RECLAMATION OF HIGH-ELEVATION WILDLIFE HABITAT AT ELK VALLEY COAL'S FORDING RIVER AND GREENHILLS OPERATIONS

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ABSTRACT

Reclamation research was initiated on the Fording River mine site in 1969, prior to commencement of mining operations, and has been an ongoing component of both Fording River and Greenhills Operations' approach to sustainable development throughout mine life. This research has focussed on optimum techniques to return land disturbed by mining to equivalent productivity, and on specific challenges encountered on the sites. One of the primary challenges on both mine sites is the restoration through reclamation of high-value wildlife habitat. Wild ungulates, predominantly elk and bighorn sheep, are a major wildlife resource that reside year-round in the Fording River Valley. Mining at the Fording River and Greenhills Operations has disturbed habitat for these species, including some valuable winter range on south and southwest-facing slopes. To ensure the successful reclamation of this important high-elevation wildlife habitat, Fording River personnel initiated winter range-targeted reclamation research in 1985. This work has continued to date, with recent programs including:

- High-elevation conifer planting trials, to provide visual and thermal cover elements for wildlife habitat.
- Use of plant protectors to establish key preferred browse shrub species in climatically adverse conditions.
- Native grass species trials, to evaluate the potential of newly available forage species.
- Design and planning used to integrate research results into operational reclamation.

This integrated research program has built on previous reclamation research undertaken at the mine sites, and has improved knowledge for these mines on species selection, establishment timing, and techniques to allow successful reclamation where more conventional approaches have not produced desired results. This increased knowledge will translate into better ability to re-create specific habitat elements, as more high-elevation areas on the mine sites become available for reclamation.

INTRODUCTION

Fording River and Greenhills Operations are located in the Fording River Valley in southeastern British Columbia, which provides habitat year-round for elk and bighorn sheep. Both mine sites have conducted extensive research programs in support of reclamation and sustainable resource extraction. Reclamation research began at the Fording River site in 1969, prior to commencement of mining operations, and has continued throughout the mine's life. Results of this research have been integrated into successful reclamation of approximately 600 ha at the Fording Rive mine, and approximately 400 ha at the Greenhills mine.

The Fording River valley supports a rich variety of wildlife populations, and provides year-round habitat for elk and bighorn sheep. Both the Fording River and Greenhills operations contain valuable wildlife habitat in the form of high-elevation south and southwest-facing slopes that are used as winter range by wild ungulates. In order to ensure successful reclamation of this habitat after mine closure, mine personnel initiated research programs into winter-range reclamation in 1985. The challenge of this research was to address establishment of appropriate winter range vegetation communities on harsh, high-elevation sites subject to immediate browse pressure. This research built on results from previous work that had pioneered techniques of successful establishment and productivity enhancement of container seedlings on lower-elevation sites. However, early work on winter-range reclamation indicated that application of methods developed for lower-elevation reclamation might not be successful due to unique site challenges, and that development of specialized techniques would be required. This development has occurred through recent research programs designed to investigate techniques to address objective and site-specific challenges of winter-range reclamation. These programs have included:

- conifer seedling trials, to evaluate species suitable for use on high-elevation sites, and methods for their establishment;
- preferred elk browse species research, evaluating optimal use of plant protectors for establishment of important shrub species, as well as stock type and planting considerations; and
- native grass species trials, to investigate use of newly available commercial grasses of local provenance on high elevation sites.

Establishment of conifers at high elevations is necessary to provide wildlife with both thermal and hiding cover. Thermal cover helps to maintain body temperature and conserve energy through both hot and cold seasons and may consist of coniferous trees with a dense canopy cover and some understory vegetation. Hiding cover provides animals with visual protection from predators.

