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An evaluation of factors influencing spontaneous vegetation succession in northern latitude disturbances: Assessment of natural recolonization of disturbances in Yukon

By

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MERG is a cooperative working group made up of the Federal and Yukon Governments, Yukon First Nations, mining companies, and non-government organizations for the promotion of research into mining and environmental issues in Yukon.



AN EVALUATION OF FACTORS INFLUENCING SPONTANEOUS VEGETATION SUCCESSION IN NORTHERN LATITUDE DISTURBANCES: ASSESSMENT OF NATURAL RECOLONIZATION OF DISTURBANCES IN YUKON¹

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ABSTRACT

Twenty sites surveyed in Yukon in 2009 indicate that moisture availability is often a key limiting factor on natural recolonization of disturbed sites in the territory. In some cases, natural recolonization processes may also be impeded by a thickly established seeded cover, and at other sites, a seeded cover appeared to have no clear positive or negative effect relative to non-seeded sites. Five invasive species were identified at the sites surveyed, and predominantly occurred at seeded sites. The most commonly colonizing native species across the 20-site dataset are the balsam poplar (*Populus balsamifera*), willow (*Salix spp.*), and fireweed (*Epilobium angustifolium*) and common yarrow (*Achillea millefolium*).

Key Words: Yukon, natural revegetation, native species, reclamation, water availability

INTRODUCTION

The intent of this paper is to give an overview of results of an ongoing study of natural recolonization initiated in Yukon in 2009. The goal of this project is to provide field-verified information to help answer the following four questions:

1. What factors positively and negatively influence spontaneous revegetation and natural succession of disturbed sites in Yukon?
2. What are some of the key steps in spontaneous vegetation succession of disturbed sites in the Yukon? When do these typically occur and what conditions are linked to their evolution?
3. What are the similarities and differences between what is observed at i) Yukon sites, and ii) other areas of Canada and the world?
4. How can this information be applied to improve our restoration practices for disturbed sites in the Yukon?

Although the initial work in 2009 has only begun to answer these four questions and in some cases has raised other issues, the results to date do shed some light on some of the key influences and processes of sites that are undergoing natural recolonization in Yukon at various rates and

¹ Paper presented at B.C.'s 34th Annual Mine Reclamation Symposium and 35th Canadian Land Reclamation Association Conference September 20th to 23rd, 2010, Courtenay, BC. © British Columbia Technical and Research Committee on Reclamation, 2010

degrees of success. In the following pages, we will summarize the general study approach, and present some of the key results to date.

BACKGROUND AND METHODOLOGY

A selection of 20 disturbances (primarily made up of decommissioned borrow areas as well as some reclaimed disturbances of closed mine sites) were surveyed in 2009. This suite of sites spanned four ecoregions within the Boreal Cordillera ecozone, and an estimated time since decommissioning ranging from 8 to 80 years. Average annual precipitation at the sites varies from 270 to upwards of 700 mm (most sites in the range of 300 mm), and altitude from 340 to 900 masl. Nine of the twenty sites surveyed were seeded upon decommissioning.

Vegetation structure was quantified at both reference and disturbed stations through estimation of percent cover at the ground, 0 to 2m, 2 to 10m, and >10m vertical layers. Plant species inventories focused mainly on tree, shrub and forb species, and relative abundance of each species was recorded. Where possible, grass species were identified, but a systematic inventory of all grasses at a given site was not undertaken. Soils were described, and at some sites, grain size analysis performed. Degree of compaction was assessed by delivering a set number of blows to a 25cm spike and recording the depth of penetration into the substrate. Photo points were established at each site to allow for ongoing monitoring. Ages of the disturbances were determined through site reports and by age-bracketing using airphotos. The location of the local water table was determined using available site data, or in most cases, estimated through topographical inference.

RESULTS

Factors Influencing Spontaneous Revegetation and Natural Succession

Moisture Availability

At most of the twenty sites surveyed in 2009, moisture availability near the soil surface appeared to be the primary obstacle or restoration ‘filter’ affecting the rate of natural recolonization, species richness, and to natural succession of the site. Climatic influences, substrate characteristics, physical geometry of the site, and site preparation factors all appear to play a key role in positively or negatively influencing moisture availability for emerging seedlings in a disturbance. Although more data from higher-precipitation sites are needed, results from 2009 point to a total annual precipitation ‘breakpoint’ in the 400mm range – below this amount of precipitation, one would expect to see lack of moisture availability as an over-riding filter affecting natural recolonization of disturbed sites in Yukon.

The various aspects of moisture availability filters are best illustrated through examples from some of the sites. Figures 1 and 2 show two sites within 14 km of each other in the Klondike valley area of central Yukon. Although the disturbances differ in age by almost 40 years, the younger disturbance shows areas of abundant natural recolonization which appear to be largely due to slope aspect and a higher proportion of silt to clay-sized particles in the substrate.



Figure 1. Sparse recolonization at site KV-07, an approximately 50-year old decommissioned borrow pit located in central Yukon. At the clearing centre, all growth is less than 2m high with less than 5 percent cover. The primary filter to natural recolonization at this site appears to be low moisture availability as influenced by: i) low precipitation (325mm annually), ii) a low proportion of silt to clay-sized particles (7 percent), iii) location at least 10m above local water table, and iv) pebble ‘armouring’ of the smooth surface.



Figure 2. Abundant natural recolonization on a gentle north-facing slope at site KV-03, a decommissioned borrow pit (13 years previous) near the closed Brewery Creek Mine. This site is approximately 14 km from and 120m higher than site KV-07 shown in Figure 1, and has similar precipitation. However, the substrate at this site is relatively high in silt to clay-sized particles (estimated at greater than 20 percent), and the north-facing aspect serves to enhance moisture availability. On the other hand, the south-facing and flat sectors in the background show much lower natural colonization.

Seeded Cover

Nine of the twenty sites surveyed in 2009 were seeded upon decommissioning, and as expected and shown in Table 1, seeding did result in a markedly higher vegetative cover within the 0 to 2 metre layer at a site. However, the gains at seeded sites within the tree and high shrub layer where native species predominate (2 to 10 metres) are less marked, and overall, this study indicates no clear quantitative evidence that an initial seeded cover enhances or detracts from the native species richness and rates natural recolonization. This ambiguity is possibly a reflection of a relatively small sample set of sites across a variety of ecoregions, ages, and seed treatments; a much larger database of samples could permit more definitive conclusions.

Table 1. Estimated percent of vegetative cover by vertical layer at the stations surveyed at the twenty disturbed sites.

		>10m Layer Cover	2-10m Layer Cover	0-2m Layer Cover	Moss/ Lichen/ Liverwort Cover
Surveyed Stations at Non-Seeded Sites (n=32)	Median	0%	2%	25%	15%
	Mean	0%	7%	31%	20%
Surveyed Stations at Seeded Sites (n=16)	Median	0%	3%	44%	23%
	Mean	1%	11%	43%	25%

On a qualitative level, it could be seen that at some seeded sites, certain of the initial seeded cover species were still the dominant species some 10 to 20 years following seeding, and in some cases, that the seeded species were impeding the expected natural colonization. This was particularly evident where brome species (*Bromus spp.*) were included in the original seed mix and where the original seed application had taken well. One example is shown in Figure 3, a small borrow pit seeded in 1998. At this location smooth brome (*Bromus inermis*) became well-established along the clearing edge, a location where typically one would see the most rapid recolonization by local deciduous trees and shrubs. As a result, a thick grass fringe with very sparse colonization by trembling aspen and willow (*Populus tremuloides* and *Salix spp.*) has instead developed. Some sites with a heavy seeded cover also showed a heavy thatch development of dead material. While this thatch appeared to impede colonization of native forbs as well as shrubs and trees, it did serve to foster development of certain moss and lichen species in the moist environment at the underlying soil level.



