ECONOMIC AND BIOLOGICAL FEASIBILITY OF NATIVE PLANTS FOR LAND RECLAMATION IN WESTERN CANADA

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INTRODUCTION

The feasibility of using native plants for land reclamation should be addressed from both a biological and an economic perspective. For a species to be biologically feasible for use in reclamation it must be readily propagated. Propagation from seed can involve various methods of dormancy breaking while propagation from cuttings usually involves hormone treatments. Once growth is established through rooting or germination, favourable heat, light, moisture and soil conditions must be provided in the nursery to promote rapid growth.

For native plants to be economically feasible, the long run costs must be less than or equal to alternate methods of reclamation, or they must provide a greater benefit for their increased cost. The direct comparison of costs between reclamation methods is complicated by the difficulties of assessing the cost benefit of the end land use.

The use of native trees and shrubs in reclamation increases the wildlife habitat value of the land. In general shrubs are higher in crude protein, phosphorus and calcium than grasses and forbs. Trees and shrubs also maintain their nutritive value throughout the growing season and in many cases are critical for wildlife survival in snow covered winter ranges. They also provide more diversity of habitat than those sites reclaimed with only agronomic species.

The aesthetics of reclaimed sites is enhanced by the planting of trees and shrubs. This is especially important in areas of high public visibility. In these areas trees can provide screening and buffer zones which cannot be accomplished through the use of a grass and legume cover.

In many cases native trees and shrubs are better adapted to harsh sites than agronomic species. Native species usually establish quicker and provide much deeper rooting and thus better erosion control than an agronomic cover.

A summary of the criteria for selection of woody species for reclamation purposes is shown in Table 1.

PROPAGATION

Propagation by Seed

The seeds of most species from northern climates exhibit varying degrees of physical and physiological dormancy which must be overcome to achieve successful germination.

Physiological dormancy is related to the physiological conditions of the anatomically mature seed (Krugman *et al.*, 1974). This dormancy can be due to chemical germination inhibitors, restricted respiration, changing levels of enzyme activities or a variety of other underlying causes.

Physical dormancy is due to morphological conditions of the

Table 1: Selection Criteria for Woody Species Used in Reclamation (from Sherlock, 1983).

Criteria	Comments
1. Native/Naturalized	Adapted to local climate Adapted to wide range of sites
2. Pioneer species	
3. Success on other sites	
4. Rapid juvenile growth	Rapid initial ground cover
5. Provide food and cover for wildlife	
6. Withstand browsing and grazing	
7. Ease of propagation	Produce on commercial scale
8. Commercial value	Value as forest products
9. Nitrogen fixing ability	
10. Contributes to end land use	
11. Disease and pest resistant	

seed which prevent germination (Krugman *et al.*, 1974). The most common reasons for physical dormancy are immature embryos, hard seed coats, or some structure such as an endocarp which prevents germination (Krugman *et al.*, 1974).

Methods of Dormancy Breaking

The most common and efficient method of breaking dormancy due to hard seed coats is immersion of the seed for varying lengths of time in concentrated sulfuric acid. The length of time is based on the thickness of the seed coat, which must be constantly monitored to ensure that embryo damage does not occur.

The usual method for overcoming physiological dormancy is through the use of varying types of stratification. Stratification is normally carried out by pre-soaking the seed for 24 hours in water then placing the seed in cold storage at 2 to 3 $^{\circ}$C for periods of several days up to six months. The seed is usually placed in a medium, such as peat or sand, to maintain high moisture levels. Alternatively, naked stratification may be used which requires much closer monitoring of moisture levels. Additionally, some species such as *Rosa acicularis* require a period of warm stratification followed by a period of cold stratification. The method for warm stratification is similar to cold stratification except temperatures are maintained at 20 to 25 $^{\circ}$C.

Table 2 shows a number of native species and their germination success with various stratification procedures.

Vegetative Propagation

Several species of trees and shrubs propagate easily from both hardwood and softwood cuttings. In some genera such as *Salix* and *Populus*, cuttings are the preferred method of propagation. In general, cuttings must be treated with a root stimulating hormone, usually indolyl-butyric acid, although occasionally indolyl-acetic acid based compounds are used. For efficient rooting of most species bottom heat is required at 18 to 20 $^{\circ}$C. With softwood cuttings, overhead misting or fogging is necessary until substantial rooting has taken place. Table 3 shows the rooting results of several species propagated from softwood and hardwood cuttings.

Growth Media

Species used in reclamation originate in a variety of different climates and have different nutrient and pH requirements. For these reasons greenhouse conditions and growth media must be modified to suit the individual species.

In general the logistics and economics of growing plants on a large commercial scale necessitate the division of plants into wet or dry climates and acidic or basic soils.