Research into establishment of elk browse shrub species was conducted due to the importance of these species in elk winter diets, and thus the importance of replacing at least a portion of these species during winter range reclamation. To address challenges noted above and to build on previous reclamation research, further work was initiated in 1995 to improve the establishment and survival of the plants through the use of plant protectors, and to investigate the use of differing stock types and planting windows, as well as other management techniques such as legume interseeding.

Trials of grass species were undertaken to provide forage that is an additional important component of elk winter range, and native species were selected since they are potentially better adapted to harsh, high-elevation sites than the agronomic varieties used in conventional reclamation mixes. In 1988, pilot scale grass trials were installed on '2' Spoil to assess the reclamation potential of native and naturalized grass mixes identified as wildlife forage. Further work was conducted from 1999 to 2002, using native seed developed by the Alberta Environmental Centre. These trials were monitored for productivity, species establishment and winter forage value.

Results from these specific operational research programs are being integrated with characteristics of post-closure landforms and with knowledge of pre-mining conditions to develop design guidelines for operational reclamation of high-elevation wildlife habitat on the reclaimed mine sites.

METHODS

High-Elevation Conifer Trials

High-elevation conifer trials were installed on resloped coal waste at both Greenhills and Fording River Operations. These sites were stratified by aspect (north, east, south and level) to produce four blocks of replicated plantings. Elevation on these trial sites ranges from approximately 2050-2250 m a.s.l. Within each block, 20 plots comprised of approximately 90 trees of one of four tested conifer species were planted on an average 2.1 m spacing. Tested species included alpine larch (*Larix lyallii*), subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*) and lodgepole pine (*Pinus contorta*). The planting was conducted in June 1999, and each seedling was planted with a 10 g (20:10:5) fertilizer tablet. To test interseed delays of 1, 2, 3, and 4 years, two plots of alpine larch and subalpine fir were randomly selected each year and seeded at a rate of 50 kg/ha of birdsfoot trefoil (*Lotus corniculatus*). Pine and spruce were only tested with a two-year interseed delay, due to conclusive results from previous work on the mine sites on optimum interseeding delays for these species (Fording River, 1990). The interseeded replicates were fertilized at the time of seeding with 400 kg/ha of 11:55:0 fertilizer. Based on the presence of Douglas-fir (*Pseuotsuga menziesii* var. *glauca*) at high elevations on Eagle Mountain prior to mining, this species was included in the conifer trials in 2001. Eight replicates of approximately 90 seedlings were installed at each of the four trial sites. Seed for these plantings was obtained from a BC Ministry of Forests seedlot collected in the location of Lakit Mountain, from elevations ranging from 1550-1850 m a.s.l. At that time, this seedlot was the highest elevation provenance available within the East Kootenay seed planning zone (Fording Coal, 1991).

Monitoring of survival was conducted twice annually for the first two years following planting and then reduced to once annually.

Preferred Browse Shrub Species

The preferred elk browse shrub species trial was installed on south and southwest-facing waste rock at Fording River Operations. Eleven species of shrubs, native to the area and identified as preferred elk browse species, were planted in two adjacent rows with 25 shrubs per row. One row of each pair per species was installed with plant protectors, while the other row was left unprotected. Species placement and protection within plots was randomized. A fertilizer tablet (20-10-5) was planted with each shrub. The shrub species selected for the trials were buffaloberry (*Shepherdia canadensis*), chokecherry (*Prunus virginiana*), prickly rose (*Rosa acicularis*), red osier dogwood (*Cornus stolonifera*), Douglas maple (*Acer *glabrum*), saskatoon (*Amelanchier alnifolia*), snowberry (*Symphoricarpos albus*), trembling aspen (*Populus tremuloides*), birch-leaved spirea (*Spirea betulifolia*), black cottonwood (*Populus balsamifera*), willow (*Salix spp.)*, and wolf willow (*Elaeagnus commutata*). Trial installations also included Engelmann spruce and lodgepole pine, to test the effects of plant protectors and planting windows on conifer species. Planting in this trial began in 1995, and continued through 1999. Trial installation included use of both 1+0 styro 77 seedlings, and 2+0 styro 45 seedlings, to evaluate the effects of using larger stock type on establishment success of container-grown shrub species.