Figure 3. Site KV-04, central Yukon, seeded in 1998. Along the clearing edge (arrows in main and inset photos), a thick cover of seeded smooth brome (*Bromus inermis*) is impeding natural encroachment of the surrounding tree and shrub species.

Some seeded sites show good balance between seeded and naturally colonizing species, such as is observed at site KL-02 in the Beaver Creek region of central-west Yukon (Figure 4). This site was decommissioned and seeded in the late 1990's, and has formed a moderate to sparse cover of grass and legumes (no brome species evident) that does not appear to impede the colonization of native species.



Figure 4. Site KL 02 in the Beaver Creek region of central-west Yukon, with integration of both seeded cover and spontaneous revegetation growth. This site receives just over 400mm of precipitation annually, approximately 25 percent greater than many sites in central and south-central Yukon.

Key Colonizing Species

As a first step towards answering questions of natural succession phases, the key colonizing species observed across the twenty sites surveyed were identified, with results and important observations presented below.

Trees

The most commonly colonizing native tree species across the 20-site dataset are the balsam poplar (*Populus balsamifera*), occurring at 13 of 20 sites, and trembling aspen (*P. tremuloides*) and white spruce (*Picea glauca*) at 11 of 20 sites. At most sites, tree height tended to be 2m or less. Alaska paper birch (*Betula neoalaskana*) and black spruce (*P. mariana*) were frequently observed at the Klondike valley sites of central Yukon. The Alaska paper birch in particular was noted as a frequent colonizer in zones where seed-producing trees are found nearby (eg. Brewery Creek Mine area, dredge tailings area near Dawson City).

Shrubs

Willow (*Salix spp.*) is the most common shrub observed, colonizing 16 of the 20 sites surveyed. Kinnikinnick (*Arctostaphylos uva-ursi*) was observed at 10 sites, and was most commonly observed encroaching into the clearing from adjacent natural vegetation. Soapberry (*Shepherdia canadensis*) occurs at 8 of 20 sites in the dataset.

Forbs

Fireweed (*Epilobium angustifolium*) was observed at 14 of the 20 sites, common yarrow (*Achillea millefolium*) at 13 of 20 sites, and arctic lupin (*Lupinus arcticus*) at 9 of 20 sites. Common yarrow was noted to take a predominant role in the more barren disturbances.

While not an ubiquitous species across all the sites survey, Drummond's mountain aven (*Dryas drummondii*), where occurring, grows vigourously both on exposed flat and sloped well-drained areas. With its spreading, woody habit and nitrogen-fixing properties (Lawrence et. al, 1967), this plant has been recognized as a pioneer species in glacial retreat areas, and may be a potential target restoration species in other disturbances in zones where it naturally occurs.

Grasses

As previously noted, while a systematic inventory of grass species was not conducted in this study, the contribution of grass was included in the vegetative cover estimate. In general, the sites surveyed showed some, but not an abundance of naturally colonizing grass species.

Mosses, Lichens, and Liverworts

Colonization by moss, lichen and liverwort species was observed at virtually all sites, ranging from fine cryptogamic crusts to much more voluminous and obvious growths. Of note is the occurrence of mosses of the *Polytrichum* genus and lichens from the *Stereocaulon* genus (probably *Stereocaulon paschale*, or wooly coral lichen), identified as colonizing several sites.

The *Stereocaulon* species was observed at several sites (KV-06, KV-07, KV-08, other undocumented sites along the North Klondike Highway, and at HR-01 on the Haines Highway). Closer examination of one of these zones at site KV-06 is shown in Figure 5 and reveals the development of a diverse moss and lichen community under the cover of the *Stereocaulon* lichen.

A systematic moss, lichen and liverwort inventory was not conducted, however given the key role that these plants are known to play in soil stabilization and nutrient cycle establishment (U.S. Department of the Interior, 2001), more in-depth study at disturbed sites may yield valuable insights of the processes of soil development and ensuing colonization by higher plants.



Figure 5. *Stereocaulon* sp. lichen colonization (left) and underlying moss and lichen community (right) at site KV-06, central Yukon.

Introduced and Invasive Species Occurrence

Five species were definitively identified in the survey as introduced, including: common dandelion, annual hawk's beard, alsike clover, white sweetclover, and smooth brome (*Taraxacum officinale*, *Crepis tectorum*, *Trifolium hybridum*, *Melilotus alba*, and *Bromus inermis*). All five of these are also tentatively ranked in Yukon as having invasive tendencies (Bennett, 2008). Several occurrences of undifferentiated mustard family were also noted (mainly from *Arabis* genus), some of which are likely introduced. Other species such as red fescue, common plantain, and undifferentiated wheatgrass (*Festuca rubra*, *Plantago major* and *Agropyron spp.*) were noted during surveys and are recognized in Yukon as having both native and introduced origins.

Of the five invasive species identified, the most commonly observed across the sites were the annual hawk's beard and the common dandelion, (at nine and seven of the twenty sites respectively). All five species show a propensity to occur at sites that had been seeded following abandonment (see Figure 6). At the 16 reference stations, the common dandelion was the only invasive species observed (at two sites in the Southern Lakes area). While annual hawk's beard was the most commonly observed across the disturbed sites, the relative abundance of this species along with common dandelion and alsike clover tended to be ranked at the survey Stations as 0.5 to 1, indicating presence, but not having a dominating effect. On the other hand at the stations where white sweetclover and smooth brome had colonized, relative abundance of these invasives tended to be ranked in the 2 to 3 range, indicating a dominant recolonizing species in the disturbance.

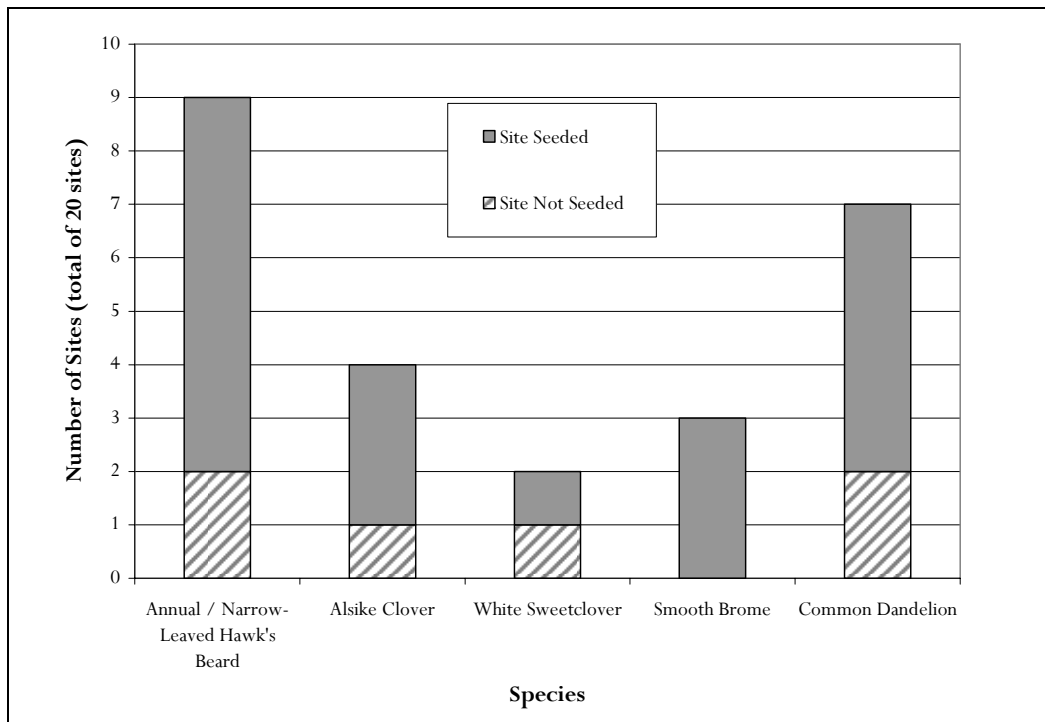


Figure 6. Occurrence of invasive species at seeded and non-seeded sites.

