Appendix 10

Reclaimed Vegetation

Vegetation Development on Reclaimed Lands at Coal Valley Mine, 1979-2003

Preliminary Results

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Introduction

Rehabilitation is being increasingly advocated as a way to reduce the negative ecological and social impacts of surface disturbances created by extraction industries (Province of Alberta 1992; Alberta Environmental Protection 1995), although there are few reference rehabilitated sites with which to evaluate success.

Coal Valley Mine (CVM) is approximately 90 km southwest of Edson via Highways 40 and 47. Coal mining has occurred in the area since the early 1900s, and systematic, documented revegetation efforts at CVM date from 1979. Coversoil for topping mine wastes was derived from stockpiles of varying lengths of storage or occasionally directly placed. Reclaimed sites were seeded with similar mixtures over the years and in the early years of the revegetation efforts, container stock and bareroot seedlings of native shrubs, trees and herbs were planted. Since 1996 only conifer seedlings have been planted.

The main objectives of this study are:

1. Characterize the vegetation on reclaimed lands with field sampling,
2. Characterize the pre-disturbance vegetation,
3. Analyze and interpret the results of the vegetation characterization with reference to the surrounding native vegetation types, and
4. Recommend reclamation practices to increase the diversity and abundance of native species on reclaimed lands.

As of October 2007, objective 1 has been achieved, the methodology for objective 2 has been identified, and objective 3 is in progress. Work will begin on objective 4 after 1 through 3 are accomplished, and is expected to be completed in late spring of 2008.

Materials and Methods

A detailed study of existing vegetation and site characteristics on reclaimed sites was developed for CVM. All areas for which detailed reclamation information exists were delineated and assessed. Valid polygons were determined to be those with no reseeding events. The Years-Since-Reclamation (YSR) was determined for each polygon, depending on the year of sampling, and ranged from 27 to three. Approximately 35 sample plots were

allocated to each YSR (n=765), distributed equally between valid polygons with the same YSR. Within each polygon, the sample locations were randomly located using a random point generator within a GIS application. These points were then uploaded to a GPS device for field work.

At each of these sampling locations, general site characteristics such as slope, aspect and surface roughness were collected. A 1 m by 1 m sample plot was established, and percent foliar cover of all vascular and common non-vascular taxa was visually estimated and the median height of individual taxa measured. Percent exposed mineral soil, litter, coarse fragments, moss, lichen cover and tree basal area were estimated. A photograph was taken at each sample location. Sampling was conducted July-August 2006 and 2007.

The surrounding pre-disturbance vegetation has been characterized in various mining permit applications for areas within or adjacent to the area under study, as well as for areas further afield. A comprehensive review of this information will allow for a characterization of the pre-disturbance vegetation and thus as a reference for the reclamation areas.