In most cases the drybelt species also require higher pH media and the wetbelt species require lower pH media. The growth

Table 2: Effectiveness of Seed Pretreatments on Various Native Species

Species	Treatment	% Germination
Alnus crispa	21 d CS	70 - 90
Amelanchier alnifolia	90 d CS	80 - 90
Artemesia tridentata	120 d CS	50 - 60
Arctostaphylos uva-ursi	1 hr. A, 90 d CS	45 - 60
Cornus stolonifera	90 d CS	80 - 90
Eleagnus commutata	120 d CS	80 - 90
Juniperus communis	2 yr. Alt. WS & CS	50 - 60
Penstemon fruticosus	120 d CS	40 - 50
Potentilla fruticosa	90 d CS	75 - 85
Prunus virginiana	30 d WS 90 d CS	60 - 70
Rosa acicularis	60 d WS 60 d CS	70 - 80
Rosa woodsii	60 d WS 60 d CS	70 - 80
Shepherdia canadensis	5-7 min. A, 10 d CS	80 - 90

Abbreviations:

A: Acid scarification, soaking seed in concentrated sulfuric acid

CS: 24 hour soak in water followed by storage at 2 to 3 ^{o}C

WS: 24 hour soak in water followed by storage at 20 to 25 ^{o}C

Table 3: Success in Rooting of Various Species Propagated by Vegetative Means

Species	Cutting	Treatment	Rooting %
Amelanchier alnifolia	H or S	#2 and #3	2 - 5
Cornus stolonifera	H	#2	75 - 80
Cornus stolonifera	S	None	85 - 90
Juniperus communis	H or S	#2 and #3	50 - 60
Populus sp.	H	None	90 - 95
Rosa acicularis	S	#1	90 - 95
Salix sp.	H	None	90 - 98

Abbreviations:

H: hardwood cutting
S: softwood cutting
#1: 0.2% IBA rooting powder
#2: 0.4% IBA rooting powder
#3: 0.8% IBA rooting powder

media is therefore relatively constant except for the addition or deletion of lime to adjust for pH. The majority of growing media are based on a combination of sterilized peat, vermiculite, perlite, micronutrients, slow release fertilizer, and lime.

RESULTS OF RECLAMATION RESEARCH WITH NATIVE PLANTS

Results of reclamation research trials of native plant species are presented from three mines in Western Canada. These mines occur in widely different climates and produce quite different types of waste materials. Lornex Mining Corporation Ltd. operates an open pit copper and molybdenum mine located in the south-central interior of British Columbia, approximately 80 km south-west of Kamloops. It is located in the Ponderosa Pine and Douglas Fir section of the Montane Forest Region (Rowe, 1972). Suncor Limited is an oil sand mine located in north central Alberta, approximately 40 km north of Ft. McMurray. This mine occurs in the northern portion of the Mixedwood section of the Boreal Forest Region (Rowe, 1972). Pine Point is a lead and zinc open pit mine operated by Cominco Ltd. in the Northwest Territories. The mine is located in the Upper Mackenzie Section of the Boreal Forest Region (Rowe, 1972), approximately 80 km east of Hay River.

In our experience in reclamation with native species, each mining area has significantly different site conditions which require an initial research phase to determine species suitability. The definition of suitable candidate species is often followed with further research into methods of site preparation and planting stock. Research results from a selection of mines is presented here to better illustrate this progression in reclamation research programs.

Lornex

Native plant studies were intiated in 1983 for use in reclaiming both waste rock and tailings materials. An assessment of vegetation colonizing natural coarse rock slopes in the area led to the development of a list of candidate species for the waste rock trials. Natural sites comparable to the tailings deposit were not available for assessment and therefore species were selected for use in the tailings trials based on experience with other tailings deposits, laboratory analysis of the materials and a knowledge of the regional plant communities.

Trials were planted in 1984, in a completely randomized plot design. Ten seedlings comprised one plot and each plot was replicated three times. Table 4 presents the percent survival after one year of each of the nine species planted in the waste rock trials. Two trial areas were established on waste rock and the values in this table represent mean survival from the two areas. Results of the survival of eleven species planted in the tailings trial are given in Table 5.

These results indicate that a shrub community could be established on both the waste rock and the tailings materials. Some species, such as *Salix* spp., *Artemesia tridentata* and *Rosa*

Table 4: Survival of Native Species Planted in Waste Rock at Lornex Mines.