IMPLICATIONS TOWARDS RESTORATION PRACTICE IMPROVEMENT

Moisture Availability: Data from the sites studied in 2009 indicates that in lower precipitation areas of Yukon (eg. less than 400mm), or at sites with lower amounts of fines (silt and clay-sized particles), site preparation measures to enhance moisture retention are particularly important. These measures are noted below, and their effectiveness has been well-documented by other practitioners:

- the ‘rough and loose’ approach encouraged by Polster (2009) serves to provide sinks or traps for moisture and organic debris accumulation, and provides shelter for emerging seedlings. In higher precipitation areas or sites with excess clay and silt sized particles, this ‘rough and loose’ approach can also reduce erosion.
- woody debris placement on surfaces also creates moisture pockets as well as protection of emerging seedlings.

Use of Seeded Cover: The 2009 results demonstrate the increased potential for the occurrence of invasive species at sites where a seeded cover has been introduced. This issue should be carefully weighed into the decision when considering use of seed sourced from outside the immediate site, regardless of whether the seed is a ‘native’ or agronomic blend. As well, a thick seeded cover appears to have a negative effect on colonization by native forb, shrub and tree species, at least within the 10 to 20 year age range where the practice of seeding disturbances has been carried out.

FUTURE WORK

Analyses of the 2009 data will continue, and as possible, surveys will be conducted at other disturbed sites in Yukon, in particular, those sites in the 400 to 600mm precipitation range such as in the south to southeast region of the territory. Natural recolonization processes in Yukon are also under study by others, and more strength in the information will be achieved through the addition of data from more sites – not just those recorded by this study. Ultimately, it is the goal to collaborate with other groups to compile other existing natural re-colonization data from the North and assist in development of a spontaneous natural re-colonization database.

ACKNOWLEDGEMENTS

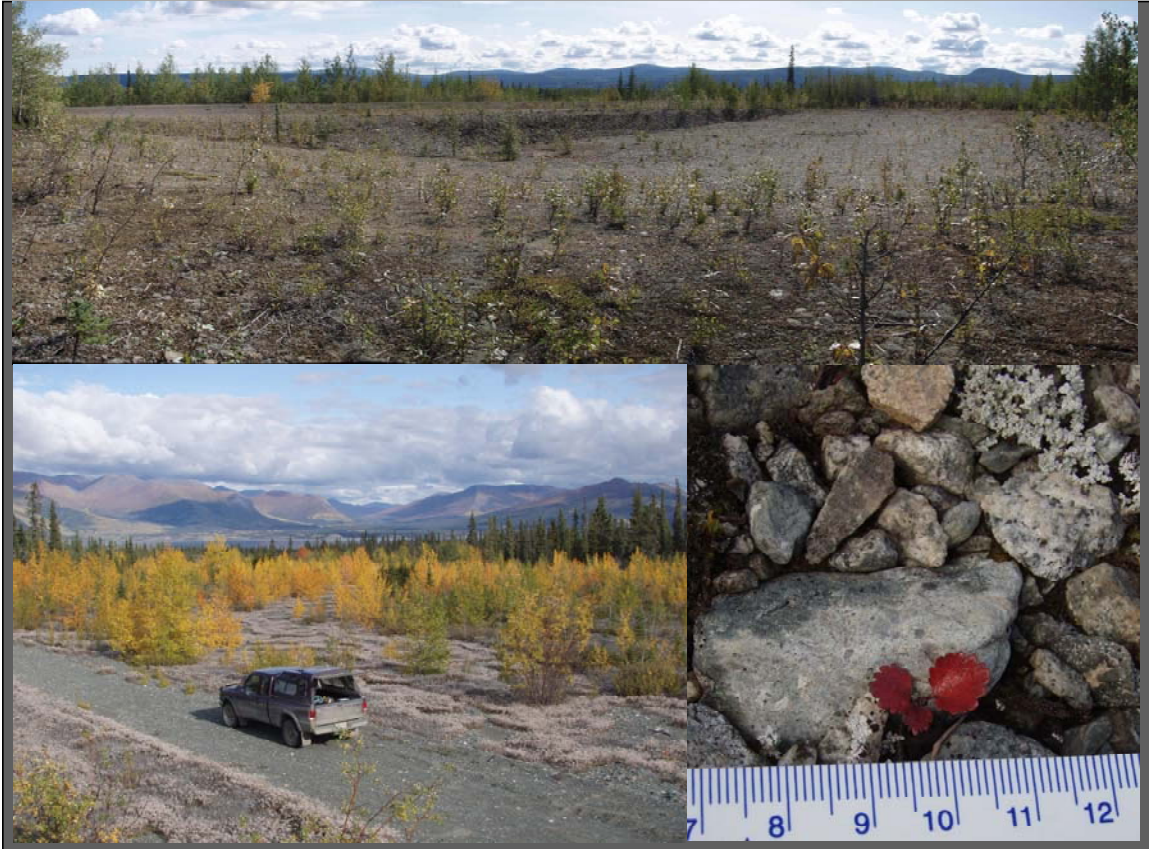
I'm very grateful to many organizations and individuals for their assistance in this study, to mention a few: i) the Mining and Petroleum Environmental Research Group and Northern Research Institute for project funding; ii) the Yukon Department of Highways and Public Works for providing access to their quarry database, providing suggestions of potential survey sites and performing grain size analyses; iii) Bruce Bennett of Environment Yukon for assistance with invasive species identification, iv) Stu Withers for plant taxonomy assistance, and v) Alexco Resource Corp. for providing accommodation during work at the Klondike valley sites, and for providing a tour and access to the Brewery Creek Mine site.

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An Evaluation of Factors Influencing Spontaneous Vegetation Succession in Northern Latitude Disturbances:

Assessment of Natural Recolonization of Historic Decommissioned Borrow Pit and Highway Sections in Yukon



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Table of Contents

1.0	Introduction.....	4
1.1	Purpose of Document	4
2.0	Background and Methodology	5
2.1	Overview	5
2.2	Site Selection	7
2.3	Surveys	7
2.3.1	Site Information.....	7
2.3.2	Station Information.....	9
2.4	Data Compilation.....	11
3.0	Results	12
3.1	Highlights of Surveys	12
3.2	General Site Characteristics	14
3.2.1	Substrate Characteristics.....	14
3.3	Occurrence and Relative Abundance of Vegetation	15
3.3.1	Cover Distribution	15
3.3.2	Species Richness.....	15
3.3.3	Colonizing Species	18
3.3.4	Commonalities and Uniqueness – Disturbed Site and Surrounding Vegetation	19
3.4	Influence of Seeded Cover.....	27
3.5	Introduced and Invasive Species Occurrence	30
3.6	Filters to Natural Colonization	31
4.0	Discussion and Conclusions.....	35
4.1	Colonization Characteristics of Key Species.....	35
4.2	Potential Colonizing Order	36
4.3	Influence of Filters	38

