

DEVELOPING AN EFFECTIVE NATIVE TREE AND SHRUB PLANTING PROGRAM AT TECK COAL LTD.'s ELKVIEW OPERATIONS

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ABSTRACT

The “20 Year Conceptual Reclamation Plan” (Przeczek 2003) for Teck Coal Ltd., Elkview Operations provides direction for promoting a range of habitats that will support a range of wildlife species over time. Creating these habitats requires consistently successful revegetation treatments including the establishment of native trees and shrubs. Tree and shrub establishment is critical to meeting target biological diversity objectives for species, spatial distribution and vertical structure set for the reclaimed environment at the mine.

Successful implementation of planting programs requires optimizing seedling quality and carefully managing any situations that can negatively impact seedling physiology. Starting in 2008, Elkview Operations has made a concerted effort to identify and control as many of the links in the “reclamation chain” as possible. We have specifically focussed on:

1. Appropriate species selection;
2. High quality seed collection;
3. High quality planting stock (regular communication with nursery staff);
4. Effective site preparation;
5. High quality planting (close communication with tree planters);
6. Rigorous seedling handling procedures from the cold storage facility to the planting hole;
7. Planting as early in the spring as possible;
8. Fertilization at the time of planting; and,
9. Monitoring success through formal survival plots and regular walk-through assessments of past plantations to inform adaptive management programs.

Plantation success has improved from 2008 – 2013 so that we are now comfortable prescribing the establishment of specific tree and shrub species plant communities. We currently focus on creating eight broad plant community types. Our program has expanded to include 4 coniferous tree species, 3 deciduous tree species, and 13 shrub species. We will continue to expand the list of species, minimize seedling physiological stress, and monitor success to ensure that the mosaic of planted vegetation types, in combination with areas seeded with agronomic grasses and legumes, will promote site level biological diversity objectives.

Key Words: Conceptual Reclamation Plan, Mine Reclamation

BACKGROUND

The 20 year conceptual reclamation plan for the Elkview property was updated in 2003 (Przeczek, John 2003, Przeczek, John and Dave Ryder 2004) and again in 2014 (Przeczek, John 2014). The plan recognizes the wildlife end land use specified in Reclamation Permit C-2 and it was prepared to ensure that additional site level biological diversity objectives are achieved and to provide direction for reclamation planning and implementation into the future. Key components of the plan include a vision for the horizontal distribution, vertical structure, and species composition of the plant communities that will be established, the recognition of Reclamation Treatment Units (RTU's) as the basis for developing reclamation treatment plans, and a commitment to develop and implement monitoring programs that can inform adaptive management needs (Przeczek, John 2003). The Conceptual Reclamation Plan is based on the concept of ecological replacement which allows us to focus on creating post-mining landscapes that have similar functioning to pre-mining conditions but does not imply that they will be the same (Cooke and Johnson 2002). The 2014 Conceptual Plan update is also consistent with Teck's "Biodiversity Management Planning" initiative (Gullison 2014).

Prior to 2007, revegetation efforts focussed on establishing self-sustaining agronomic grass and forb dominated plant communities. Engelmann spruce (*Picea engelmannii* Parry ex Engelm.) and lodgepole pine (*Pinus contorta* Douglas ex Loudon var. *latifolia* Engelm. ex S. Watson) plantations were also established in a few areas with wolf-willow (*Elaeagnus commutata* Bernh. ex Rydb.) patches established in one of the spruce plantations. Black cottonwood (*Populus balsamifera* L. ssp. *trichocarpa* (T & G) Brayshaw) commonly volunteers throughout the reclaimed areas. By 2007 it was clear that establishing tree and shrub dominated plant communities with a larger diversity of species would be required to meet end land use.

