SPECIES RICHNESS AT A SMALL METALS MINE NEAR AN ABUNDANT SOURCE OF NATIVE PROPAGULES

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ABSTRACT

Nyrstar Myra Falls mine is located within the boundaries of Strathcona - Westmin Provincial Park on Vancouver Island. Vegetation assessment of NMF's revegetated tailings disposal facility (TDF) seismic berm indicates the success of revegetation efforts in establishing cover, as well as modifying microclimates that support increased native species recruitment from local, proximate native seed sources. Via these processes, a site-specific, site-adapted, diverse vegetation community is forming. Planting programs at Myra Falls have been successful in establishing a high density of three native tree species, with 40 additional species establishing on the primary survey units of the upper TDF seismic berm, and 22 further species establishing along the lower portion of the TDF seismic berm, through processes of natural colonization. Native species percent composition is high, between 70-90%, despite being located near a roadway, which are known dispersal corridors for non-native species. The prevalence and proximity of native propagules in the area appear to be primary factors in the degree of successful germination and competition with non-native individuals for niche opportunities. Surveys conducted approximately 5 years following alder planting will help determine whether additional revegetation is required, or whether natural processes are likely to accomplish sufficient site revegetation within an acceptable timeframe.

Key words: Biodiversity, Reclamation, Revegetation, Native species, Seed sources

INTRODUCTION

Nyrstar Myra Falls (NMF) is a multi-metal (Zn-Cu-Pb-Ag-Au) mine located on central Vancouver Island, which has operated since 1966. Although current mining is underground, there are some areas of surface disturbance requiring reclamation and revegetation. Recent revegetation efforts have been directed at planting and seeding of woody species on the Tailings Disposal Facility (TDF), and at decommissioned infrastructure sites.

In 2012, the Integral Ecology Group Ltd. (Integral Ecology) conducted reclamation monitoring on revegetated portions of the TDF seismic upgrade berm. This monitoring focussed primarily on assessing the success of revegetation in establishing plants on the TDF seismic berm, and on documenting natural ingress of vegetation from adjacent ecosystems.

Three objectives of the 2012 revegetation and reclamation monitoring effort were to evaluate and document success of NMF's revegetation actions, in order that:

1. adjustments could be made to operational reclamation practice, where necessary;

2. to provide information on natural revegetation of surveyed reclaimed areas at NMF, to assemble information on the trajectory of vegetation-community recovery from disturbance; and
3. to demonstrate that vegetation recovery and reclamation management are contributing to fulfillment of NMF's reclamation obligations.

METHODS

Vegetation surveys were conducted between July 3 and July 5, 2012. Areas selected for survey were stratified by different treatment units according to material composition, planting history, and location into three areas: "Old Alder", "East Berm", and "West Berm". We refer to these three delineated survey areas as primary survey units. Permanent Sample Plots (PSPs) were selected with uniform spacing using GIS to achieve unbiased and roughly equal coverage of revegetated polygons. Circular 100-m^2 plots were generated at an intensity of approximately ten plots per ha.

At each PSP, information on plot characteristics, species presence and abundance, site history, and other comments/factors thought to be influencing vegetation response were collected. A map of survey unit polygons and PSP locations, as well as the Rip Rap and Low Road incidental areas, is provided in Figure 1.