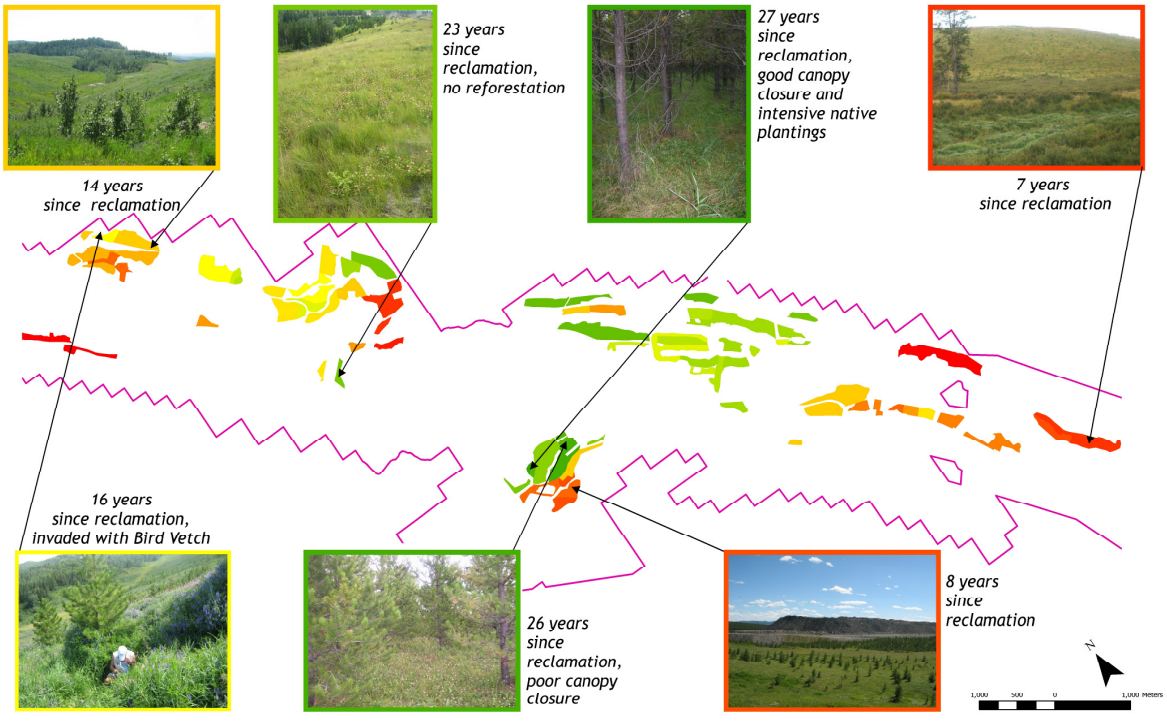

Figure 1 Characterization of reclamation polygons.

Preliminary Results

In the surveyed plots (n=765), 96 species were recorded. *Festuca rubra* , planted as part of the rehabilitation program, had the highest constancy (91%). *Taraxacum officinale* (59%) had the second highest constancy and was not intentionally seeded or planted. Nine species were recorded in only one plot, and 75 species (78%) had a constancy of less than 10%.

The percent foliar cover ranged from 310% to 6% with a mean of 110%. The mean species richness per plot was nine, ranging from 25 down to three. This lower number warrants investigation, because seven to nine species were seeded as part of the rehabilitation program, and often a number of other species were planted as seedlings.

Of the 765 plots sampled, 636 or 83% had at least one native species present. The average number of native species per plot was three, however the median was two. The maximum number of native species found in a plot was 20, and this was only found in a single plot.

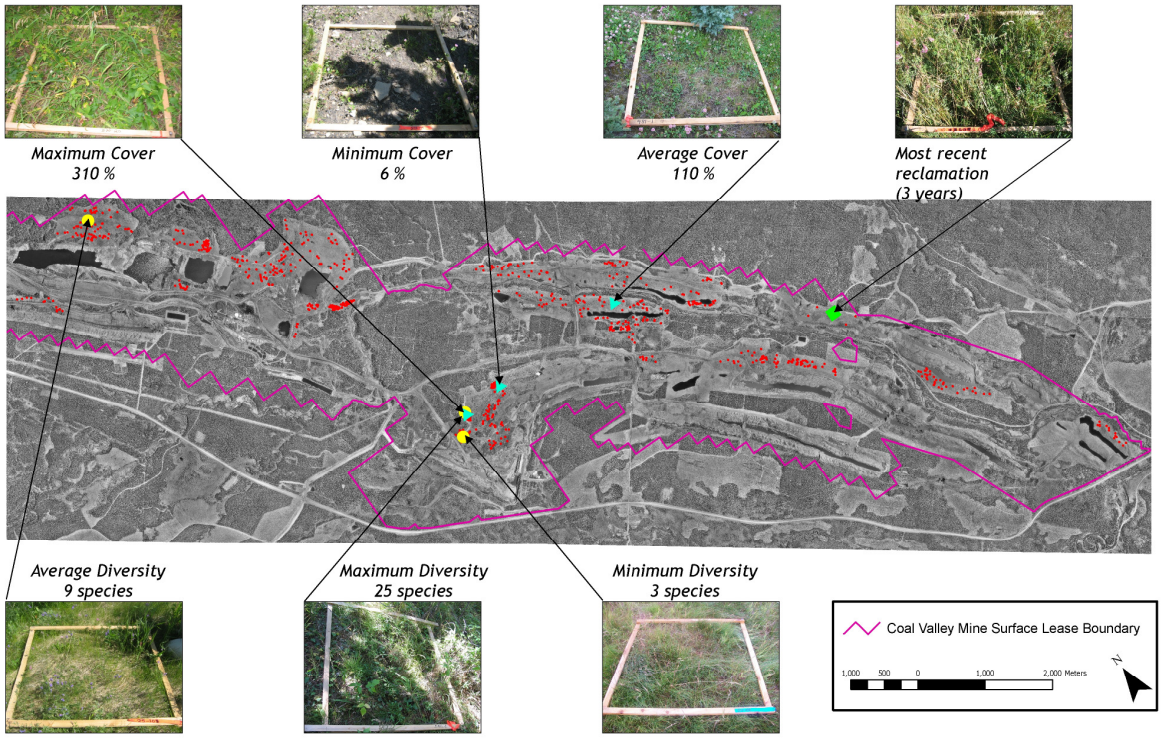

Figure 2 Examples of species diversity and foliar cover variation.

Native Species Richness and Abundance

Figure 3 shows the percentage of total cover contributed by native species and by species planted as part of the reclamation. Note that a species some reclamation species are native.