Varying levels of plantation success through 2007 were limiting our ability to meet reclamation objectives. The goal of consistently establishing plant communities with specific species composition and vertical structure required us to focus on the factors that affect plantation success. These factors have been compared to the links in a chain; if any one of them is weak, the chain will break and success will not be possible (Helgerson 2004). In 2008 we began to focus on the components of the planting program that we could control to improve the probability of success. All of our efforts have been designed using the extensive experience and research results that guide the reforestation programs of the Forest Industry. Everything we promote in the tree and shrub establishment program is aimed at acquiring the best planting stock possible, minimize seedling physiological stress, and establishing diverse plant communities.

PLANTING PROGRAM CONSIDERATIONS

Species selection is probably the most important decision we make in the reclamation process. The 2014 Conceptual Reclamation Plan identifies the species that we work with at Elkview Operations; this list will continue to evolve as we move forward (Table 1). A detailed seed needs analysis was conducted to allow

for the purchase of a 20 year supply of desired conifer species¹ and to determine the amount of seed that would be required to maintain a 2- 4 year supply of other tree and shrub species. “The capability of stored seeds to produce vigorous seedlings is affected by seed quality at the time of collection and the care with which seeds are handled during collection, transport, processing, and storage” (Leadem, C.L., R.D. Eremko and I.H. Davis 1990, p.193).

Conifer seed is purchased from certified registered seedlots and it is stored in the BC Forest Service Tree Seed Centre in Surrey, BC. Seed collections for other species are coordinated and conducted by consultants with extensive native tree and shrub seed collection experience. Collected material is stored in refrigerators prior to shipping to extraction facilities, temperature is controlled with freezer packs during shipping, seed extraction is completed by qualified facilities with a proven record of success, seed is dried down to 8 – 10% moisture content and then kept refrigerated at 2 – 4 degrees until needed for a reclaimed site. Each seed collection for a species is given a unique number (Seedlot Number) and seed is used on a first-in first-out basis. It takes approximately 16 months to order and grow a seedling for spring planting. Having high quality seed available provides the flexibility required to plan effective planting programs at the range of elevations that we work with at Elkview Operations (1150 – 2200 meters). We started to experiment with freezing aspen, cottonwood and willow seed in 2013 and the results look promising which will provide more flexibility and more consistent seedling quality for these species in the future.

We grow our seedlings at private nurseries that have a proven ability to consistently provide high quality seedlings at requested levels. Our planting program is spring-based and we have adopted the “forestry” production regime which includes fall/winter seed stratification, spring sowing, fall lifting, freezing seedlings for storage over the winter and a short (10 day) controlled thaw regime just prior to planting. We believe that it is important to develop a strong working relationship with an experienced grower; it is not good enough just to order your plants in the fall and plant them 18 months later. Your knowledge of your sites in combination with your grower’s knowledge of nursery culture generates a powerful contribution to plantation success. Nurserymen should be able to provide guidance regarding stocktype options and growing regimes based on the requirements of your different sites. They should also be responsive to your requests for boxing, labeling, shipping and storage.

We continue to have good plantation success on simple resloping treatments that create relatively continuous 26 degree slopes. However, our post-resloping site preparation treatments now focus on incorporating diversity without compromising slope stability. Micro-topographic features that reflect conditions that we find in adjacent undisturbed sites are created through twist and turn treatments with the crawler-tractor or through creating small mounds, up to 50 cm high, with an excavator. We will also continue to use ripping treatments to promote seedling establishment where the topography is relatively subdued. All treatments are completed before snowfall to ensure that the maximum potential soil moisture is available during spring planting operations. We have experimented with spring site preparation treatments but they create conditions that become excessively dry due to the windy conditions at the mine site.

¹ Purchases will be made periodically to maintain a 20 year conifer seed supply.

Table 1. Native tree and shrub species used in the reclamation program at Teck Coal Ltd., Elkview Operations.