In 1999, the emphasis of research on the FC-1-95 trial was shifted to focus on the optimum timing of protector removal and interseeding on elk winter range sites reclaimed with protected seedlings. Protector removal is necessary due to the ongoing costs of maintaining/re-installing protectors in a harsh environment. Thus, the earlier protectors can be removed without causing significant plant mortality, the more cost-effective this reclamation will be. In order to achieve this research objective, the browse species shrub trial was re-designed to include removal of protectors on plots after different lengths of protected periods. Starting in July 1999, half of the plot replicates had protectors removed at different intervals after planting, to provide information on survival given 1-year (conifers only), 2-year, 3-year, and 4-year protection duration. The other half of plot replicates were left protected, to provide controls for comparison.

Beginning in 2000, research to determine the appropriate legume interseeding delay for elk browse species was initiated on the browse species shrub plantings. Interseeding of planted container seedlings has been used at Fording River and Greenhills Operations as a method of increasing site nutrient status (through symbiotic nitrogen fixation) and enhancing habitat value while providing ground cover to limit surface soil erosion. Previous work on appropriate timing of legume interseeding on conifer species has indicated that seeding needs to be delayed for a minimum of two years after planting to prevent seedling losses due to excessive competition. For this reason, two-year and longer delays were tested for establishment of elk winter range on the trial sites. Protectors were removed from all remaining styro 45 plots two years after planting and plots were interseeded with birdsfoot trefoil. Interseeding occurred at delays of two, three and four years since planting (or zero, one or two years following protector removal), and was completed in 2002

Monitoring for survival and growth parameters on this trial was conducted twice annually from 1995 to 2003, once in the spring and once in the fall. Fall monitoring included an assessment of the health and vigour of each plant.

<u>Single Species Native Grass Trials</u>

Native seed developed by Alberta Environment Centre was seeded in four replicated plots – two at Fording River Operations and two at Greenhills Operations – at elevations of approximately 1850-2150 m. Each plot location included eight 3 x 4 m subplots, with two replicates of each of four grass species used, for a total of 10 subplots per plot. Species included in this trial were alpine bluegrass (*Poa alpina* – AEC Glacier), slender wheatgrass (*Agropyron trachycaulum* – AEC Highlander), awned slender wheatgrass (*Agropyron trachycaulum* var. *secundum* – AEC Hillcrest), and broad-glumed wheatgrass

(*Agropyron trachycaulum* var. *violaceus* – AEC Mountaineer). Seed was applied at a rate of approximately 2000 seeds/m^2 along with fertilizer (11-55-0) applied at a rate of 400 kg/ha. Plot installation occurred in 1999. Due to anomalous weather conditions in 1999 and resulting poor establishment of seeded species, the Glacier, Highlander and Hillcrest AEC varieties were re-seeded over the original plots in 2000. The Mountaineer variety was not available in 2000, but an additional species, violet wheatgrass (*Agropyron violaceum*) was obtained and seeded new on plots adjacent to the 1999 installations.

Monitoring of these trials included assessing above-ground biomass production in 2002, as an index of the establishment success and productivity of the trial species. Three 1 m^2 quadrats were sampled in each subplot, for a total of 120 sampled quadrats in the trial. All live, above-ground vegetation within each quadrat was clipped to within 1 cm of the ground, collected in a paper bag and had the oven-dry weight determined in the laboratory.

RESULTS

High-Elevation Conifer Trials

Results of survival by species indicate that when the four planting sites are grouped, spruce reports significantly higher survival than all other species, and larch reports significantly higher survival than Douglas-fir, fir or pine (Figure 1).

