium was assessed in the growth room using crushed drill core material (Figure 1). The capability of agronomic grass and legume species to grow and reproduce at elevations eventually encountered on waste dumps was initially assessed in field plots established on Turnbull Mountain (Figure 2). Grass-legume

specie mixes, seeding rates, seeding dates and fertilizer-recommendations for reclamation of land disturbed during exploration and construction were developed and applied (Figures 3, 4).

SHORT-TERM WASTE DUMP STUDIES

The information developed during the pre-production phase provided the basis for designing field studies established on temporary waste dump sites available for the first time in 1973. Selected grass and legume species, plus indigenous and introduced woody plant species were planted on Greenhills (1700m) and Eagle (2100m) waste dumps, on level sites and on steep slopes (Figure 5). The effect of alternative cultural practices on vegetation establishment, species composition and productivity were monitored over the next four growing seasons.

A significant result of these short term studies concluded that:

- A satisfactory vegetative cover could be established and sustained through four growing seasons on high and low elevation waste dumps.

LONG TERM WASTE DUMP STUDIES

Spoil sites suitable for assessing slope steepness and "soil" cover effects on vegetation establishment and productivity were developed between 1976 and 1978. Completed sections of Greenhiils and Turnbull spoil were regraded to slope angles ranging from 26°, (the "biological" angle of repose), up to 32° (Figure 6). At the Greenhills site, part of each slope steepness treatment was covered with 30cm of glacial till (Figure 7). During this period, studies were initiated on low (1700m) and high (2100m) elevation spoils. This enabled long-term assessment of relative productivity of self-sustaining vegetation dominated by nitrogen-fixing legumes on waste dumps and glacial till covering waste dumps. Legume specie, seed rate, seeding date as well as well as fertilizer requirements for maximum organic matter and organic nitrogen production and fertilizer use were investigated.

Intensively monitored for more than 10 years, the studies conclusively demonstrated that:

- legume dominated vegetation will establish and sustain growth on waste dumps over the range of elevations and aspects expected within the mine site (Figure 8)
- only modest quantities of nitrogen and phosphorus fertilizer are required to aid legume and grass seedling establishment
- legume-dominated vegetation adds large quantities of organic matter, i.e. 32.5 tonne/ha and organic nitrogen, i.e. 899 kg/ha to a waste dump over time, i.e. 11 years
- vegetation and acceptable diversity and productivity can establish and sustain

growth on steep spoil slopes up to 37° (Figure 9), without the addition of maintenance fertilizer applications

- covering waste dumps with "soil" (glacial till overburden) did not improve productivity of legume-dominated vegetation, i.e. 31.8 tonne/ha compared to 32.5 tonne/ha over 11 years on waste dumps. Consequently, saving soil during pit development for the purpose of reclamation is not required.

SPECIFIC LAND USE STUDIES

Since 1980 research emphasis has been on development of technology for rehabilitating waste dumps to productive forest and ungulate range. Initiation of this phase of the program was dependent upon availability of completed spoil piles with appropriate elevation, aspect and slope steepness.

AFFORESTATION RESEARCH

Greenhills, Turnbull and Eagle experimental sites were suitable for investigating afforestation of vegetated waste dumps. Afforestation studies on unvegetated waste dumps were initiated in 1986 following completion of a major resloping study on South Greenhills "C" spoil (Figure 10). In 1979 greenhouse and latthouse facilities were developed on the mine site for propagation of conifer seedlings to be used for waste dump afforestation (Figure 11).

Afforestation research is an on-going program with investigations related to propagation of high quality planting stock. This progresses in parallel with field studies directed toward development of cost-effective techniques for planting and growth improvement. Use of quality seed collected at the mine, modification of the greenhouse atmosphere, effective fertilization and selection of appropriate sized containers have resulted in production of quality spruce and pine seedings capable of high survival rates on unvegetated waste dump slopes (Figure 12). The mean survival rate for Engelemann spruce planted on waste dumps is 80 percent four (4) years after planting. Likewise, Lodgepole pine's mean survival rate is greater than 90 percent three (3) years after planting.

Seeding legumes or forage the same year as planting spruce and pine reduced survival rates to 40 percent and 20 percent, respectively. Consequently, the procedure is to plant trees on bare spoil and delay seeding of grasses or legumes several years until trees are well established. Power augering and planting through the entire frost-free season are being investigated as techniques for improving planting crew efficiency on these difficult planting sites. Use of fertilizerand combined planting with N-fixing legumes are being assessed as techniques for improving seedling and juvenile growth on waste dumps (Figure 13). Survival and growth rates are monitored regularly (Figure 14). Age-height relationship curves are being developed as a means of comparing productivity on waste dump slopes with that of logged natural forest sites in the Fording Valley.