Scientific Name	Common Name
Plant species regularly used in the reclamation program at Elkview Operations	
<i>Alnus viridis</i> (Chaix) DC, ssp. <i>sinuata</i> (Regel) A. & D. Love	Sitka alder
<i>Amelanchier alnifolia</i> Nutt.	saskatoon
<i>Betula papyrifera</i> Marsh.	white birch
<i>Cornus stolonifera</i> Michx.	red-osier dogwood
<i>Pentaphylloides floribunda</i> (Pursh) A. Love	shrubby cinquefoil
<i>Elaeagnus commutata</i> Bernh. ex Rydb.	wolf-willow
<i>Larix occidentalis</i> Nutt.	western larch
<i>Picea engelmanni</i> Parry ex Engelm.	Engelmann spruce
<i>Pinus contorta</i> Dougl. ex Loud.	lodgepole pine
<i>Populus balsamifera</i> L. ssp. <i>trichocarpa</i> (T & G) Brayshaw	black cottonwood
<i>Populus tremuloides</i> Michx.	trembling aspen
<i>Prunus virginiana</i> L.	chokecherry
<i>Rosa acicularis</i> Lindl. ssp. <i>sayi</i> (Schwein.) W.H. Lewis	prickly rose
<i>Rubus idaeus</i> L. var. <i>strigosus</i> (Michx.) Maxim	red raspberry
<i>Salix</i> sp.	upland willow
<i>Sambucus racemosa</i> L. ssp. <i>pubens</i> (Michx.) House var. <i>melancocarpa</i> (A. Gray) McMinn	black elderberry
<i>Vaccinium membranaceum</i> Douglas ex Hook.	black huckleberry
Plant species used in the reclamation program at Elkview Operations (limited data)	
* <i>Acer glabrum</i> Torr. var. <i>douglasii</i> (Hook.) Dippel	Douglas maple
* <i>Rubus parviflorus</i> Nutt. var. <i>parviflorus</i>	thimbleberry
* <i>Shepherdia canadensis</i> (L.) Nutt.	Canadian buffalo-berry
Plant species with potential for use in the reclamation program at Elkview Operations	
<i>Arctostaphylos uva-ursi</i> (L.) Spreng.	kinnikinnick
<i>Ceanothus sanguineus</i> Pursh	redstem ceanothus
<i>Ceanothus velutinus</i> Douglas ex Hook.	snowbrush
<i>Dryas integrifolia</i> Vahl	entire-leaved mountain-avens
<i>Juniperis communis</i> L.	common juniper
<i>Pseudotsuga menziesii</i> (Mirb.) Franco var. <i>glauca</i> (Beissn.) Franco	Douglas-fir
<i>Salix</i> sp.	riparian willow
<i>Symphoricarpos albus</i> (L.) Blake	common snowberry
<i>Sorbus sitchensis</i> M. Roem.	Sitka mountain-ash

As the implementation of a planting program approaches it is important to remember that frozen storage facilities typically require a minimum of 10 days to execute a thaw request and you need to build some flexibility into your timing to allow for planter scheduling, days off and taking advantage of optimal soil moisture conditions. We have found that planting high elevation sites (over 1600 meters) requires us to accept that a proportion of the planting site will be covered with snow patches because of differential melting at the site. Our general rule of thumb is to start planting when approximately 75% – 80 % of the planting area is snow-free. This also provides for a higher level of horizontal diversity in plant communities because the areas affected by slower snow melt will become grass and legume dominated when the planting area is seeded after two or three growing seasons.

It is important to thoroughly inspect seedlings upon receipt from the seedling storage facility. Check foliage, stems and roots for signs of mechanical damage, desiccation, freezing, or storage molds. Some deciduous species respond quickly to increased temperatures during thawing and may start flushing in the boxes; plant them as quickly as possible if this occurs. A small, shallow scrape of the stem should reveal a healthy green cambium layer. After a brief inspection, re-seal the vapour barrier and close the box. Make detailed notes of observed issues with specific species or seedlots so that you can follow plantation results through time with the information required to isolate factors that may affect plantation survival and performance.