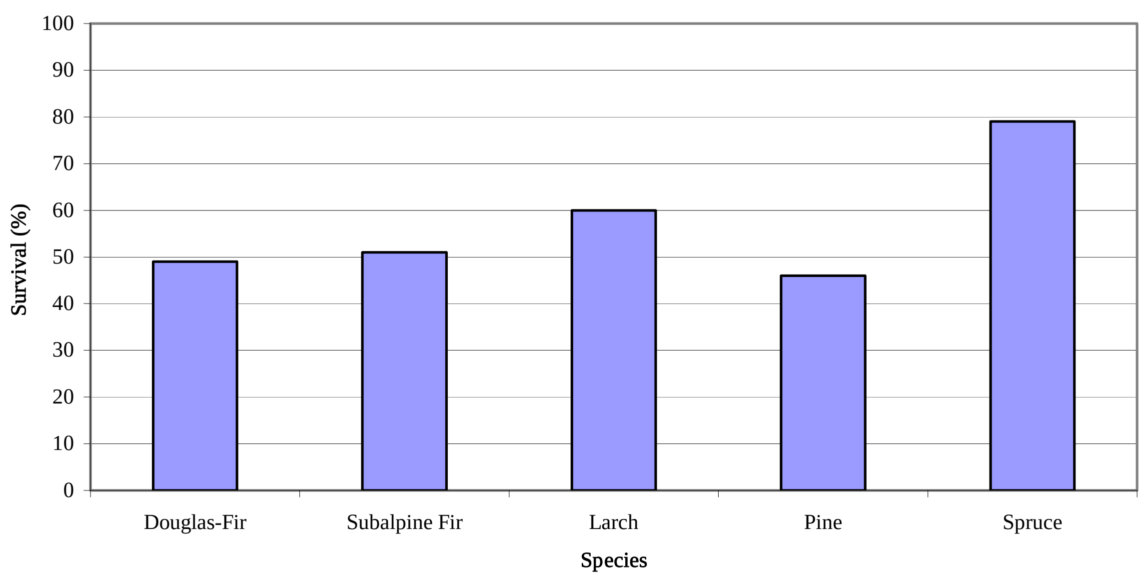

Figure 1. Survival by Species after 3 Growing Seasons

Analysis of survival data by season of planting for pine and spruce on the Raven spoil sites indicates statistically significant differences in survival by planting season for both species. Survival of fall-planted pine seedlings is approximately 25 percent higher than spring-planted pine seedlings. Fall-planted spruce seedlings had approximately 10 percent higher survival than spring-planted spruce seedlings. It should be noted that fall-planted seedlings are “hot-lifted” seedlings hardened off at the Fording River nursery and planted in September of the year of sowing, while spring-planted seedlings are the same stock, cold-stored and planted in June of the year following sowing. The lack of cold storage (which has been shown to cause stress to seedlings), and the ability for fall-planted seedlings to complete some root growth during dormant shoot periods, prior to onset of shoot moisture demand in late spring, may contribute to the observed higher survival of fall planted seedlings in this trial.

Preferred Shrub Browse Species

Results from the browse species shrub trial have indicated significant increases in survival and vigour of protected plants, in comparison to adjacent unprotected seedlings. With the exception of spruce and wolf-willow, all species showed survival increases when planted with seedling protectors. Season of planting had variable effects depending upon species, which suggests that a species-specific approach to the timing of operational planting on harsh sites would be beneficial. If logistical considerations prevent using different planting windows for different species, results indicate that spring planting will result in higher survival than fall planting for deciduous shrub species on reclaimed elk winter range. However, results for conifer seedlings included in this trial show that season of planting may have a greater effect on survival of these species than protection, and that, as on the high-elevation conifer trials discussed above, significantly higher survival rates are obtained on fall-planted plots than on spring-planted plots. Results also indicated no cost-effective benefits resulting from utilization of 2+0 styro 45 stock, which supports the continued use of the standard 1+0 styro 77 seedlings in planting programs on the Fording River and Fording Greenhills mine sites.