ELK WINTER RANGE ESTABLISHMENT

Ungulates are the major wildlife resource in the vicinity of the Fording River mine. Elk are the most abundant and are year-round residents (Figure 15). The lack of winter range is the limiting factor for elk population. Comparatively, there is abundant summer range. Therefore, the Fording River Operations research efforts are focused on providing good quality winter range. South slopes of Eagle and Turnbull mountains are important winter-spring range for elk and have been studied by use of enclosures (Figure 16). Areas of Class 3 winter range on Eagle Mountain will be disturbed by mining during the 1990s. Investigations were initiated in 1985 to develop the technology necessary to rehabilitate waste dump slopes with appropriate elevation, aspect and steepness to elk winter range.

Literature and field surveys have provided useful background information on elk population, movement and habitat relationships in the vicinity of Eagle and Turnbull Mountains as well as on food habits and preferred food species in winter diets. Physiographic features, floristic composition and productivity indices have been determined for dry and wet grassland components of winter range on Turnbull Mountain. (Figure 16). Structural composition, nutritional quality and mineral element content of indigenous forage species were determined using accepted analytical methods. Use of fertilizer to enhance productivity and quality of winter range was assessed on a mesic grassland on Turnbull Mountain. Productivity and nutritional quality of native and naturalized plant species classed as preferred food species in elk winter diets are in the early stage of assessment on south and south westerly slopes of "C" spoil and Clode "2" spoil experimental sites (Figure 17).

A major component of elk winter range studies is the propagation and assessment of thirteen woody plant species identified during field surveys as important browse species (Figure 18). These browse species were planted in the fall of 1990 on 2 Spoil, a potential winter range site. Survival, productivity and nutritional quality of forge and browse species growing on spoil will be monitored throughout the 1990's.

OPERATIONAL RECLAMATION

Operational reclamation and reclamation research have been well integrated into the mining plans of the Fording River Operation since its inception. For the past twenty years research conducted on site at the Fording River Mine has made an important contribution to the development of mine reclamation technology in British Columbia. Operational reclamation has been conducted within the guidelines determined by the research programs. The earlier reclamation programs were restricted to mostly construction disturbances. They have evolved to the full scale spoil resloping and vegetation programs existing today, with emphasis on long term end land use and productivity objectives.

PROPAGATION FACILITIES

Seed collection for both coniferous and deciduous tree and shrub species is carried out from local sources at the minesite (Figure 19). These seeds are propagated in the onsite greenhouse which has outside dimensions of 10 meters by 18 meters. To date, Fording Coal Limited has grown over 400,000 seedlings in this facility. A latthouse (Figure 20) for overwintering greenhouse stock is used in conjunction with the greenhouse. There is also a cooler facility where seedlings are kept dormant in spring until they are planted on resloped waste dumps.

SITE PREPARATION

In order to establish satisfactory forestry end land use, it is preferable to reslope spoils from the natural angle of repose of 37° to an angle of 28°. This is accomplished using dozers incorporating a horizontal cut method of resloping (Figure 21). After the resloping of a spoil is complete it is planted with seedlings. Due to the coarseness of the material a power driven auger is used to drill holes in which the seedlings are planted. (Figures 22 & 23). Over 350,000 coniferous and deciduous seedlings have been planted at the Fording River Minesite between 1979 and 1990.

REVEGETATION

In addition to tree planting, other methods of revegetating resloped spoils are used such as helicopter seeding and fertilizing (Figure 24), hand seeding and fertilizing (Figure 25) or hydroseeding (Figure 26) for wildlife end land use. To date, approximately 220 hectares of area disturbed by mining have been reclaimed using these methods.

EXPLORATION RECLAMATION

The Environmental services group works jointly with the Geology department in the layout of exploration roads that access the drillsite locations. Roads are designed to minimize impact on wildlife habitat and water courses. The roads are designed with a maximum grade of eight percent. If the area will not be explored again in the near future, these roads are reclaimed to conform with the natural landscape. If the area is to be used again the roads are ditched and water-barred to control erosion. To date, 80 hectares of exploration disturbances have been reclaimed. Figure 27 shows an example of a reclaimed exploration road.

LONG TERM RECLAMATION PLAN

The long term reclamation goals for the Fording River minesite are to progressively reclaim the disturbed areas as they become dormant and available for reclamation. The current thirty-year reclamation plan proposes to achieve this by reclaiming up to fifty hectares of waste dumps and planting approximately 30,000 seedlings on an annual basis. Research and operational reclamation will continue to be an integral part of the mining operation. To date, Fording Coal Limited's reclamation successes have shown we can meet the challenge of restoring disturbed land back to useful forests and wildlife habitat.