We have implemented rigorous stock handling procedures that are designed to reduce physiological stress and maximize seedling performance potential (Lavender 1990). Stock handling procedures focus on minimizing physical damage, keeping seedlings cool and moist, and avoiding the development of storage molds. We use snow caches for the main on-site storage to control inbox temperatures. We strictly enforce the use of insulated seedling canopies on planter's trucks, a maximum half-day seedling supply for removal from the main cache, and use of thermal-cool tarps for any seedlings stored on the site for a maximum of 3 hours. Seedling boxes need to be handled carefully. Tabbush (1986) found that dropping seedling boxes one to fifteen times, from a height of three meters, reduced seedling survival and performance significantly. "Similar effects may be seen if boxes and seedlings are crushed by compaction, therefore boxes should never be stocked more than three high. (Mitchell et al 1990, p 239). It is important to include planters in stock handling discussions so that they understand how their behavior can influence seedling survival and performance.

Maintaining high levels of planter morale is critical in promoting plantation establishment and growth. This is particularly important at Elkview Operations because planters are generally astonished that planting trees and shrubs would be considered viable on resloped coal spoils. We always show planters and planting contractors the success levels of past planting projects so that they will understand that their efforts and our requirements will result in the establishment of impressive plantations with diverse species mixes that they are generally not used to seeing. Planting conditions are difficult and our stock handling requirements are demanding; happy planters make for happy plantations. All seedlings are also planted with a fertilizer tea-bag to promote establishment and early growth in the nutrient poor environment typical of resloped coal spoils.

RESULTS AND FUTURE EXPECTATIONS

The period from 2008 through 2010 was spent getting all of the players in line with what we were trying to accomplish with our comprehensive seed to planting hole approach to improving plantation success. Our expectations were communicated and issues with nurseries and cold storage facilities were ironed out. We were not sure which species would be most reliable at this point but experience from other mine sites provided some guidance. Seedling survival study plots were established each year to provide localized data and they will continue being established annually. By 2011 we were comfortable that we could successfully implement a more complex planting regime and that we had sufficient local survival information to support our decisions. In 2012 we started allocating specific species mixes to various planting units and in 2013 the whole planting program was implemented around the idea of creating specific plant communities (Figure 1).