4.4	Study Limitations.....	38
5.0	Recommendations	39
5.1	Implications for Practice	39
5.1.1	Additional Information.....	39
6.0	Acknowledgements.....	40
7.0	References	40

List of Tables

Table 2-1	Site Information Parameters
Table 2-2	Vegetation Layers Described in this Study
Figure 2-3	Relative Abundance of Species
Table 3-1	Reference – Disturbance Species Commonalities within the 0-2m Layer at Study Sites
Table 3-2	Disturbance-Unique Species within the 0-2m Layer at Study Sites
Table 3-3	Reference Site-Unique Species within the 0-2m Layer at Study Sites
Table 3-4	Comparison of Estimated Cover between Non-Seeded and Seeded Sites
Table 3-5	Potential Negative and Positive Filters Considered in Site Assessments
Table 4-1	Summary Characteristics of Key Colonizing Species Identified in Study

List of Figures

Figure 2-1	Map of Yukon and Surroundings Showing Location of the Twenty Study Sites
Figure 3-1	Dredge tailings pile, 80+ years recovery
Figure 3-2	Site SL-01, Southern Lakes region approximately 25-35 years' recovery
Figure 3-3	Site SL-04, recovering for 20+years
Figure 3-4	Site KL-04, recovering for less than 10 years
Figure 3-5	Distribution of Estimated Percent Cover Data for Disturbed Stations
Figure 3-6	Stereocaulon sp. lichen colonization
Figure 3-7	Edge encroachment of kinnikinnick (shown by red arrow) at site SL-02 near Whitehorse
Figure 3-8	Site KV-04, Klondike River basin region, seeded in 1998
Figure 3-9	Site SL-02, agronomic cover seeded in 1988
Figure 3-10	Site KL-02, seeded approximately 1997, showing soil development below the clover-dominated cover
Figure 3-11	Site KL 02 in the Beaver Creek region of central-west Yukon, with integration of both seeded cover and spontaneous revegetation growth
Figure 3-12	Occurrence of Invasive Species at Seeded and Non-seeded Sites
Figure 3-13	Sparse recolonization at site KV-07, an approximately 50-year old decommissioned borrow pit located in central Yukon
Figure 3-14	Abundant natural recolonization on a gentle north-facing slope at site KV-03, a decommissioned borrow pit (13 years previous) near the closed Brewery Creek Mine
Figure 3-13	Sparse recolonization at site KV-07, an approximately 50-year old decommissioned borrow pit located in central Yukon

APPENDICES

A	Table of Common and Scientific Names for Plants Referenced in this Study
B	Photographs of Study Sites
C	Compiled Study Data

1.0 Introduction

1.1 Purpose of Document

This document presents the results of surveys of natural plant recolonization conducted during summer and fall 2009 at 20 disturbed sites located in central, south, and southeast Yukon. The objective of the surveys was to provide field-verified information to help answer the following four questions:

1. What factors positively and negatively influence spontaneous revegetation and natural succession of disturbed sites in Yukon?
2. What are some of the key steps in spontaneous vegetation succession of disturbed sites in the Yukon? When do these typically occur and what conditions are linked to their evolution?
3. What are the similarities and differences between what is observed at i) Yukon sites, and ii) other areas of Canada and the world?
4. How can this information be applied to improve our restoration practices for disturbed sites in the Yukon?

2.0 Background and Methodology

2.1 Overview

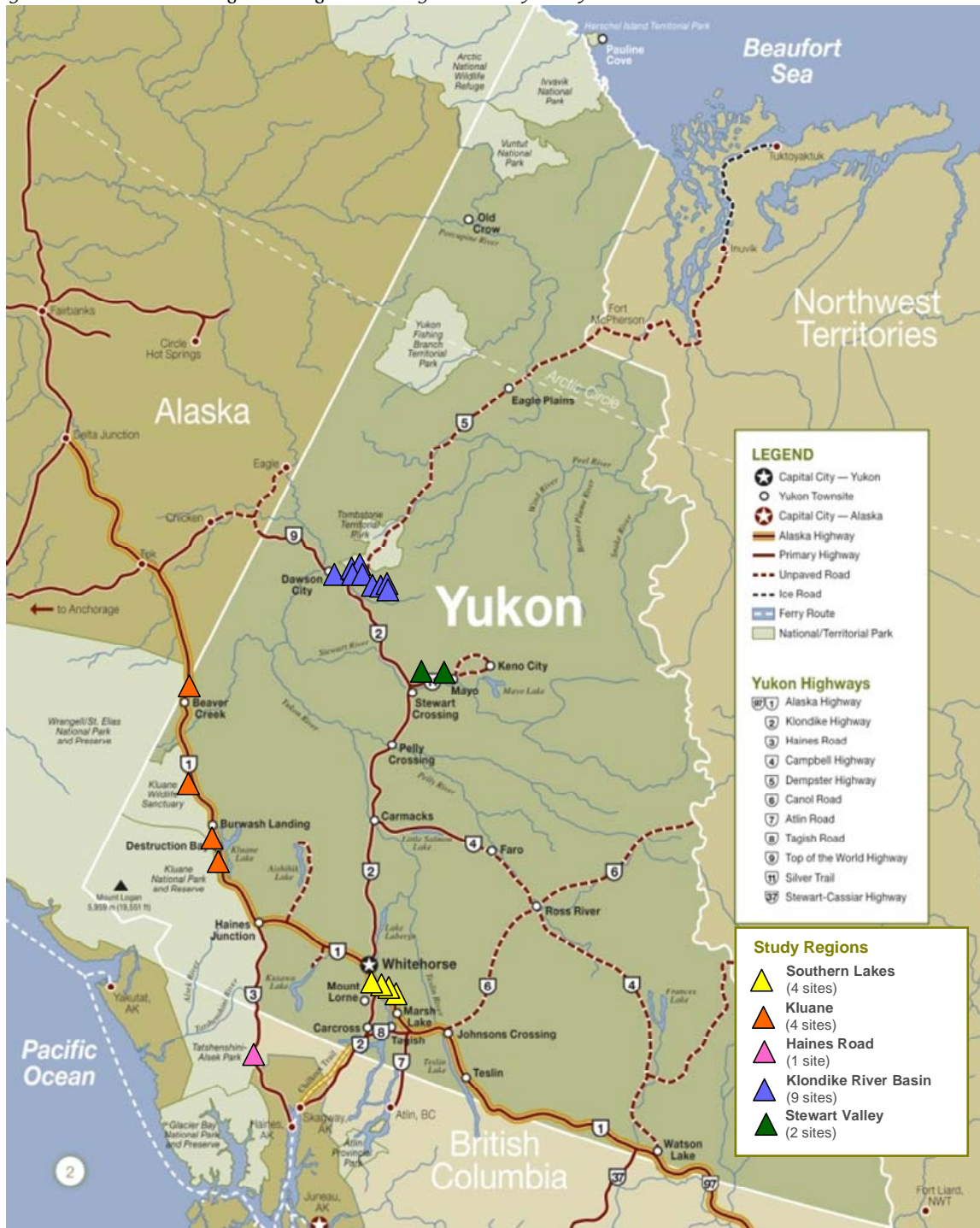
A selection of 20 disturbances (primarily made up of decommissioned borrow areas as well as some reclaimed disturbances of closed mine sites) were surveyed in 2009. This suite of sites spanned four ecoregions within the Boreal Cordillera ecozone, and an estimated time since decommissioning ranging from 8 to 80 years. Average annual precipitation at the sites varies from 270 to upwards of 700 mm (most sites in the range of 300 mm), and altitude from 340 to 900 masl. Nine of the twenty sites surveyed were seeded upon decommissioning.