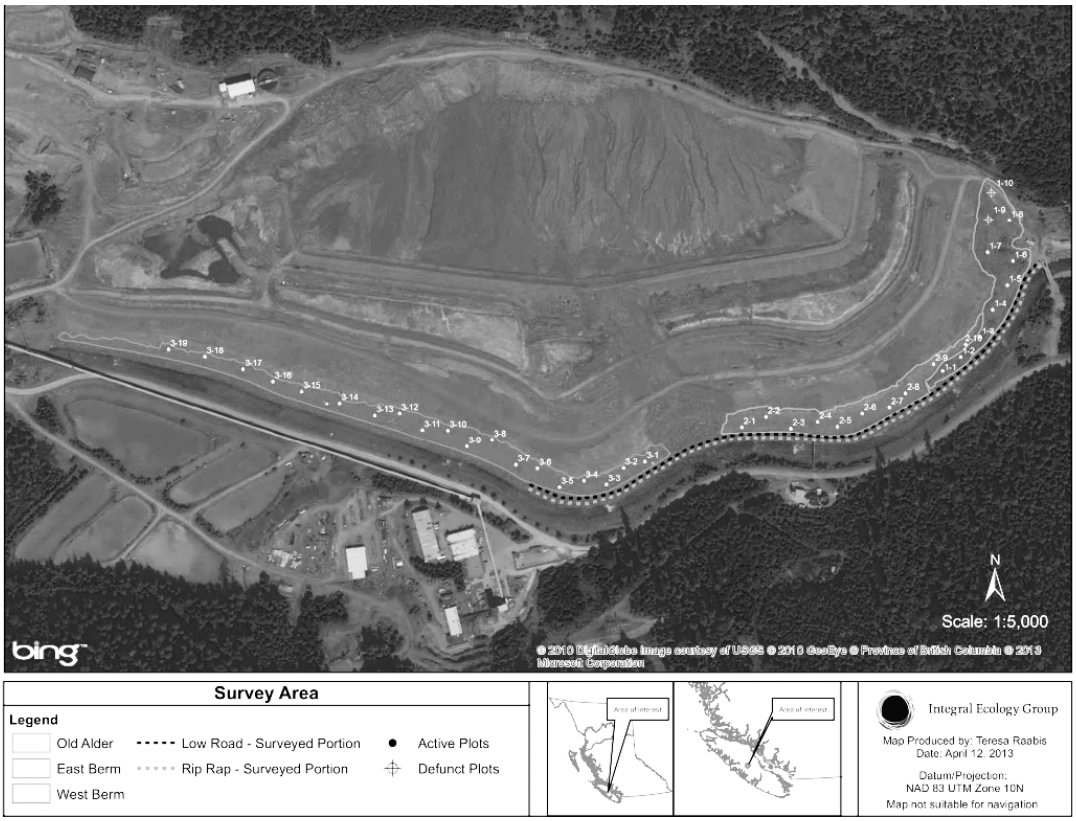

Figure 1. Map of primary survey units with associated plots, and incidental survey areas on the TDF at Myra Falls.

ANALYSES

Species accumulation

A species accumulation curve for the primary survey units was calculated by totaling newly observed species at each plot, and adding this number to the number of previously observed species until no new species were observed. The same process was used to calculate a second species accumulation curve that included incidental areas as well as the primary survey units, beginning with the number of species observed in the first incidental area, and adding to this the number of new species observed in the second incidental area, then proceeding to add new species observed by plot, as above.

Richness and Diversity

Species presence and percent cover were collected at each plot. Species richness was calculated as the number of individual species per plot or survey unit. Diversity was described using bar charts to plot species average abundance on a log scale for each survey unit. Species richness for incidental species observed in the adjacent incidental areas was calculated as the number of species observed in the Rip-Rap and Low Road areas. Species percent cover was not collected for these non-delineated areas, so only richness, and not diversity, of these areas is reported.

Native species

Species were labeled as native, introduced, or unknown according to status information provided by the B.C. Conservation Data Centre (2013). Species identification was according to the Illustrated Flora of British Columbia (1998 – 2002). For some species, particularly of the genus *Salix*, phenology of the plants did not coincide with presence of key structures; as well, small specimen sizes and browsing from wildlife, sometimes prevented species-level identification. The term *c.f.* is used to denote probable species identifications.

RESULTS

Total cover

Total vegetation cover was highest in the Old Alder survey unit, and generally quite low in the other two survey units. Litter presence was low overall, but highest in the Old Alder area. These findings were not unexpected, as the vegetation on the Old Alder survey unit is older, with larger seedling sizes and greater overall cover.

Table 1. Average plot composition by survey unit.

	Litter (%)	Woody Debris (%)	Vegetation (%)
Old Alder	0.6	<0.1	14.2
East Berm	0.2	<0.1	0.3
West Berm	0.2	<0.1	0.2

Species Accumulation

Information on the number of new species observed per plot surveyed is presented in Figure 2. These data indicate:

1. When plots of the primary survey units on the TDF are considered, the total number of different plant species observed is 43, over a surveyed area of 0.39 ha. The majority of these species are volunteers, as only three species, *Alnus rubra*, *Pseudotsuga menziesii*, and *Tsuga heterophylla*, have been introduced through revegetation on the TDF. Given the young age of this area, this is a relatively high, number of species, but not unexpected as the TDF is a small facility surrounded by undisturbed land with high vegetation cover and natural diversity, and thus by abundant seed sources.
2. Sampling intensity is currently high enough to capture the number of species establishing on the TDF. Species richness generally increases with area sampled, plateauing as ambient levels of richness are reached (Ugland *et al*. 2003). No new species were observed after 20 plots, demonstrating that PSP density is capturing current species richness of the primary survey areas.