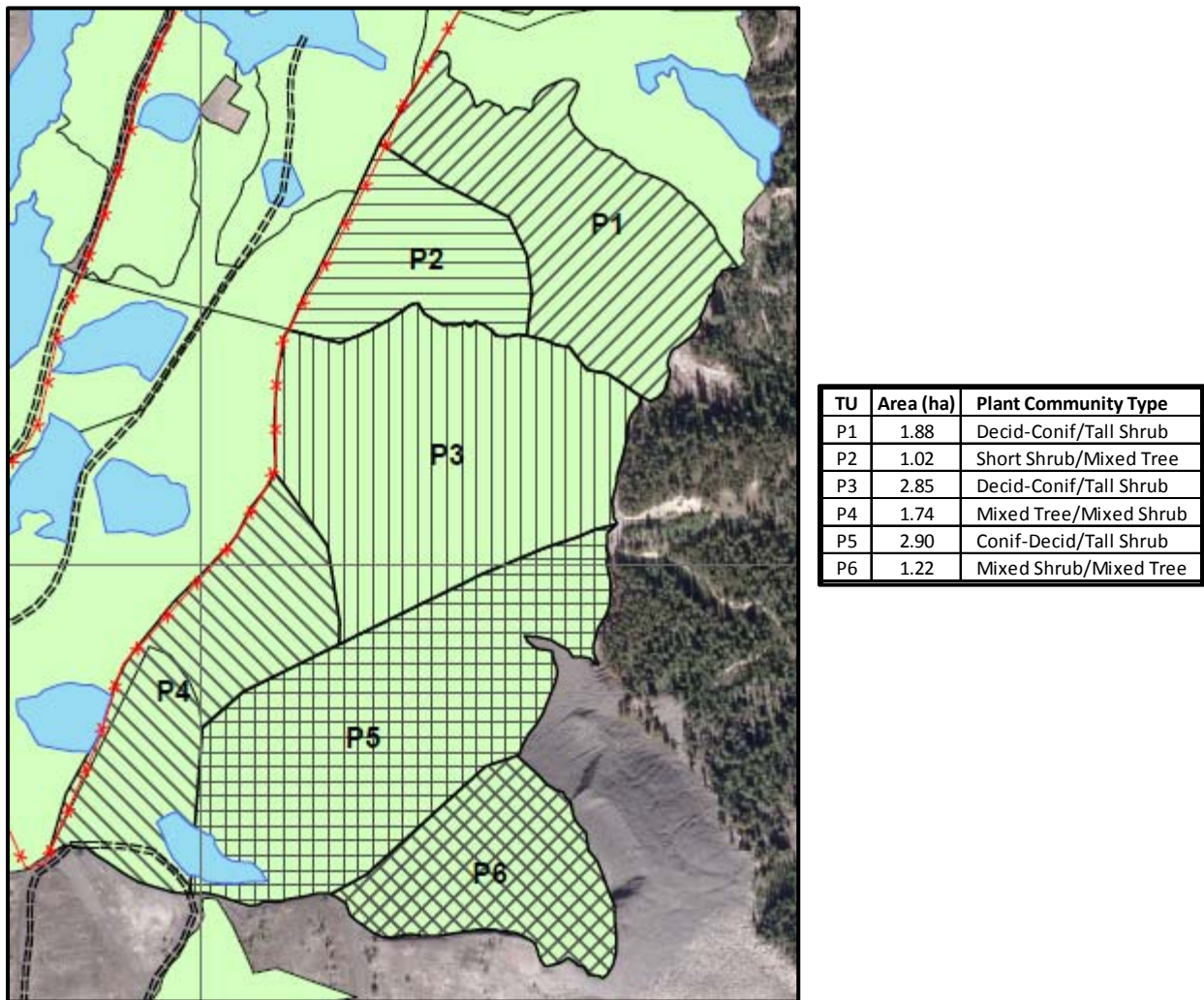


Figure 1. Planting units from the 2013 planting program at Teck Coal Ltd., Elkview Operations.

Survival plot data collected since 2008 shows that survival generally exceeds 70% for species that are regularly used in the reclamation program (Figure 2). There have been cases where planting stock quality, very rocky planting medium or unknown factors have caused higher levels of seedling mortality. The survival plot monitoring system has been implemented to allow us to isolate survival problems that may be nursery/seedling storage versus site/planting related. This allows us the opportunity to follow seedling survival over time and explain the reasons behind failures and take corrective action in future planting projects. We maintain close communication with the nurseries that grow our stock and with the frozen storage facilities that we use and everyone in the program strives for continual improvement.