Site locations are shown in Figure 2-1. Detailed locations and descriptions of each site are provided in Appendix C.

Field research for the study was conducted Yukon-Canada Scientist and Explorers Act License #09-79S&E. Permission to enter the one study site (SL-01) on a First Nation land parcel was obtained from Kwanlin Dün First Nation.

Figure 2-1
 of Yukon and Surroundings Showing Location of the Twenty Study Sites

Map



2.2 Site Selection

Yukon Government Department of Highways and Public Works provided details of borrow pits located along major highways of interest, and these sites were reviewed prior to field work. Certain areas were identified as being of specific interest including several of the Shakwak project borrow areas utilized through the 1990's, and the Stonehouse Creek quarry site on the Haines highway for which it had been decided to forego the conventional seeding approach and allow the site to natural recolonize (Yukon Highways and Public Works, 2008). The area of the Brewery Creek Mine was also identified as potential candidate sites since reclamation measures are well-documented and inventories of naturally recolonizing plant surveys have been carried out at the site during routine vegetation monitoring of the site (LaBerge Environmental Services, 2009).

Most other sites were selected while in the field based on their characteristics. Several sites were discounted due to ongoing disturbance.

2.3 Surveys

2.3.1 Site Information

Table 2-1 shows all the site information parameters recorded during the study. The field survey of a selected site began with establishment of one or more panorama photo points of the disturbance to provide a baseline for any future monitoring. The disturbance type (eg. road cut, decommissioned borrow pit, tailings pile) and approximate size were noted, and other parameters such as distance from active highway, proximity to active facilities, and evidence of reclamation work performed were recorded. The final step during the site survey was to note any special characteristics observed at the particular Site, as well as factors that appeared to be limiting or encouraging natural recolonization. Back in the office, other site parameters including climate and ecological, and land-related information were added to the database.

Table 2-1

Site

Information Parameters

Parameter	Description	Data Source(s)
1. Surface Tenure	Ownership of land (Crown Land, private tenure, or First Nations Settlement Land)	Yukon Mining and Lands Viewer ¹
2. Site Location	Longitude, latitude, elevation range	Handheld Garmin 60CSx GPS
3. Photo Point Location	Longitude, latitude, elevation, azimuth	Handheld Garmin 60CSx GPS and Silva Ranger Compass
4. Disturbance Type	Brief description of the cause and nature of the disturbance (eg. decommissioned borrow pit, road cut, dredge tailings pile)	
5. Size of Disturbance	Order of magnitude estimate (ha) of the contiguous size of the disturbance.	Visual (for 1-2ha disturbances). Site Reports Google™ earth
6. Estimated Disturbance Age as of 2009	Earliest and latest estimated disturbance dates, estimated disturbance age as of 2009, and dating method used	Air photos Site Reports or Other Historical Records
7. Distance from Active Highway	Approximate distance from active highway	Google™ earth Site Reports
8. Nearby Active Facilities	Active facilities within 1km (eg. towns, industrial activity, campground)	Field observation
9. Ecozone	Ecozone as defined by the National Ecological Framework for Canada ²	EcoAtlas of Canada metadata ³
10. Ecoregion	Ecoregion as defined by the National Ecological Framework for Canada	EcoAtlas of Canada metadata

¹ Yukon Mining and Lands Viewer, available through the Government of Yukon Energy, Mines and Resources website:
http://www.emr.gov.yk.ca/mlv_jump.html

² See: <http://sis.agr.gc.ca/cansis/nsdb/ecostrat/intro.html#overview>

³ EcoAtlas of Canada in ESRI Shape File format <http://geogratis.ca/geogratis/en/option/select.do?id=FB148951-6AF6-33FA-4EDA-ED26B8B579A1>

Parameter	Description	Data Source(s)
11. Climate	Mean annual precipitation and temperature of nearest climate station, source of climate data	Environment Canada Canadian Climate Normals 1971-2000 ⁺ Local Reports as available
12. Previous Reclamation	Site preparation, seeding, other work, and data source	Field observation Site Reports
13. General Notes	Other pertinent information such as previous studies, special notes on data entered in other fields	Site Reports Field observation
14. Possible Factors Controlling Recolonization Success	Based on site survey, any obvious controlling factors to recolonization (eg. moisture availability, aspect)	Field observation
15. Other Comments	General observations of the site, including any special occurrences of species	Field observation

2.3.2 Station Information

Within each of the 20 Sites, ‘Stations’ were established to recorded vegetation and soil characteristics in further detail.

For almost all sites, a nearby undisturbed location, or ‘Reference Station’ was surveyed in order to document characteristics of the local environment. At sites in close proximity to one another such as on the lower Dempster Highway, one reference station served for more than one site.

At each station, location was recorded using a handheld Garmin 60CSx GPS with indicated accuracy in the order of $\pm 4\text{m}$, and one or more photographs taken. General soil characteristics were noted.

Vegetation was assessed in vertical ‘layers’, using a system adapted from the B.C. Field Manual for Describing Terrestrial Ecosystems (B.C. Ministry of Environment, Lands and Parks, and B.C. Ministry of Forests, 1998). The description of layers is given in Table 2-2.

⁺ See: http://www.climate.weatheroffice.gc.ca/climate_normals/index_e.html

Table 2-2

Vegetation

Vegetation Layers Described in this Study

This Study		BC MELP / BC MoF, 1998	
>10m Layer	All plants > 10m tall ¹	A – Tree Layer	All woody plants >10m tall
2-10m Layer	All plants 2-10 m tall ^a	B1 – Tall Shrub Layer	All woody plants 2 10m tall
0-2m Layer	All plants 0-2m tall (includes herbaceous and woody plants)	B2 – Low Shrub Layer	All woody plants <2m tall, except low (<15cm) woody or trailing plants
		C – Herb Layer	All herbaceous species regardless of height, and some woody plants less than 15 cm tall
Ground Layer	<ul style="list-style-type: none"> • “Ground-hugging” species such as moss, lichen, liverwort • Plant litter • Exposed rock and soil 	D Layer	moss, lichen, liverwort and seedlings
		E Layer	epiphyte

^a in Yukon plants over 2m tall are woody species by default

Within each layer, species were identified and noted, with particular emphasis on trees, shrubs, and forbs. Herbarium samples and photos were taken of questionable species for follow-up taxonomy with a local vegetation specialist. Grasses, not intended as the focus of this study, were identified as possible.

Introduced and invasive species were identified by cross-referencing against the Introduced Plants of the Yukon list (2008 revision by Bennett).

Observed species at each station were assigned a ‘relative abundance’ value, in accordance with the criteria shown in Table 2-3.

Figure 2-3

Relati

ve Abundance of Species

Value	In Layer with More than One Species	In Layer with One Species
3	Prevalent – distinctly the most frequently occurring species	≥ 50% cover
2	Very Common – occurs more frequently than any other species	25-49% cover
1	Present but not in large numbers relative to other species	10-24% cover
0.5	Infrequent relative to other species	3-9% cover
0.25	Rare relative to other species	<1 to 2% cover
0	Does not occur in area	0% cover
-1	Species noted to occur but abundance not noted	Species noted to occur but abundance not noted

2.4 Data Compilation

Field data and supplementary site data obtained from sources in Table 2-1 were compiled into excel spreadsheets to facilitate data maintenance and analysis. XLStatTM was utilized as required to produce statistical plots.