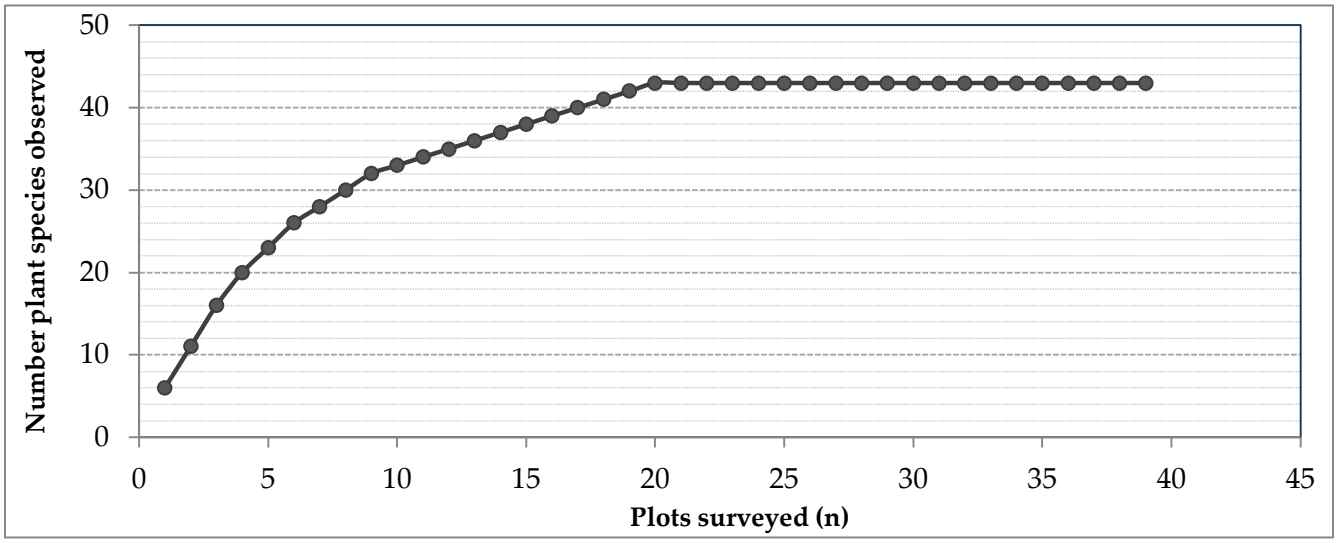

Figure 2. Species-accumulation curve for PSPs sampled on the Myra Falls TDF. Incidental species are not included.

Richness

Richness across plots varied, but in general richness was highest on the older Old Alder area (mean value of ~8 species per plot), and lower on the younger East Berm and West Berm areas (mean values of ~7 and ~6 species per plot, respectively), as shown in Figure 3.

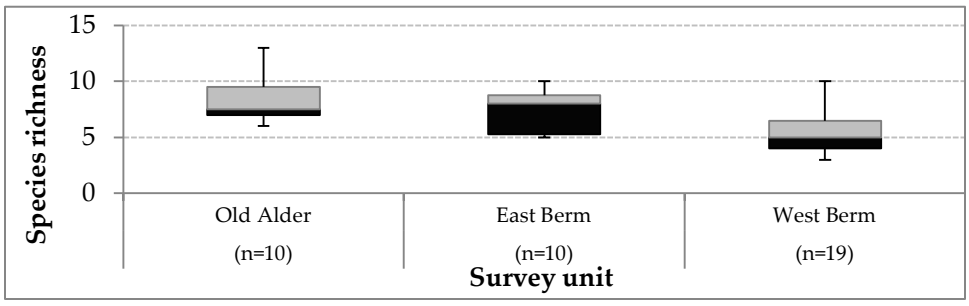

Figure 3. Species richness by survey unit. Boxes denote 25th, 50th, and 75th percentiles; the mean is the mid-point of the box; whiskers denote min and max values.

Diversity

Species cover at the Old Alder area was heavily dominated by Alnus rubra. Frequently observed secondary species with greatest cover were Pseudotsuga menziesii, Salix 1 spp. (not ID'd), Anaphalis margaritacea, Epilobium foliosum, Mycelis muralis, Calamagrostis canadensis, Cirsium vulgare, Salix hookeriana, and Salix 4 spp. (not ID'd) (Figure 4).