Species	Survival (%)
Salix spp.	98
Rosa spp.	83
Artemesia tridentata	80
Clematis ligustifolia	75
Amelanchier alnifolia	63
Arctostaphylos uva-ursi	55
Shepherdia canadensis	38
Potentilla fruticosa	35
Pinus contorta	25

Table 5: Survival of Native Species Planted in Tailings at Lornex Mines

Species	Survival (%)
Salix spp.	90
Eleagnus commutata	87
Artemesia tridentata	66
Pinus contorta	63
Rosa spp.	56
Arctostaphylos uva-ursi	43
Potentilla fruticosa	33
Penstemon fruticosus	30
Shepherdia canadensis	17
Clematis ligustifolia	10
Amelanchier alnifolia	7

spp. are suitable candidates for both the waste rock and tailings areas, while others such as *Amelanchier alnifolia* and *Pinus contorta* were much more successful on waste rock than on tailings. Species with low survival values will not be considered in further trials.

Once an initial screening of candidate species is complete, efforts are concentrated on defining the site treatments most suitable for native plant establishment and growth. One consideration is the effect of competition for moisture and nutrients between the seedlings and a grass and legume ground cover. At Lornex Mines, two trials have been established to assess the effect of this competition.

On the tailings, a trial of five species was planted into areas of established agronomic cover and into bare tailings. The experimental design was similar to that described previously. Results of this trial are presented in Figure 1. Some species, such as *Artemisia tridentata* and *Rosa acicularis* were found to have increased survival rates when planted with a ground cover. The other species experienced the opposite effect and had reduced survival rates when in competition with an agronomic cover.

The effect of competition from a grass and legume cover on *Pinus contorta* seedlings was tested on both waste rock and till covered waste. In this trial, ground cover was reduced by withholding maintenance fertilizer. Results of this trial, shown in Figure 2, demonstrate a different response to ground cover on the waste rock site as compared to the till covered site. In the waste rock, the survival of *Pinus contorta* seedlings was increased through reduction of ground cover. The till covered site experienced only a slight reduction of ground cover due to the lack of fertilizer application, however, the reduced nutrients may have negatively affected the percent survival of *Pinus contorta* seedlings. This suggests that on the waste rock, where moisture availability is critical, reduced plant competition can increase seedling survival. Others (Grossnickle and Reid, 1984), have found a grass cover on mine wastes in areas of high solar radiation and low soil moisture levels can reduce the soil moisture availability in the upper portion of the soil profile. This cover also increases the soil an air temperatures around the conifer seedlings, negatively affecting their establishment and growth.

Suncor:

Research at Suncor has assessed the survival of native species when grown in varying degrees of ground cover. The data presented here is a portion of a larger study which began at Suncor in 1980. Figure 3 presents the results of a trial in which six native tree and shrub species were planted into two ground cover treatments (McTavish and Shopik, 1983). Most species tested, *Populus balsamifera*, *Cornus stolonifera*, *Amelanchier alnifolia*, and *Potentilla fruticosa*, were found to respond negatively to a dense ground cover, however *Picea glauca* and *Prunus virginiana* had increased survival when planted into a dense cover. As a result of this trial and others, Suncor has concluded