3.0	Results	12
3.1	Highlights of Surveys.....	12
3.2	General Site Characteristics	14
3.2.1	Substrate Characteristics	14
3.3	Occurrence and Relative Abundance of Vegetation.....	15
3.3.1	Cover Distribution	15
3.3.2	Species Richness	15
3.3.3	Colonizing Species.....	18
3.3.4	Commonalities and Uniqueness – Disturbed Site and Surrounding Vegetation...	19
3.4	Influence of Seeded Cover	27
3.5	Introduced and Invasive Species Occurrence	30
3.6	Filters to Natural Colonization.....	31
4.0	Discussion and Conclusions	35
4.1	Colonization Characteristics of Key Species	35
4.2	Potential Colonizing Order	36
4.3	Influence of Filters	38
4.4	Study Limitations	38
5.0	Recommendations	39
5.1	Implications for Practice	39
5.1.1	Additional Information	39
6.0	Acknowledgements.....	40
7.0	References.....	40

3.0 Results

This section highlights some of the key results of the study; the reader is also referred to Appendix B and C for photographs of each site and the compiled data.

The discussion herein refers to plant species by common name where possible. A list of the common names used in this study and associated scientific name is given in Appendix A.

3.1 Highlights of Surveys

The 2009 field work illustrated sites with a diversity of colonization challenges and in various degrees of natural recovery.

What was overall surprising to the author was that in many cases, time did not seem to be an overriding factor in the advance of colonization or natural succession. Certain disturbed sites, abandoned for less than 10 years, often showed more advanced recovery than those in the 30 to 50 year range. Figures 3-1 through 3-4 illustrate certain examples of the variety of site recoveries and respective ages.

Figure 3-1 Dredge tailings pile, 80+ years' recovery



Figure 3-2 Site SL-01, Southern Lakes region approximately 25-35 years' recovery



Figure 3-3 Site SL-04, recovering for 20+ years, showing extensive seeded grass and legume cover but virtually no growth of trees.



Figure 3-4 Site KL-03, recovering for less than 10 years, showing extensive recolonization. See also Figure 3-11, section 3.4.



3.2 General Site Characteristics

3.2.1 Substrate Characteristics

Sites showed a broad range of soil textures, but nonetheless, given that the majority were decommissioned borrow sites, most of the material is of glacial-fluvial origin. Predictably, grain size analyses performed on a selection of sites indicated the material to range from poorly to well graded mix of silt, sand, and gravel. One site located within the Klondike River valley tailings piles consisted

primarily of cobble to boulder-sized material with minimal fines. A site on the decommissioned leach pad at the Brewery Creek Mine site is underlain by a predominantly silt-textured capping material.

Some sites showed residual compaction in certain areas, particularly within the lower platform of a borrow pit where presumably most of the vehicular traffic occurred.

Based on either topographic inference, local occurrences of water bodies, or groundwater well data, the majority of sites and stations were situated well above (>10m) the local water table.

3.3 Occurrence and Relative Abundance of Vegetation

3.3.1 Cover Distribution

As mentioned in the methodology section (2.0), due to the tendency for many disturbances to have extremely low vegetation density, percent vegetation cover was not estimated on an individual species basis, but on a layer basis.

Figure 3-5 illustrates the overall results and tendencies by vertical vegetation layer. As seen, most coverage in the disturbed stations occurs within the 0 to 2m layer – although even within this layer, estimated cover ranges broadly from 1 to 80 percent. At some sites, a seeded cover is contributing to the total cover in this layer (see section 3.4 for further discussion of the role of seeded cover).

3.3.2 Species Richness

Richness, the number of species within a given area, was calculated for the 0 to 2m layer of disturbed sites. This layer demonstrates the greatest overall cover and tends to represent most if not all species identified in the study.

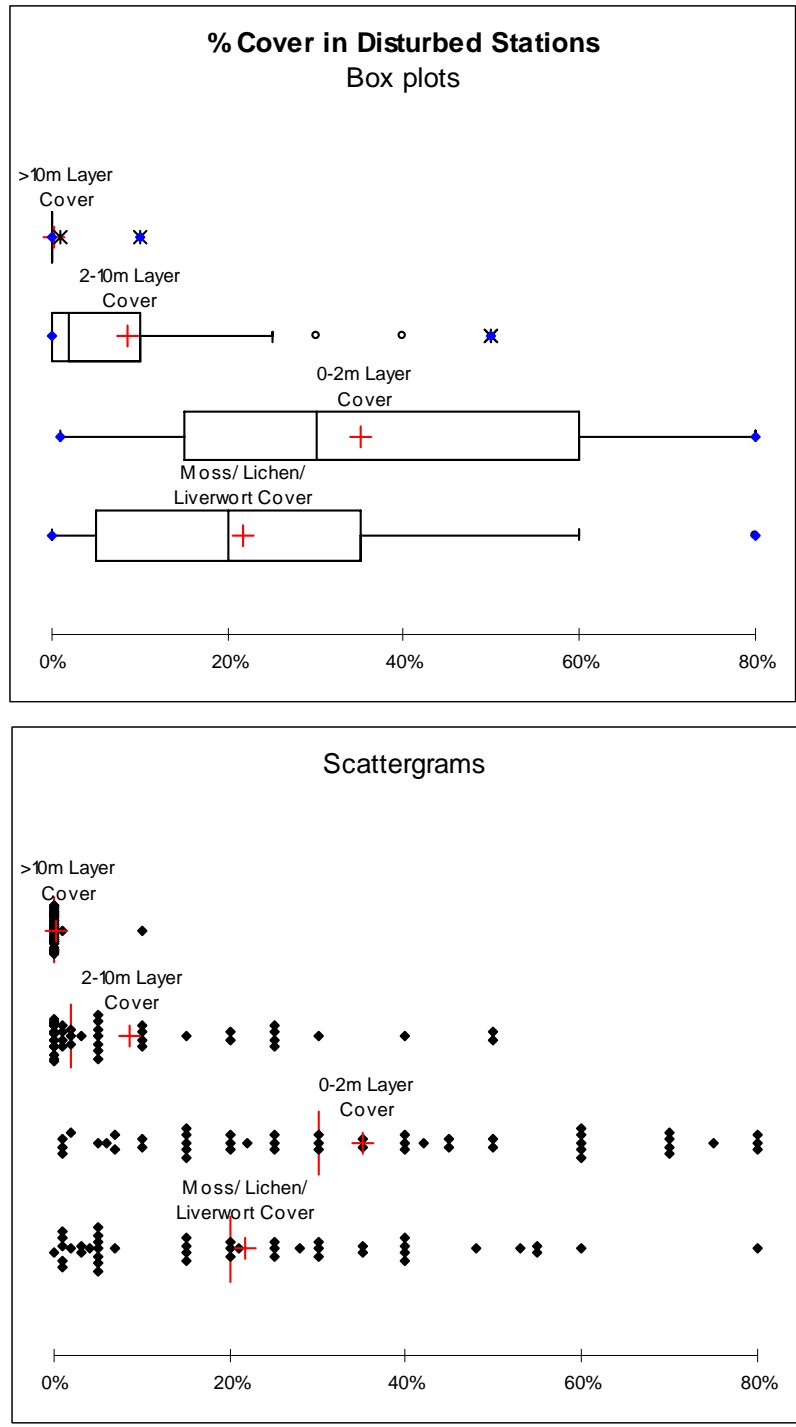
Tree, shrub, dwarf shrub, and forbs were included in the richness calculations for each site. Grasses were not included in order to minimize inclusion of seeded species in the calculation.