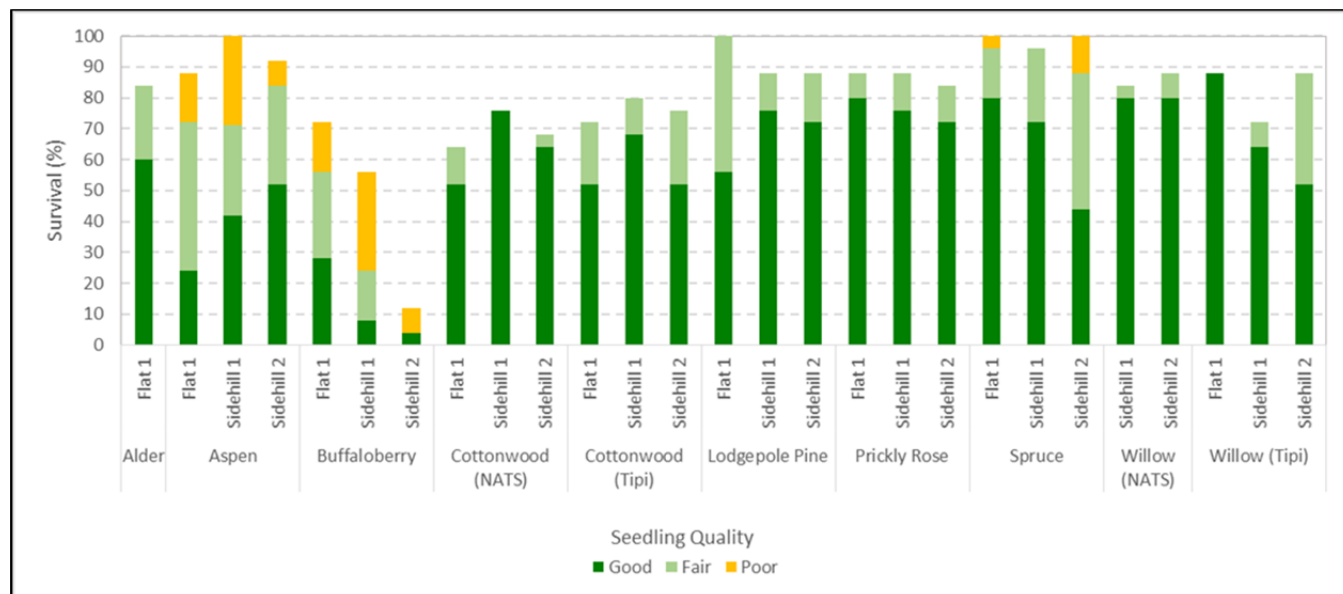


Figure 2. Third growing season seedling survival on plots established in 2011, Harmer East, Elkview Operations.

The planting program at Elkview Operations will continue to concentrate on the factors that appear to have the most profound influence on plantation success. The species list of trees and shrubs that are regularly used in the reclamation program will continue to expand as we test new species and generate the data required to support their use. We also recognize that some species with intermediate levels of seedling survival may be used in the reclamation program because they are important to specific Communities of Interest. For the next 5 - 10 years we will continue to promote the establishment of the plant community types that are shown in Table 2. Diversity in each type will occur on the ground by using the range of tree and shrub component targets and using different species mixes in the planting units that are identified prior to planting (Figure 3).

We believe that focussing on all of the links in the “reclamation chain” will continue to yield positive outcomes in the tree and shrub establishment program at Elkview Operations. This will feed directly into current Biodiversity Management Planning initiatives at Teck and will help to ensure that end land use objectives designated for the Elkview Property are realized.

Table 2. Plant community types that will be established through the reclamation program at Teck Coal Ltd., Elkview Operations.

Name	Tree Component (%)		Shrub Component (%)		Comments
	Conif.	Decid.	Tall	Short	
Coniferous	85 - 95	5 - 15	0 - 10	0 - 10	
Deciduous	5 - 15	85 - 95	0 - 10	0 - 10	
Coniferous - Deciduous	50 - 80	30 - 40	0 - 15	0 - 15	Tree component will be at least 85%
Deciduous - Coniferous	30 - 40	50 - 80	0 - 15	0 - 15	Tree component will be at least 85%
Tall Shrub	0 - 15	0 - 15	85 - 100	0 - 15	
Short Shrub	0 - 15	0 - 15	0 - 15	85 - 100	
Mixed Tall and Short Shrub	0 - 15	0 - 15	30 - 50	30 - 50	Shrub component will be at least 85%
Mixed Tree and Shrub	15 - 40	15 - 40	15 - 40	15 - 40	



Figure 3. Example of a 6 year old Deciduous-Coniferous plant community type on the Harmer West spoil, Elkview Operations.

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