FIGURE 1

EFFECT OF GROUND COVER ON

SPECIES SURVIVAL AT LORNEX TAILINGS

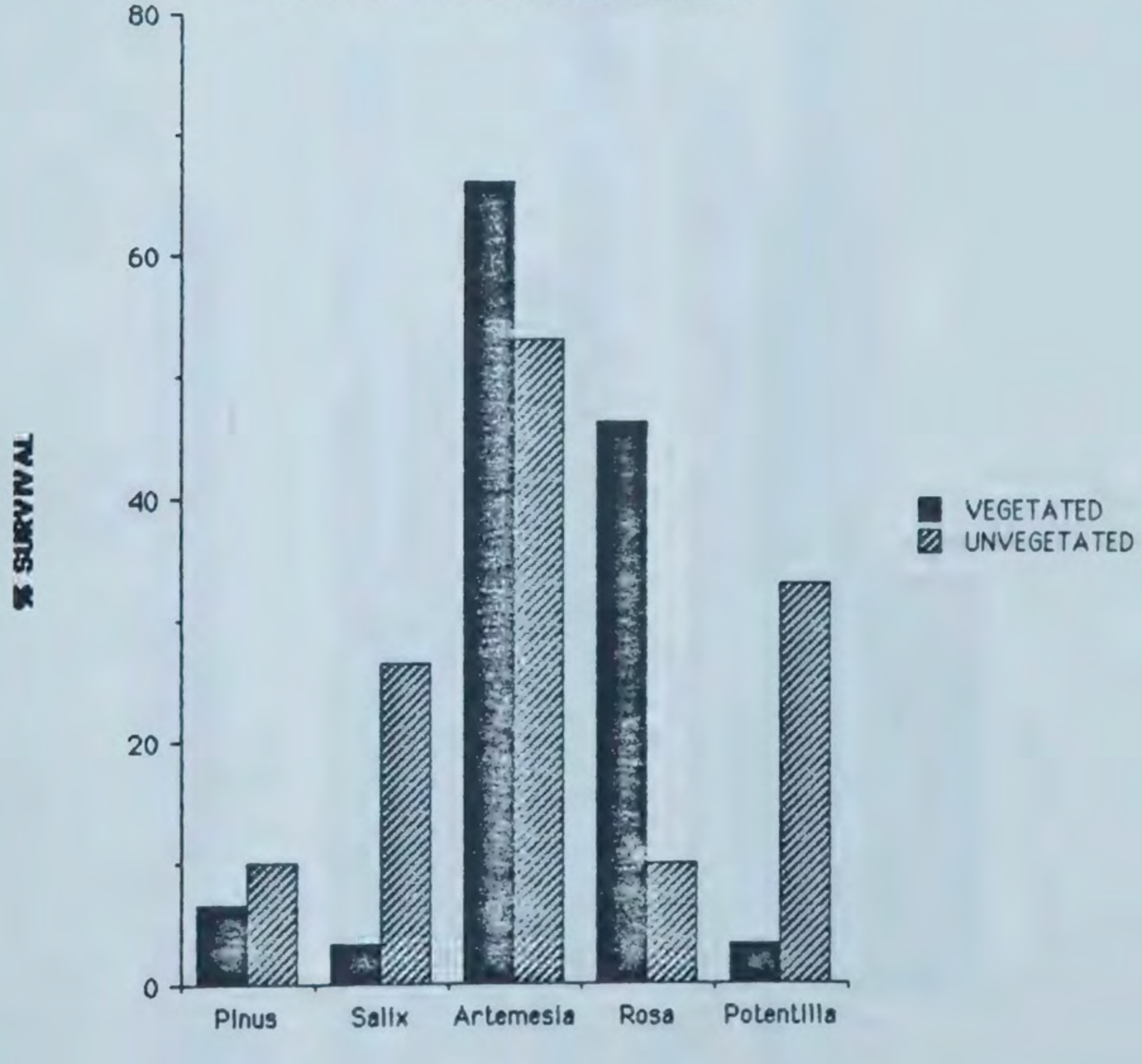


FIGURE 2