Richness ranged from a high of 18 to a low of 3 species. It should be noted that in this study, calculated richness is partly influenced by the number of survey stations with a disturbance – the more stations, the greater likelihood of a higher number of species being identified. Nonetheless, some important tendencies in the data are highlighted:

- two of the lowest richness sites (3 and 7 species) are those with aggressively colonizing Drummond's mountain aven. Although certain grasses as well as trees and willow were seen to colonize these disturbances, occurrence of other forbs tends to be low.
- another low richness site (5 species) is SL-04 in the southern lakes region, seen in Figure 3-3, with a well-established 20+ year old agronomic cover. The lack of tree establishment on this site was particularly striking, since an identically treated site of the same age (SL-02) a few kilometres away showed substantial tree colonization.

- the two sites with the highest richness (SV-01, and KL-04) are sites with water table estimated within several metres of surface. Nonetheless, there are several sites with slightly lower richness in well-drained conditions.

Figure 3-5 Distribution of Estimated Percent Cover Data for Disturbed Stations. Extent of the 'box' indicates upper and lower quartiles of the data, split by the median value. The red cross indicates average value, and the blue dots the extreme maximum and minimum. The 'whiskers' denote the statistical upper and lower limits of the data.



3.3.3 Colonizing Species

Trees

The most commonly colonizing native tree species across the 20-site dataset are the balsam poplar, occurring at 13 of 20 sites, and trembling aspen and white spruce at 11 of 20 sites. At most sites, tree height tended to be 2m or less. Alaska paper birch and black spruce were frequently observed at the Klondike valley sites of central Yukon. The Alaska paper birch in particular was noted as a frequent colonizer in zones where seed-producing trees are found nearby (eg. Brewery Creek Mine area, dredge tailings area near Dawson City).

Shrubs

Willow is the most common shrub observed, colonizing 16 of the 20 sites surveyed. Kinnikinnick was observed at 10 sites, and was most commonly observed encroaching into the clearing from adjacent natural vegetation. Soapberry occurs at 8 of 20 sites in the dataset.

While not an ubiquitous species across all the sites survey, Drummond's mountain aven, where occurring, was noted to grow vigorously both on exposed flat and sloped well-drained areas.

Forbs

Fireweed was observed at 14 of the 20 sites, common yarrow at 13 of 20 sites, and arctic lupin at 9 of 20 sites. Common yarrow was noted to take a predominant role in the more barren disturbances.

Grasses

As previously noted, while a systematic inventory of grass species was not conducted in this study, the contribution of grass was included in the vegetative cover estimate. In general, the sites surveyed showed some, but not an abundance of naturally colonizing grass species.

The surveys did note the occurrence of sheep fescue colonizing seven of the fourteen disturbances in the Klondike River basin, Haines Road, and Southern Lakes regions. Other species identified as occurring at three or more sites include foxtail barley and various wheatgrass species (*Agropyron spp.*).

Mosses, Lichens, and Liverworts

Colonization by moss, lichen and liverwort species was observed at virtually all sites, ranging from fine cryptogamic crusts to much more voluminous and obvious growths. Of note is the occurrence of mosses of the *Polytrichum* genus and lichens from the *Stereocaulon* genus (probably *Stereocaulon paschale*, or wooly coral lichen), identified as colonizing several sites.

The *Stereocaulon* species was observed at several sites (KV-06, KV-07, KV-08, other un-documented sites along the North Klondike Highway, and at HR-01 on the Haines Highway). Closer examination of one of these zones at site KV-06 is shown in Figure 3-6 and reveals the development of a diverse moss and lichen community under the cover of the *Stereocaulon* lichen. The occurrence of *Stereocaulon* as a

pioneer lichen species on exposed sites is consistent with findings of a detailed survey of dredge tailings revegetation in central Alaska (Holmes, 1982).

Figure 3-6 *Stereocaulon* sp. lichen colonization (left) and underlying moss and lichen community (right) at site KV-06, central Yukon.



3.3.4 Commonalities and Uniqueness – Disturbed Site and Surrounding Vegetation

One important approach used in this study to assess colonization patterns and mechanisms was to compare the species present in the adjacent undisturbed area with those colonizing the disturbance. In application, results can suggest which local species are more likely to colonize from seed dispersal or encroachment from bordering vegetation, or which may be expected to show up in a disturbance without an obvious local propagule source. Conversely, results can also indicate local species that are unlikely to self-colonize a disturbance.

Evaluation of these mechanisms was carried out in this study through examining each site's 0 to 2m layer data (the layer where most species diversity occurs in the disturbances) and identifying the occurrence of species in one of the following relationships:

1. Reference – Disturbance Common Species: a given species is present in the undisturbed Reference area and is also colonizing the adjacent disturbance;

2. Disturbance-Unique Species: a given species is showing notable colonization¹ of the disturbance but is not found in the adjacent undisturbed Reference station; and
3. Reference-Unique Species: a given species is only colonizing the undisturbed Reference station and is not found in surveyed stations in the disturbed area.

Reference and Disturbed Site Common Species

Across all twenty Sites in the study, Reference-Disturbance species commonalities occurred at 63 stations, and highlighted 20 species. Results are shown in Table 3-1. As shown, trembling aspen, white spruce, and willow are the most frequently occurring species between a given disturbance and its respective reference site (7 of the 20 Sites).

Certain regional tendencies are suggested in the data as well: in the Klondike River basin region, adjacent stands of trembling aspen, black spruce, Alaska paper birch and willow are suggested as likely seed sources for disturbance colonization of these species. In the Southern Lakes and Kluane areas, white spruce colonization is similarly linked to occurrences of this species in adjacent stands. The data indicates that kinnikinnick also colonizes from adjacent undisturbed sources, and field observations indicate that encroachment from the disturbance edges, rather than seed dispersal, is the primary colonization route for this species (Figure 3-7).

Figure 3-7 *Edge encroachment of kinnikinnick (shown by red arrow) at site SL-02 near Whitehorse.*



¹ a Disturbance-Unique species was observed in either: i) more than one surveyed station in a given disturbance, or ii) have a relative abundance rank of 1 or more.

Native species Unique to Disturbed Sites

Across the sites surveyed a total of 25 species were identified present in relative abundance and/or persistence in a given disturbance, but at the same time not observed in its respective reference site.

Three species (balsam poplar, common yarrow and fireweed) show the most frequent Disturbance-Unique occurrences across the four regions, implying the propensity of these species to colonize Yukon disturbances without an adjacent seed source.

The results are not as clear for the various willow species. As seen in Table 3-2, this common shrub is observed to be a disturbance-unique species in four of the twenty sites. Nonetheless, at seven other sites in the study (Table 3-1), willow is noted as a common species between the disturbance and adjacent undisturbed reference site.

Of regional interest, drought-tolerant species such as showy Jacob's ladder and locoweed appear to be relatively frequent disturbance-only colonizers in the Southern Lakes region. Various goldenrod species are also observed both in the Southern Lakes and Kluane regions.

Drummond's mountain aven noted above in section 3.3.3, with its propensity towards gravelly floodplains and scree slopes (Cody, 2000), demonstrated a definitive preference for colonization of disturbed sites a not in stands of mature vegetation. The species was observed in certain sites in the Klondike River Basin, Stewart Valley and Kluane regions.

Native species Unique to Reference Sites

A total of 22 species were observed within reference sites, but not seen colonizing the adjacent disturbance.

Species most frequently demonstrating this relationship across the study sites were Labrador tea, kinnikinnick, lingonberry, northern bastard toadflax, and twinflower. With the exception of kinnikinnick, these species are most commonly found under a mature boreal forest tree canopy (Johnson et. al, 1995), and are likely not well-adapted to the exposed and well-drained conditions on most disturbances.