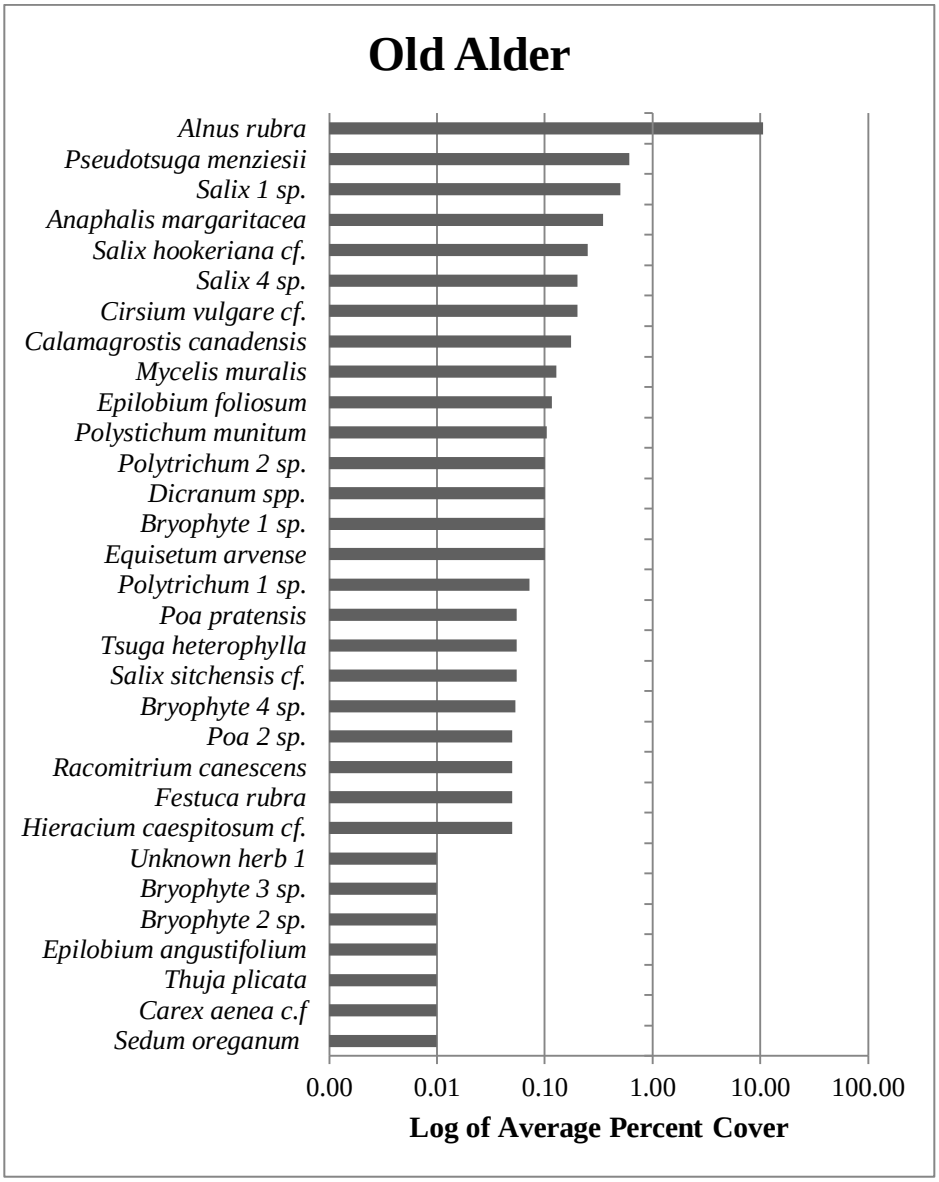

Figure 4. Species diversity and composition for the Old Alder survey unit.

Species cover on the East Berm was more evenly diverse than at the Old Alder area (Figure 5). The two most prevalent species were *Alnus rubra* and *Salix sitchensis cf*. Additional relatively abundant species included a shrub (*Salix hookeriana cf.*), a grass (*Festuca rubra*), a pteridophyte (*Polystichum munitum*), and a tree (*Pseudotsuga menziesii*). Maximum observed percent covers on the East Berm and West Berm survey units are an order of magnitude lower than on the Old Alder area, due to the young age and small size of established vegetation on the East and West Berm.

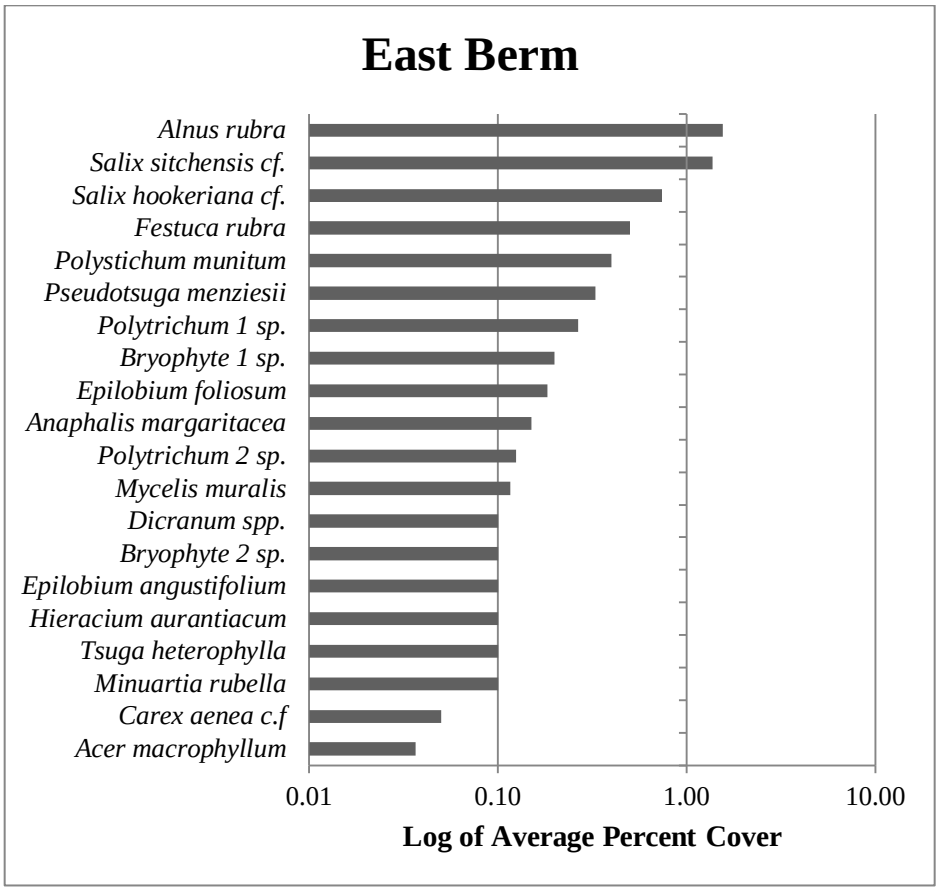

Figure 5. Species diversity and composition for the East Berm survey unit.