Figure 2 summarizes the effects of protection and protector removal, by providing examples of the average survival of chokecherry (*Prunus virginiana*), lodgepole pine (*Pinus contorta*) and Douglas maple (*Acer glabrum*) for various protection durations. Protection durations are given in years, with year ‘0’ representing unprotected plants. Chokecherry exhibits peak survival with three years of protection, after which time survival decreases. Lodgepole pine has peak survival with two years protection. Further protection of pine is more detrimental than no protection. Douglas maple benefits strongly from four years of protection, with no mortality experienced by plants protected for four years.

Other tested species conform to one of these requirement patterns for protection, generally to the first pattern (demonstrated by chokecherry in Figure 2). For the majority of species, removal of protectors two years after planting causes a significant increase in plant mortality in comparison to protected plots, but removal of protectors after three years produces no significant differences in plant survival between removed and protected plants. This finding suggests that most species planted on coal spoil reclaimed to elk winter range require a minimum of three years of protection prior to removal to maintain the survival advantages of plant protection, but that following the 3-year period, protectors may be removed without causing significant mortality. Species for which this treatment is valid include: saskatoon, red-osier dogwood, aspen, chokecherry, willow, buffaloberry, and birch-leaved spirea.

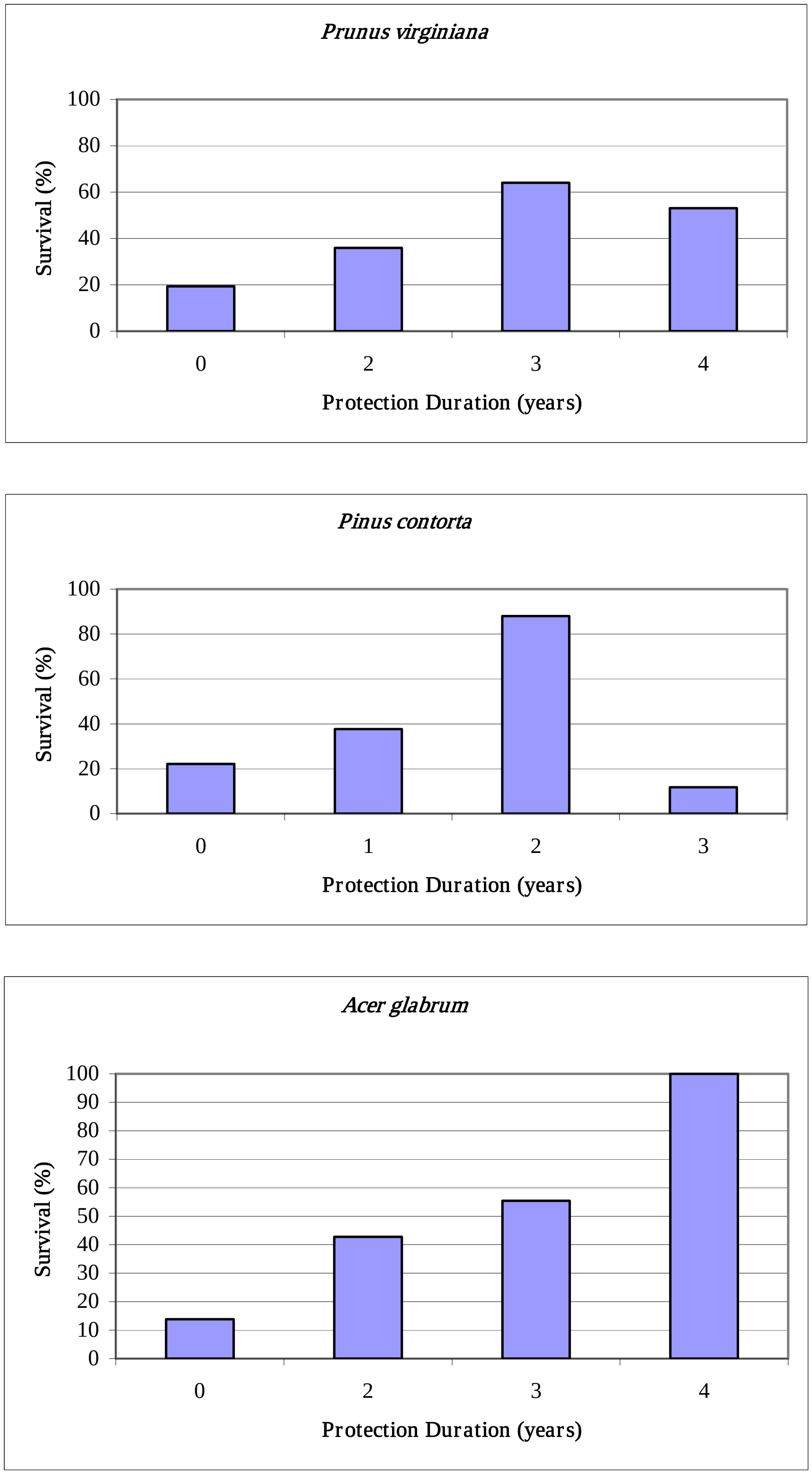

Figure 2. Percent Survival of Three Protected Species at ‘2’ Spoil

Results of monitoring of interseeding effects on plant survival indicate that, for the majority of species, early interseeding (on a 2-3 year delay following protector removal) may have negative effects on survival. For all species but spruce, survival on the non-seeded trials was significantly better than when seeding was conducted 2-3 years after planting. This likely indicates that a longer seeding delay (4-5 years) is necessary to limit early competition and maintain good shrub survival. Results from this interseeding trial may be confounded by the removal of protectors from all trial plots two years after planting, which has been shown by the other study component to increase plant mortality.

Single Species Native Grass Trials

Results collected in 2002 indicate that the wheatgrasses (Agropyron) were generally successful at establishment and production, which ranged from 100-350 kg/ha (Figure 3). Note that *Agropyron trachycaulum* var. *violaceus* – AEC Mountaineer was not reseeded in 2000, and thus had half the seeding rate of the other grasses. The bluegrass, *Poa alpina* – AEC Glacier was overall less successful and produced less than 65 kg/ha, and there was no establishment of violet wheatgrass, *Agropyron violaceum* at any location.