EFFECT OF GROUND COVER ON

PINUS CONTORTA SURVIVAL AT LORNEX

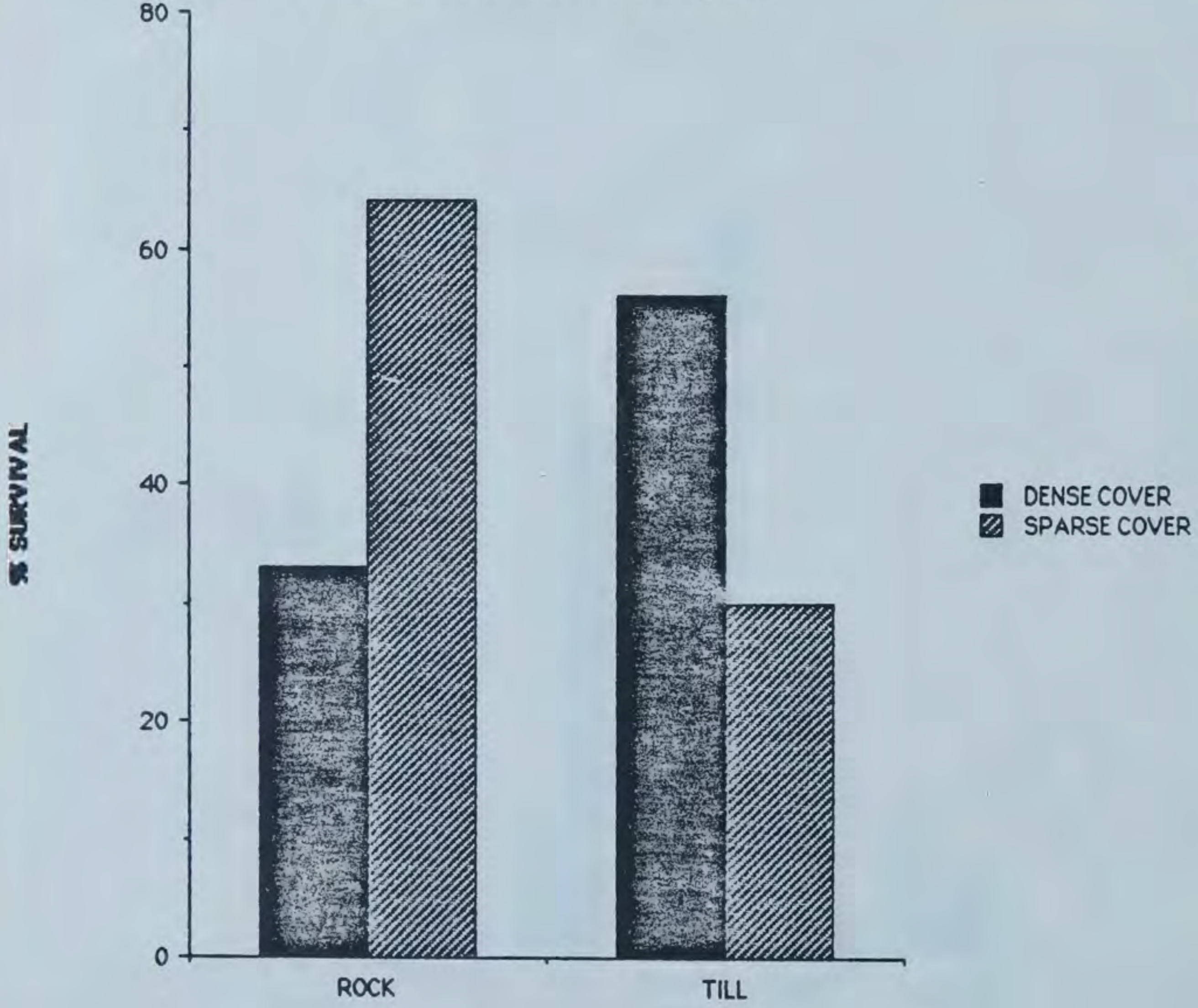
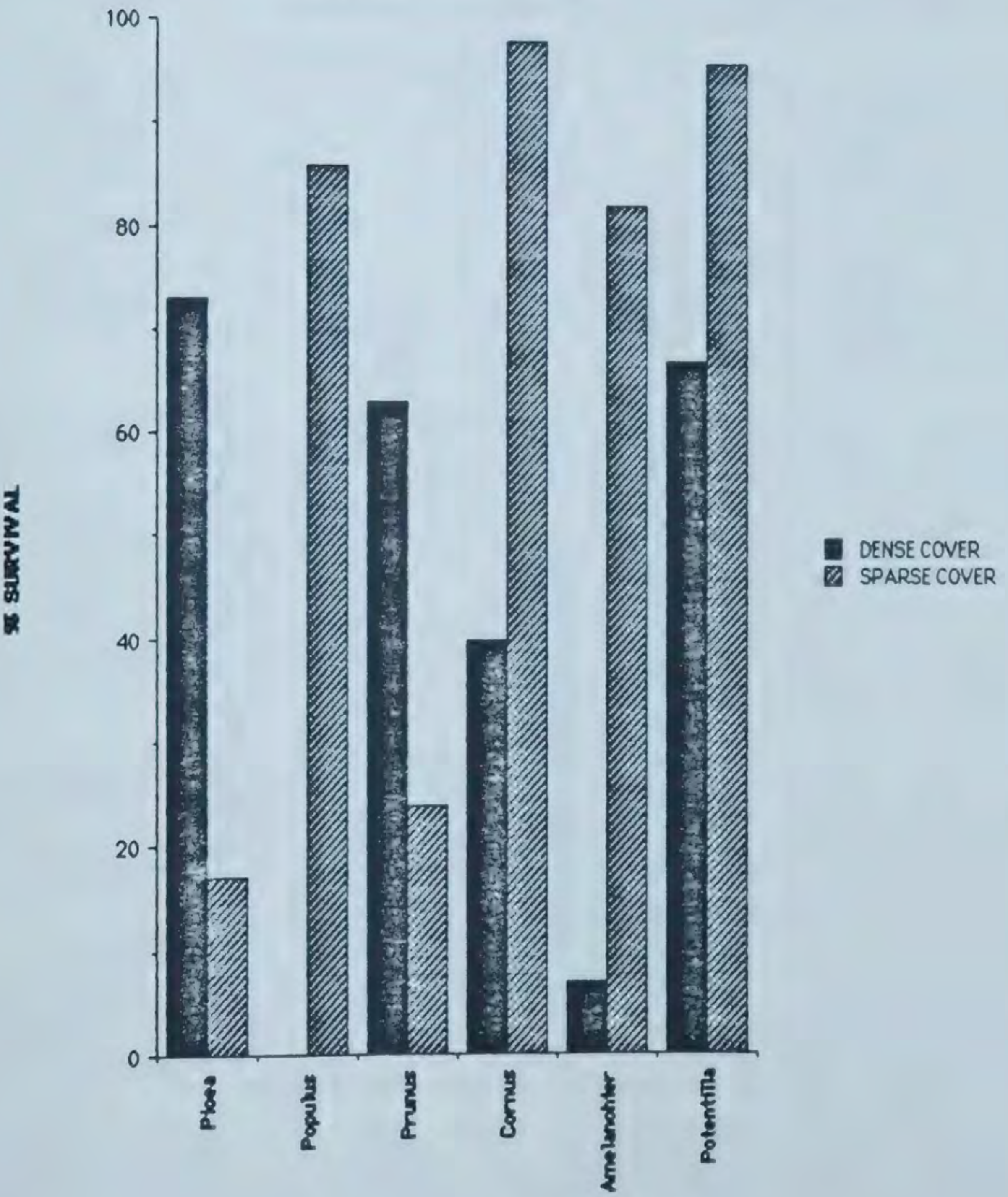