The most prevalent species on the West Berm area were the planted tree seedlings of *Alnus rubra* and *Pseudotsuga menziesii*. Species diversity was more even than in the Old Alder area but less than the East Berm. Secondary species included three *Salix* species and *Anaphalis margaritacea* (Figure 6).

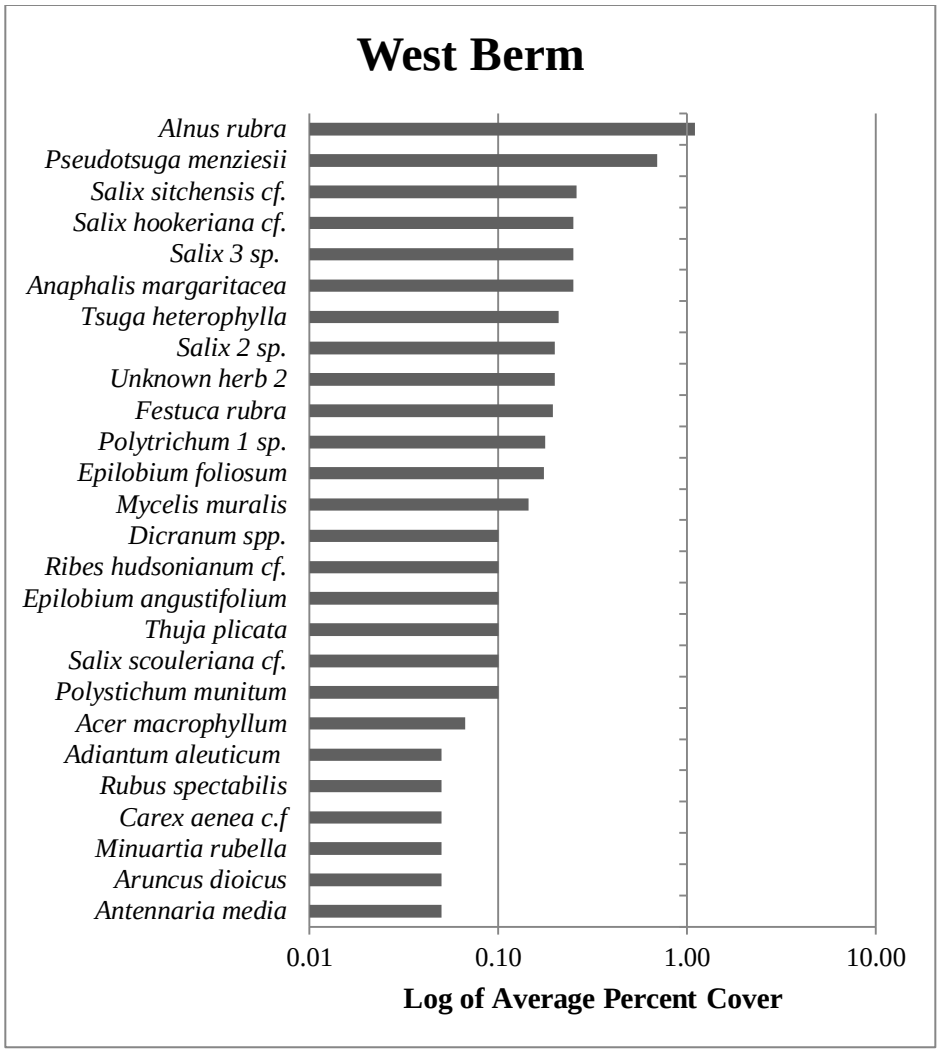

Figure 6. Species diversity and composition for the West Berm survey unit.

Composition

In terms of relative abundance of different vegetation types, tree species were generally responsible for the majority of observed cover, followed by shrubs, and then forbs (Figure 7).