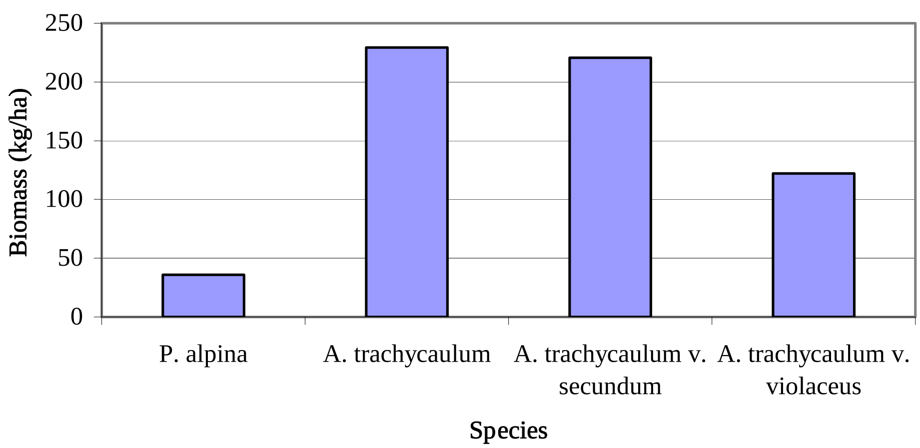

Figure 3. Mean Biomass Production in the Single Species Native Grass Trials

The native grass species research trial has demonstrated that use of recently available native grass species from (relatively) local provenances can be a successful component of reclamation of elk winter range. However, results from previous research indicate that higher productivity levels will be achieved using either more standard "native" species mixes (species that are native to North America, but not necessarily native to the region local to the Elk Valley mine sites), or using agronomic varieties. Biomass results from trials using these mixes indicated that in 1994, the agronomic species mix had a mean production of approximately 1535 kg/ha and the "native" species mix had a mean production of approximately 800 kg/ha. By 1996, this difference in productivity was reduced as the naturalized species mix produced a mean of 575 kg/ha and the native species mix produced a mean of 510 kg/ha.

DISCUSSION AND CONCLUSIONS

Analysis of data collected to date in the high-elevation conifer planting trials has identified differences in survival both by species and by season of planting. In general, spruce has been the most successful species, with subalpine larch being the next most successful. Survival of Douglas-fir, subalpine fir and pine has been generally poorer than the above species. Additionally, season of planting is important with fall planted spruce and pine seedlings exhibiting 10 to 25 percent higher survival than spring planted seedlings. Data in this trial indicates that fall planted spruce grown on-site at Fording River's nursery is the best choice for reforestation on high-elevation coal spoil on these mine sites. All other tested species show some promise for high-elevation reclamation, but their use should be confined to better sites such as lower elevation (below 2200 m) resloped coal waste, and pine should be planted only as a direct-lifted seedling in September. Observations in this trial suggest substantial mortality of pine seedlings due to browsing, primarily by sheep, which suggests that successful use of this species might be enhanced through utilization of seedling protectors and/or chemical browse deterrents.

Preferred browse shrub species trials have shown that the majority of species benefit from three years of protection, with no significant mortality occurring after protector removal. Current data has also confirmed that the survival of some species is not affected by protection and thus these species can be successfully established without incurring this additional cost. Combining the findings of the protection-duration research with previous work conducted on the effectiveness of protection and on planting season yields the following species-specific categories of treatment recommendations to achieve maximum survival:

Species	Season of Planting	Protection Duration (years)
wolf-willow	spring	none
saskatoon	spring	three
red-osier dogwood	spring	three
trembling aspen	spring	three
birch-leaved spirea	spring	three
snowberry	spring	three
Douglas maple	spring	four
prickly rose	spring	four
buffaloberry	spring or fall	three
Engelmann spruce	fall	none
lodgepole pine	fall	two
chokecherry	fall	three

The above recommendations are based on relative survival data, and do not indicate the success of the different treatments in terms of absolute survival. In order to test the finding that protectors can be removed after recommended durations without incurring significant mortality, absolute survival data from plants that have had protectors removed was compared to data from plants that had never been protected. Statistical comparison shows that at this time, all plants except wolf-willow that have been protected for the durations recommended above have survival rates that remain significantly above unprotected plants.

Assessment of the plants indicates that most species show increased vigour when protected. When protectors are removed, overall survival of the plants that had protection is higher, though health and vigour become comparable between treatments. Following protector removal, seedlings may be subject to initial die-back from increased browse pressure and adjustment to harsher microclimate conditions.

The single-species native grass trials have indicated a potential for successful establishment of most of the trial species. The more successful of the trial species had biomass production that was comparable to that found on undisturbed mesic grasslands on adjacent Turnbull Mountain. An assessment of these grasslands (at similar slope positions, aspects and elevations as the native grass species trial sites) recorded mean grass biomass levels of 282 kg/ha, as compared to 65-350 kg/ha on the native species trials, and approximately 500 kg/ha on the previous “native” and agronomic trials.

Native forage has the potential for successful establishment on high-elevation winter range sites and has comparable production to similar off-site areas. These results show that selection of grass species for reclamation on these sites can be tailored to specific objectives (high productivity vs. use of native species), with a range of candidate species demonstrated to be successful at establishment and growth on reclaimed coal spoil.