FIGURE 3

EFFECT OF GROUND COVER

ON SPECIES SURVIVAL AT SUNCOR



that for the best reclamation success at their minesite, woody species should be planted into a sparse ground cover (McTavish and Shopik, 1983).

Pine Point

At Pine Point, Mr. Bob Gardiner has established long term reclamation trials using native species. In addition to selection of candidate species and monitoring planting conditions, Gardiner has assessed the effect of seedling age and provenance on the percent survival of the native species.

In a long term trial on mine waste at Pine Point, Gardiner has compared the survival of seedlings planted at one and two years of age. Figure 4 presents the results of this trial, assessed six years after planting. Some species, *Rosa acicularis* and *Shepherdia canadensis* show little or no difference in survival between the two seedling ages. Others, *Populus tremuloides* and *Potentilla fruticosa* had much greater survival when planted at two years of age. This difference is due in part to the limited rooting which can be achieved in *Populus tremuloides* cuttings after one year of growth. Species which are slow to produce roots from cuttings are often grown on in the nursery for an additional year before planting on site.

In another trial, three species were grown from two seed sources, one collected from the locality of the Pine Point mine and the other source from Ft. McMurray, Alberta, approximately 550 km to the south. The species tested were *Rosa acicularis*, *Potentilla fruticosa*, and *Pinus banksiana*. The trial was established in September 1982 and the results presented in Figure 5 are of an assessment made in July, 1985. The results of this study indicate that the source or provenance of the seed does effect the survival of the seedlings, particularly of *Pinus banksiana*. The importance of seed provenance is well known in forestry applications and this study confirms its value in land reclamation.

The research projects discussed here give only a brief overview of some of the work in progress at many western Canadian minesites. They do however demonstrate the approach taken by many researchers in determining the most advantageous use of native plant species in site specific applications in mine reclamation.

COSTS ASSOCIATED WITH USE OF NATIVE PLANTS

The comparison of costs between reclamation methods is complicated by the difficulty in comparing end land use benefits. For this reason only the direct costs of planting under varying conditions are given in Table 6. No attempt is made to analyze the cost/benefit of different reclamation methods.

The cost comparisons are all based on planting Spencer Lemaire Hillson containers. Two methods are used for planting depending on the site, either an auger method or a mattock planting. The auger method utilizes four inch diameter carbide tipped augers mounted on chainsaw engines to drill holes for