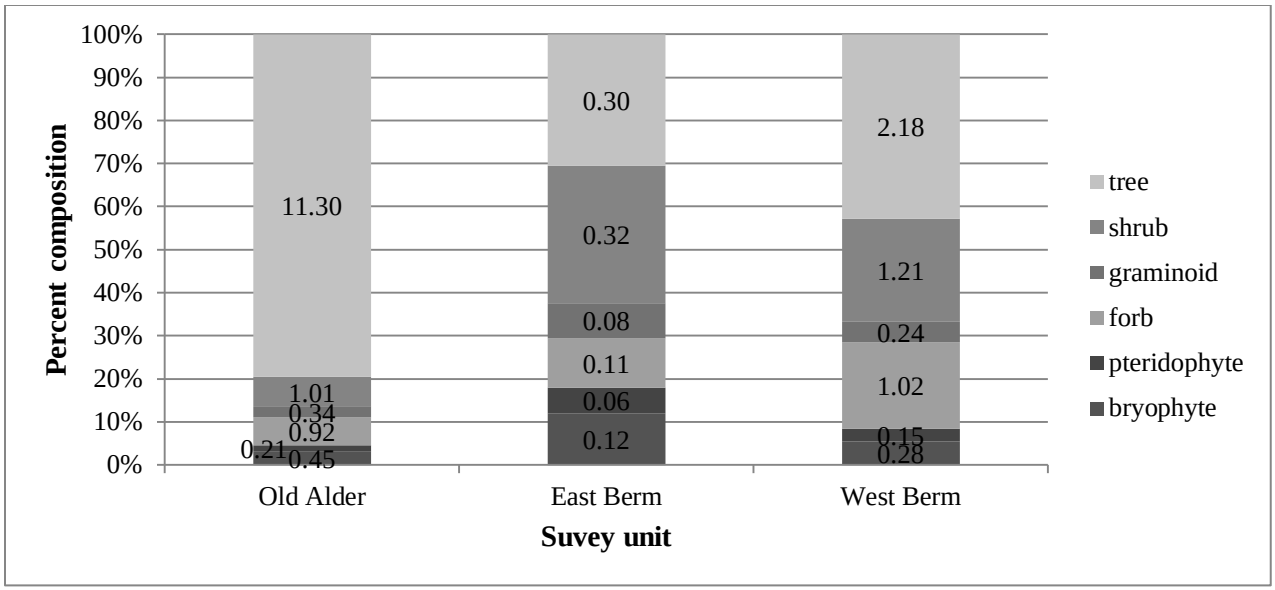

Figure 7. Vegetation percent composition by type for each survey unit. Bars represent relative percent cover while superimposed numbers represent absolute average percent cover.

Native species

The vast majority of species found on the TDF are native to British Columbia, with the highest percent composition in the Old Alder survey unit (~88%), and lowest in the West Berm survey unit (70%) based on average species abundance. Introduced species account for between 2% and 6% of total presence, and have highest absolute and relative composition values in the East Berm survey unit (Figure 8).

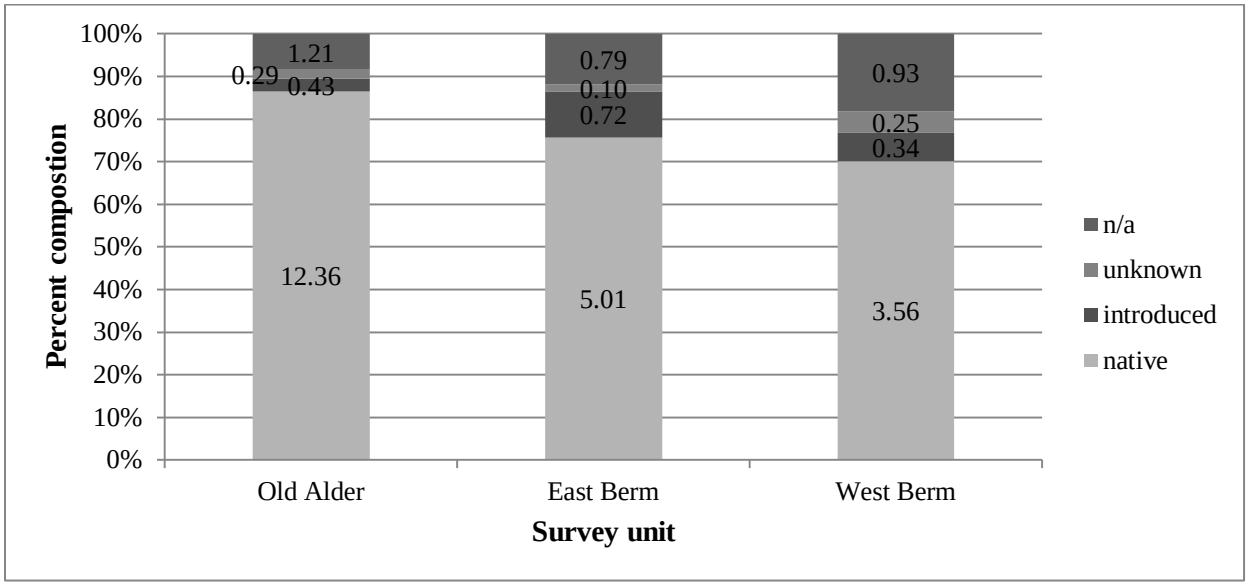

Figure 8. Percent composition by species origin for each survey unit. Bars represent relative percent cover while superimposed numbers represent absolute average percent cover.

Incidental Species

When the adjacent 'Low Road' and 'Rip-Rap' incidental areas (external to the primary survey units on the upper TDF) were assessed for incidental species, an additional 22 species were observed, bringing the total number of combined observed species on the TDF to 65. Including these incidental species in an accumulation curve further indicates that species richness has been adequately assessed for this general area, with no new species having been observed after 22 plots/areas were examined (Figure 9). Twelve species were identified in the Rip-Rap area (Table 2) and ten species were identified in the Low Road area (Table 3), that had not previously been observed in the primary survey units on the TDF.

Forbs composed the majority of vegetation within the incidental survey areas, and were co-dominant with shrubs in the Rip-Rap area. Vegetation along the Low Road was dominated by forb species (Figure 10). The majority of species found in the incidental areas are native, however a higher percentage of them are classified as having 'unknown' origin according to status information provided by the B.C. Conservation Data Centre (2013). Introduced species are a small component of overall species presence, and are slightly higher in the Low Road area as compared to the Rip-Rap area (Figure 11).