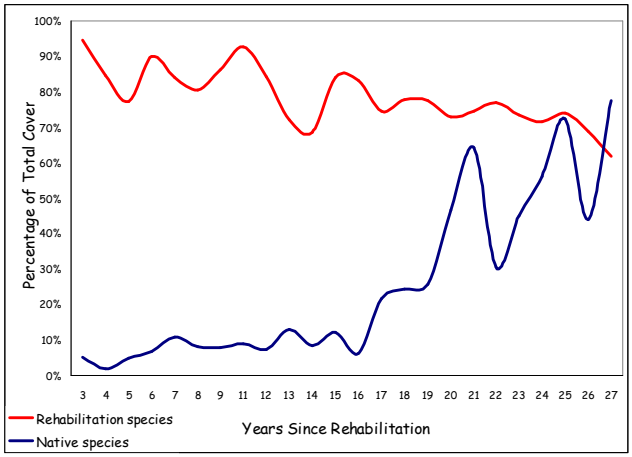

Figure 3 Variation of native and reclamation species percentage foliar cover over Years Since Reclamation.

The proportion of total cover made up of native species appears to increase with increasing age. However the proportion of reclamation species remains relatively constant. Because a species may be both native and reclamation, these results suggest that species other than those used in reclamation are increasing. It may, however, be the result of a more complex interaction between a variety of species. This warrants more detailed investigation into the change in native species over time in the sample plots.

Figure 4 shows native and reclamation species richness. An increase in native species richness is evident with time, and indeed a significant (p<0.01) correlation exists between native species richness and YSR.

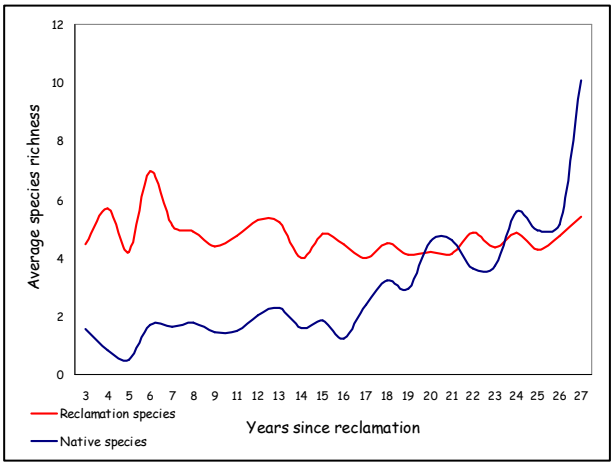

Figure 4 Variation of native and reclamation species richness over Years Since Reclamation.

However there is very little change in the number of reclamation species, specifically there is not a decrease over time. This would indicate that the increase in native species richness must be due to the invasion of native species that were not planted as part of the reclamation program. This finding also warrants further investigation, because there could be a number of factors at play. The reclamation species group is a coarse measure because it simply notes whether a

species was ever used in reclamation seeding or planting. It is not able to identify whether a species was planted at a particular site or not. A more detailed investigation of where and when certain native species used in reclamation were planted will allow for a better understanding of this relationship.

Also, non-vascular taxa are included in this analysis and the increase in richness could be due to a higher number of lichens and mosses.

Vegetation Classification

An objective of this study was to characterize the vegetation into communities. Initial work on classification has yielded mixed results but will be an area of focus in future analyses. In general, *F. rubra*, *P. contorta* and *Bromus inermis* tend to dominate the upper strata, but there is great variety in the lower strata. The presence of mosses appears to also be critical in the classification.

Future Investigation

Native Species Richness and Abundance

Areas of focus for future analyses include:

- The collection and interpretation of native species planting areas and years. This data does exist on a coarse level but an effort needs to be made to relate literature with physical locations.
- Analysis of field data to relate heights of native species with potential planting dates to determine if the species is likely a volunteer.
- Investigation of the relationship between increasing Lodgepole pine cover and increasing overall native species cover.

Vegetation Classification

The nature of the reclamation vegetation poses problems for traditional vegetation classification methods, as there is a high proportion of rare species in this data set. As noted, 78% of the species had a constancy of less than 10%. Future investigations will include an analysis of the appropriate species to be used in the classification, and the identification of the most appropriate classification methods.

Reference Pre-disturbance Vegetation

A literature review will be conducted of the available reports and investigations that have been conducted on CVM and surrounding areas. This will provide a reference for target vegetation communities.

Reclamation Recommendations

The foregoing information will be used to develop guidelines and recommendations as to how CVM can increase the diversity and abundance of native species in their reclaimed areas, with specific reference to upcoming reclamation activities.