FIGURE 4

EFFECT OF SEEDLING AGE ON

SPECIES SURVIVAL AT PINE POINT

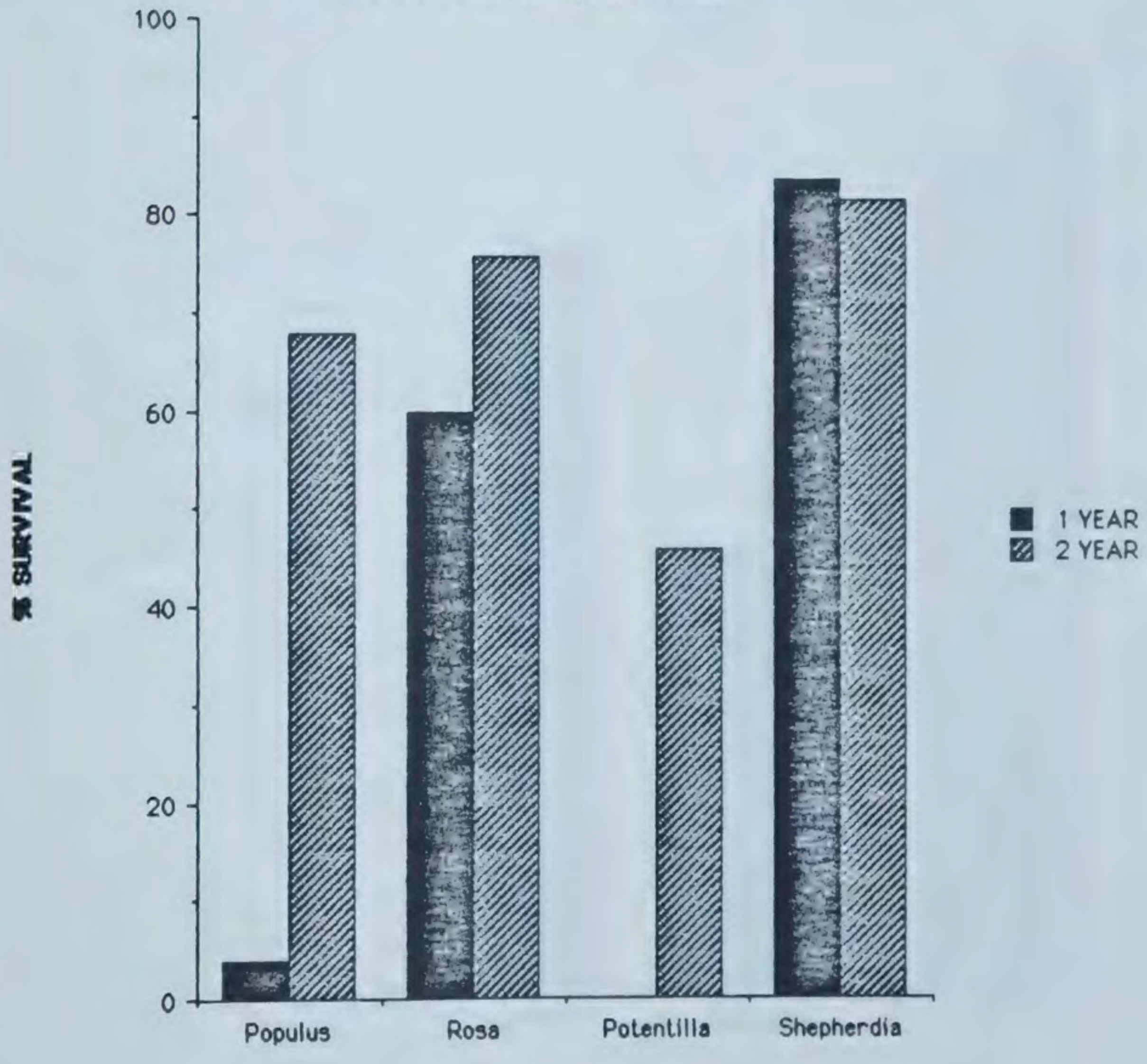


FIGURE 5

EFFECT OF PROVENANCE ON

SPECIES SURVIVAL AT PINE POINT

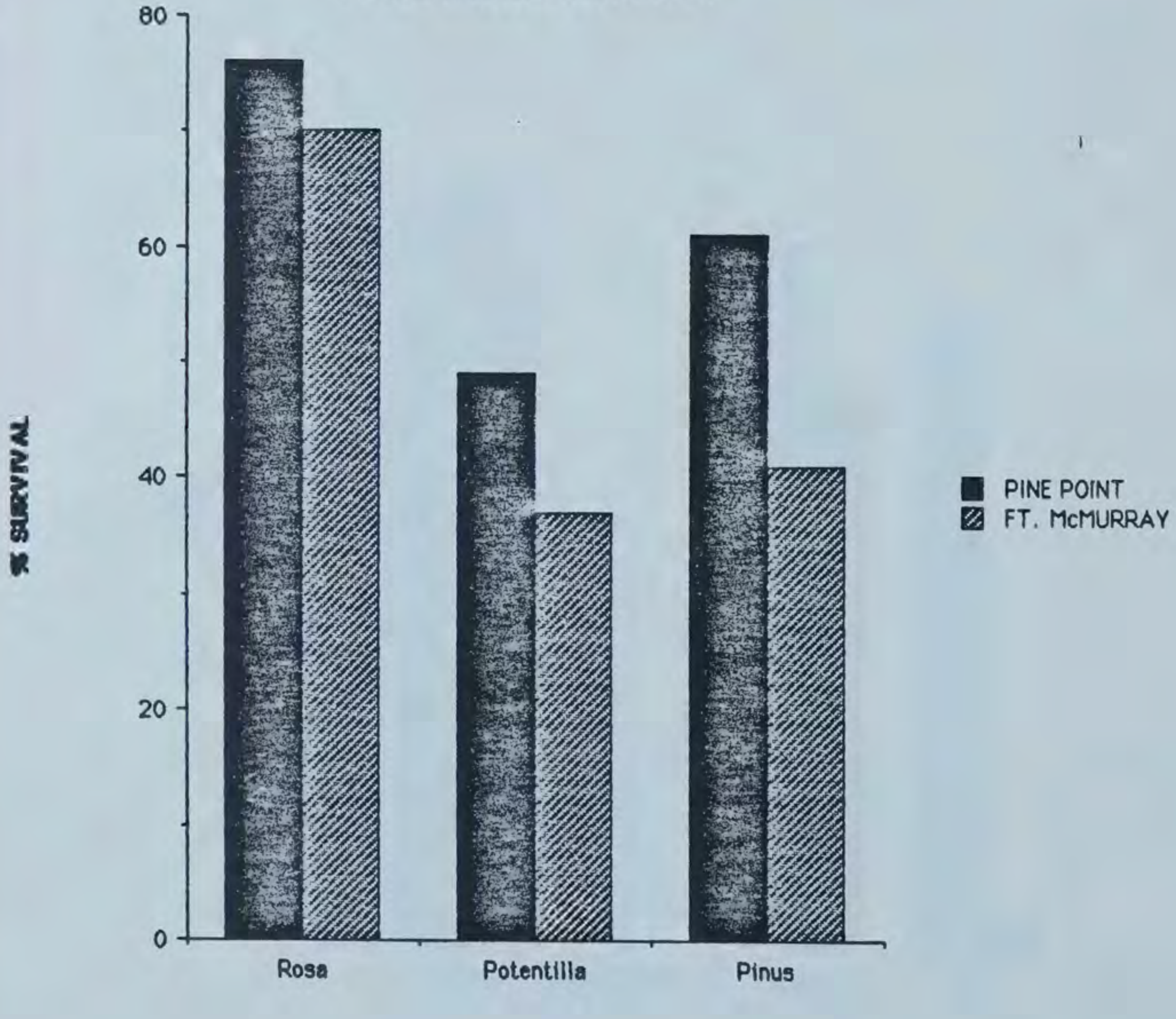


Table 6: Costs of Planting Woody Species on Various Sites

Reclamation Site	Planting Density 3000 stems/ha	Planting Density 6000 stems/ha
*Hard rock mines resloped waste rock	$2600	$5200
*Coal mines/Oil sands	$2010	$4020
*Road sides, slopes 2:1 or less	$1860	$3720
*Avalanche slopes steep road sides 1.5:1 or greater	$3200	$7300

All prices based on one year old seedlings in 10 cubic cm containers. Base price of $0.37 per seedling.

planting. The use of augers is particularly effective on coarse or compacted waste rock where traditional mattock planting methods are impossible or at best very difficult.

On hard rock mines with resloped waste rock the rate of planting can vary from three hundred to five hundred plants per day per person depending on site specific conditions. On coal mines and oil shales the sites are generally less coarse and compacted than on hard rock mines and therefore planting efficiency is improved. On these sites planting rates should vary from six hundred to eight hundred stems per man day. On road sides with reasonable slopes and soil conditions planting rates can vary between seven hundred and one thousand stems per man day. Our experience on extremely steep slopes such as avalanche tracks has indicated that planting efficiency can drop to two hundred to three hundred stems per man day.

In general, to determine the cost of the installation of plant material, the density of planting, site specific soil and slope conditions and on-site transportation logistics must all be considered. In addition the cost of the supply of the plant material from either a commercial nursery or an in-house nursery operation must be added.