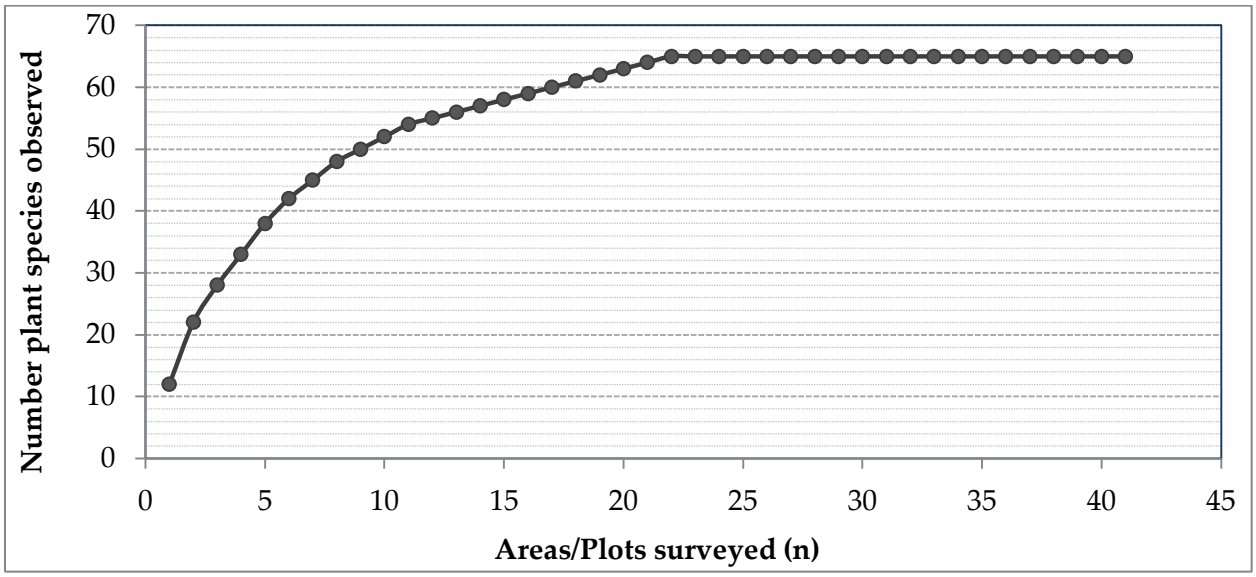

Figure 9. Species-accumulation curve for survey units and incidental areas sampled on the Myra Falls TDF. Incidental species recorded at the Low Road and Rip-Rap sites are included in the first two points on the graph.

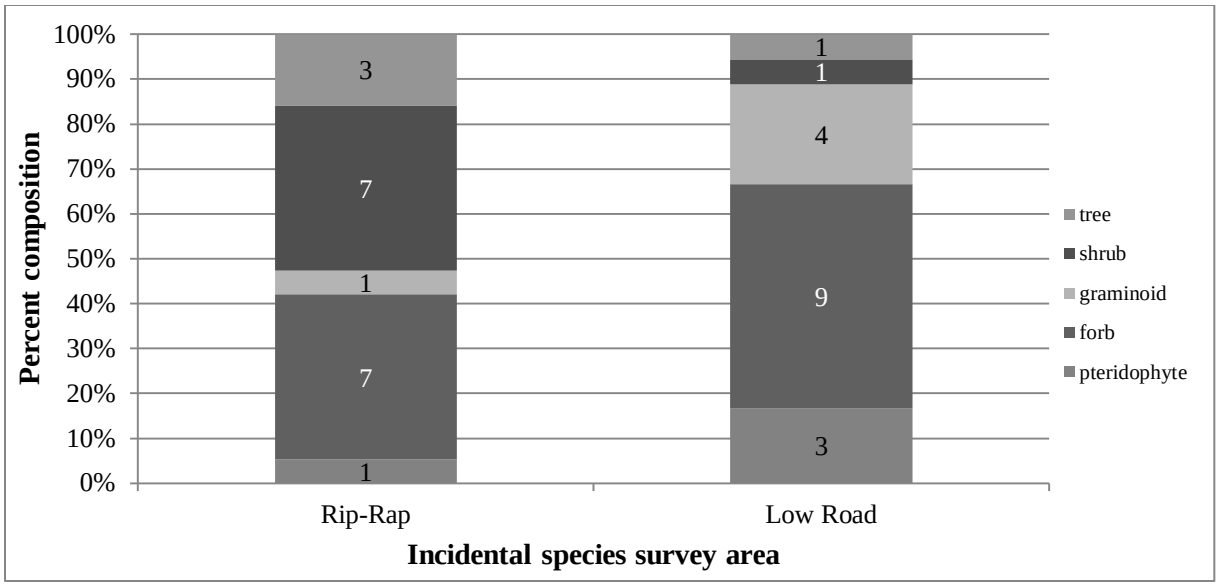

Figure 10. Vegetation percent composition by type for each incidental area. Bars represent relative richness while superimposed numbers represent absolute richness.