Acknowledgements

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Appendix 1 – Species List*

Apiaceae	
Daucus carota	Wild carrot
Heracleum lanatum	Common cowparsnip
Asteraceae	
Achillea millefolium	Common yarrow
Antennaria microphylla	Littleleaf pussytoes
Antennaria neglecta	Field pussytoes
Aster ciliolatus	Ciliolate aster
Chrysanthemum leucanthemum	Ox-eye daisy
Cirsium arvense	Canada thistle
Petasites palmatus	Palmate-leaved coltsfoot
Taraxacum laevigatum	Red-seeded dandelion
Taraxacum officinale	Common dandelion
Betulaceae	
Alnus crispa	Green alder
Betula glandulosa	Bog birch
Boraginaceae	
Mertensia paniculata	Tall bluebells
Brassicaceae	
Erysimum cheiranthoides	Wormseed mustard
Caryophyllaceae	
Cerastium arvense	Mouse-ear chickweed
Stellaria media	mouse-eared chickweed
Cornaceae	
Cornus canadensis	Bunchberry
Cyperaceae	
Carex bebbii	Bebb's sedge
Carex siccata	Dryspike sedge
Equisetaceae	
Equisetum arvense	Field horestail
Equisetum sylvaticum	Meadow horsetail
Ericaceae	
Arctostaphylos uva-ursi	Bearberry
Vaccinium caespitosum	Dwarf bilberry
Vaccinium vitis-idaea	Cranberry
Fabaceae	
Astragulus cicer	Cicer milkvetch
Lotus corniculatus	Bird's foot trefoil
Medicago sativa	Alfalfa
Melilotus alba	White sweet clover

* Species list is incomplete due to the preliminary stage of this study. It is expected that more species will be added once collections have been finalized. This is particularly true for non-vascular taxa.

Fabaceae (cont)	
Melilotus offincinalis	Yellow sweet clover
Onobrychis viciifolia	Sainfoin
Oxytropis deflexa	Nodding locoweed
Trifolium hybridum	Alsike clover
Trifolium pratense	Red clover
Trifolium repens	White clover
Vicia americana	American vetch
Vicia cracca	Bird vetch
Gentianaceae	
Gentianella amarella	Dwarf gentian
Juncaceae	
Juncus sp	Rush
Lamiaceae	
Galeopsis tetrahit	Brittlestem hempnettle
Liliaceae	
Maianthemum canadense	Canada mayflower
Lycopodiaceae	
Lycopodium annotinum	Stiff clubmoss
Onagraceae	
Epilobium angustifolium	Fireweed
Ophioglossaceae	
Botrychium lunaria	Moonwort
Pinaceae	
Larix sibirica	Siberian larch
Picea glauca	White spruce
Pinus contorta	Lodgepole pine
Poaceae	
Agropyron dasystachyum	Northern wheatgrass
Agropyron trachycaulum	Slender wheatgrass
Agrostis scabra	Rough bentgrass
Agrostis stolonifera	Spreading bentgrass
Alopecurus aequalis	Short-awn foxtail
Bromus ciliatus	Fringed brome
Bromus inermis	Smooth brome
Calamagrostis canadensis	Canada bluejoint
Calamagrostis inexpansa	Northern reedgrass
Dechampsia cespitosa	Tufted hair grass
Elymus innovatus	Hairy wild rye
Festuca ovina	Sheep's fescue
Festuca rubra	Red fescue
Hordeum jubatum	Foxtail barley
Phalaris arundinacea	Reed canarygrass
Phleum pratense	Timothy
Polygonaceae	
Polygonum species	Polyganum species
Rumex triangulivalvis	Mexian dock

Pyrolaceae	
Orthilia secunda	One-sided wintergreen
Pyrola asarifolia	Liverleaf wintergreen
Ranunculaceae	
Ranunculus acris	Tall buttercup
Thalictrum sparsiflorum	Flat-fruited meadow rue
Rosaceae	
Fragaria virginiana	Virginia strawberry
Geum macrophyllum	Yellow avens
Potentilla norvegica	Norwegian cinquefoil
Rosa acicularis	Prickly rose
Rubus chamaemorus	Cloudberry
Rubus idaeus	American red raspberry
Rubus pubescens	Dwarf raspberry
Rubiaceae	
Galium sp.	Galium species
Salicaceae	
Populus balsamifera	Balsam poplar
Populus tremuloides	Trembling aspen
Salix discolor	Pussy willow
Salix pyrifolia	Balsam willow
Salix sp.	Salix species
Saxifragaceae	
Parnassia palustris	Northern grass-of-parnassus
Scrophulariaceae	
Castilleja miniata	Common red paintbrush
Violaceae	
Viola adunca	Early blue violet
Viola renifolia	Kidney-leaf White Violet

Lichens
Peltigera aphthosa
Peltigera canina
Cladonia cariosa
Cladonia cenotea
Moss
Dicranum spp.
Hylocomium splendens
Pleurozium schreberi
Ptilium crista-castrensis