If the plant material has been well selected and planted properly there should be no subsequent maintenance costs for refertilizing or reseeding. This should allow the mine operator to complete final reclamation without concern for follow up maintenance procedures that may be necessary when agronomic grasses and legumes are used.

ACKNOWLEDGEMENTS

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ELEVENTH ANNUAL MEETING

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Policy, Planning Systems and Operational Programs

June 3 - 6, 1986

University of British Columbia
Vancouver, B.C.

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FOREWORD

The British Columbia Chapter of the Canadian Land Reclamation Association was formed in 1985 to provide a local public forum for the exchange of information and experience in land rehabilitation. Comprised of professionals from a wide range of backgrounds and interests, this organization pulled together quickly to host the 1986 Annual Meeting. The diverse membership in the B.C. Chapter was realized in a program that expanded the scope of the conference to include many fields that have not been represented in past programs. The quality of presentations and range of topics kept audience participation at a spirited level. It is our hope that we have initiated a trend to widen the scope of the annual meetings so as to not focus on traditional mining or energy development issues.

I wish to thank all speakers and attendees for making this first formal function of the B.C. Chapter a success. The enthusiastic support of chapter members in the planning and administration of the conference demonstrated a strong desire for a quality meeting. This drive bodes well for the future of our chapter.

A great deal of effort went into the publication of the proceedings of the 1986 Annual Meeting. Care was taken to accurately reproducce all papers, however minor errors may have escaped the review process. We hope that this will not detract from the information presented by the authors.

May the CLRA and all local chapters continue to grow and function as a focal point for land rehabilitation.