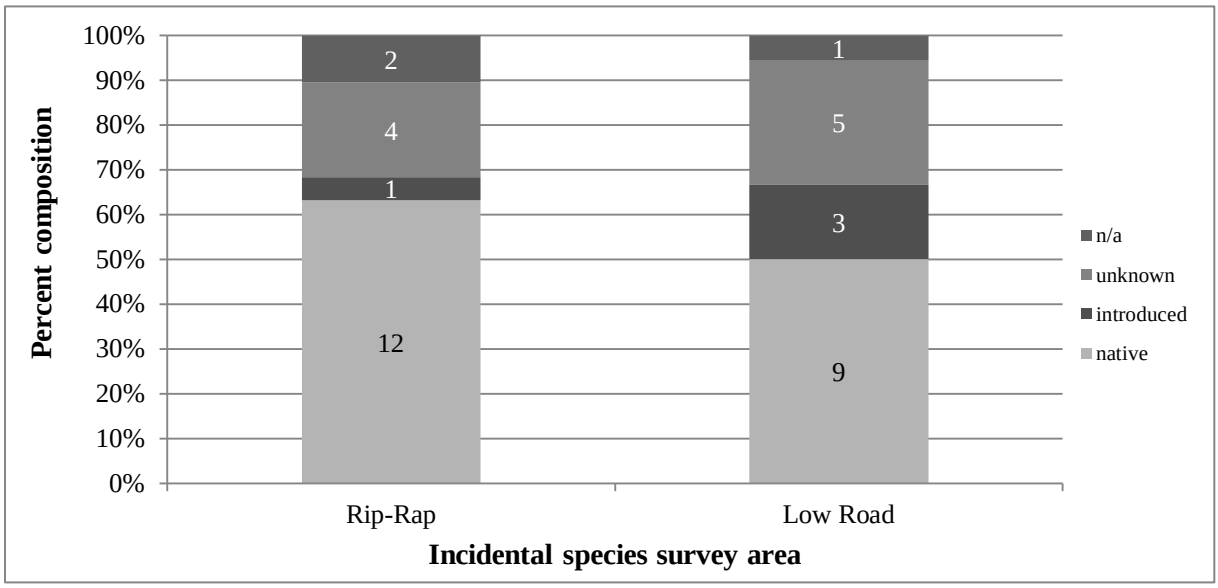

Figure 11. Percent composition of count by species origin for incidental area. Bars represent relative richness while superimposed numbers represent absolute richness.

Table 2. Incidental species observed in the Rip-Rap area. *Asterisk indicates a species observed only in this incidental survey area.

Species	Growth Form	Origin
*Aquilegia formosa	forb	native
*Dicentra formosa	forb	native
*Osmorhiza berteroi	forb	native
*Trautvetteria caroliniensis	forb	native
*Viola langsdorfii	forb	native
*Dryopteris carthusiana c.f.	pteridophyte	native
Alnus rubra	shrub	native
*Ribes bracteosum	shrub	native
Rubus spectabilis	shrub	native
Salix hookeriana c.f.	shrub	native
Acer macrophyllum	tree	native
Pseudotsuga menziesii	tree	native
*Lotus corniculatus	forb	introduced
Calamagrostis canadensis	graminoid	unknown
Ribes hudsonianum c.f.	shrub	unknown
*Rubus parviflorus	shrub	unknown
*Sambucus racemosa	shrub	unknown
*Unknown herb 3	forb	n/a
*Ribes sp.	shrub	n/a

Table 3. Incidental species observed in the Low road area. *Asterisk indicates a species observed only in this incidental survey area.

Species	Growth Form	Origin
*Collinsia parviflora	forb	native
*Minuartia tenella	forb	native
Sedum oreganum	forb	native
*Bromis ciliolatus c.f.	graminoid	native
*Carex concinnoides c.f.	graminoid	native
*Cryptogramma acrostichoides	pteridophyte	native
Equisetum arvense	pteridophyte	native
Polystichum munitum	pteridophyte	native
Thuja plicata	tree	native
*Camelina sativa	forb	introduced
Lotus corniculatus	forb	introduced
Mycelis muralis	forb	introduced
Epilobium angustifolium	forb	unknown
*Prunella vulgaris	forb	unknown
*Vicia sativa	forb	unknown

Poa pratensis	graminoid	unknown
*Sorbus sitchensis	shrub	unknown
*Poa 1 sp.	graminoid	n/a

DISCUSSION

The 2012 revegetation-monitoring program on the Nyrstar Myra Falls Tailings Disposal Facility seismic berm indicates the success of revegetation efforts in establishing an appropriate, diverse vegetation community, aided by the surrounding natural environment and available local seed pool. Planting programs have been successful at establishing a high density of native tree species, with 40 additional species establishing through processes of natural colonization.

Current species richness across the TDF is higher than would be expected at an average reclamation site with no surface-soil cover, due to the spatial dynamics at the facility, patch and disturbance size, the proximity of undisturbed adjacent seed sources (Turner 1989), and the relatively amenable climate. Inclusion of the nearby landscape context in reclamation and mine planning can have extensive and positive influences on outcomes of reclamation efforts (Corry *et. al* 2010). A thus revegetated community, as on the TDF at NMF, has qualities embedded in it that will facilitate its integration in the landscape (Bormann and Likens 1979) in the context of surrounding and shifting successional patterns.

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