Of note is that kinnikinnick is also highlighted above in Table 3-3 as a key species that potentially colonizes from adjacent natural vegetation. Due to the 'encroachment' style colonization of this species, possibly this split in data indicates that we are seeing an opportunistic-based tendency of the species to, over time, creep into the disturbance under the right conditions (for example, where natural kinnikinnick vegetation is directly exposed along the disturbance edge, as shown in Figure 3-7.

Table 3-1 Reference – Disturbance Species Commonalities within the 0-2m Layer at Study Sites.

Plant Category	Common Name	Genus	Number of Sites with Occurrence in both Undisturbed and Disturbed Stations					
			All Sites (n=20)	Southern Lakes (n=4 Sites)	Klondike River Basin (n=9 Sites)	Stewart Valley (n=2 Sites)	Kluane (n=4 Sites)	Haines Road (n=1 Site)
Tree	Trembling Aspen	<i>Populus tremuloides</i>	7	1	5	1	0	0
Tree	Balsam Poplar	<i>Populus balsamifera</i>	1	1	0	0	0	0
Tree	White Spruce	<i>Picea glauca</i>	7	3	0	2	2	0
Tree	Black Spruce	<i>Picea mariana</i>	4	0	4	0	0	0
Tree	Lodgepole Pine	<i>Pinus contorta ssp. Latifolia</i>	1	1	0	0	0	0
Tree	Alaska Paper Birch	<i>Betula neoalaskana</i>	5	0	5	0	0	0
Tree	Dwarf / Shrub Birch	<i>Betula glandulosa</i>	1	0	0	0	0	1
Shrub	Willow, undiff.	<i>Salix sp.</i>	7	1	5	0	0	1
Shrub	Prickly Rose	<i>Rosa acicularis</i>	2	1	0	0	1	0
Shrub	Soapberry	<i>Shepherdia canadensis</i>	4	2	0	1	1	0
Dwarf Shrub	Kinnikinnick	<i>Arctostaphylos uva-ursi</i>	5	2	3	0	0	0
Dwarf Shrub	Crowberry	<i>Empetrum nigrum</i>	1	0	0	0	0	1
Forb	Common yarrow	<i>Achillea millefolium</i>	2	1	1	0	0	0
Forb	Arctic Lupin	<i>Lupinus arcticus</i>	6	1	3	1	1	0
Forb	Fireweed	<i>Epilobium angustifolium</i>	2	1	1	0	0	0
Forb	Common Horsetail	<i>Equisetum arvense</i>	1	0	0	0	1	0
Forb	Horsetail, undiff.	<i>Equisetum sp.</i>	1	1	0	0	0	0
Forb	Tufted Milk Vetch	<i>Astragalus adsurgens</i>	1	0	0	0	1	0
Forb	Mackenzie's Hedysarum	<i>Hedysarum mackenzii</i>	1	0	0	0	1	0
Grass	Sheep fescue	<i>Festuca ovina</i>	4	0	3	0	0	1

¹ Gray shading indicates reference/disturbance species commonalities at $\geq 25\%$ of the sites

Table 3-2 Disturbance-Unique Species within the 0-2m Layer at Study Sites.

Plant Category	Common Name	Genus	Number of Sites present in Disturbed Stations, and not in Undisturbed Station ¹					
			All Sites (n=20)	Southern Lakes (n=4 Sites)	Klondike River Basin (n=9 Sites)	Stewart Valley (n=2 Sites)	Kluane (n=4 Sites)	Haines Road (n=1 Site)
Tree	Balsam Poplar	<i>Populus balsamifera</i>	8	1	5	0	1	1
Tree	White Spruce	<i>Picea glauca</i>	1	0	1	0	0	0
Tree	Black Spruce	<i>Picea mariana</i>	1	0	1	0	0	0
Shrub	Willow, undiff.	<i>Salix sp.</i>	4	1	2	0	1	0
Shrub	Prickly Rose	<i>Rosa acicularis</i>	1	1	0	0	0	0
Shrub	Soapberry	<i>Shepherdia canadensis</i>	2	0	1	0	1	0
Shrub	Wild Red Raspberry	<i>Rubus idaeus</i>	2	1	0	1	0	0
Dwarf Shrub	Drummond's Mountain Aven	<i>Dryas drummondii</i>	3	0	1	1	1	0
Forb	Common yarrow	<i>Achillea millefolium</i>	5	1	2	1	1	0
Forb	Arctic Lupin	<i>Lupinus arcticus</i>	1	0	0	0	1	0
Forb	Fireweed	<i>Epilobium angustifolium</i>	7	2	2	1	2	0
Forb	Common Dandelion ²	<i>Taraxacum officinale</i>	3	3	0	0	0	0
Forb	Dune Golden Rod	<i>Solidago simplex</i>	1	1	0	0	0	0
Forb	Golden Rod, undiff.	<i>Solidago sp.</i>	2	1	1	0	0	0
Forb	Purple Rock Cress	<i>Arabis divaricarpa</i>	1	1	0	0	0	0
Forb	Rock Cress, undiff.	<i>Arabis sp.</i>	1	0	1	0	0	0
Forb	Locoweed, undiff.	<i>Oxytropis sp.</i>	1	1	0	0	0	0
Forb	Showy Jacob's Ladder	<i>Polemonium pulcherrimum</i>	2	2	0	0	0	0
Forb	Annual / Narrow-Leaved Hawk's Beard	<i>Crepis tectorum</i>	4	2	2	0	0	0
Forb	Horsetail, undiff.	<i>Equisetum sp.</i>	1	0	1	0	0	0

Plant Category	Common Name	Genus	Number of Sites present in Disturbed Stations, and not in Undisturbed Station ¹					
			All Sites (n=20)	Southern Lakes (n=4 Sites)	Klondike River Basin (n=9 Sites)	Stewart Valley (n=2 Sites)	Kluane (n=4 Sites)	Haines Road (n=1 Site)
Forb	Field Sagewort	<i>Artemisia campestris</i>	1	0	0	1	0	0
Forb	Hedysarum, undiff.	<i>Hedysarum sp.</i>	1	1	0	0	0	0
Grass	Foxtail barley	<i>Hordeum jubatum</i>	1	0	1	0	0	0
Grass	Sheep fescue	<i>Festuca ovina</i>	2	1	1	0	0	0
Grass	Red Fescue	<i>Festuca rubra</i>	1	1	0	0	0	0

¹ Gray shading indicates species is disturbance-unique at $\geq 25\%$ of the sites

² Acknowledged to be a long term introduced species to North America, but with documented traditional use by certain first nation groups (Mackinnon et. al., 1992)

Table 3-3 Reference Site-Unique Species within the 0-2m Layer at Study Sites.

Plant Category	Common Name	Genus	Number of Sites present in Undisturbed Station, and not in Disturbed Station					
			All Sites (n=20)	Southern Lakes (n=4 Sites)	Klondike River Basin (n=9 Sites)	Stewart Valley (n=2 Sites)	Kluane (n=4 Sites)	Haines Road (n=1 Site)
Tree	Black Spruce	<i>Picea mariana</i>	3	1	1	0	1	0
Shrub	Prickly Rose	<i>Rosa acicularis</i>	2	1	1	0	0	0
Shrub	Highbush Cranberry	<i>Viburnum edule</i>	2	1	0	0	1	0
Shrub	Soapberry	<i>Shepherdia canadensis</i>	3	1	1	1	0	0
Shrub	Labrador Tea	<i>Ledum groenlandicum</i>	6	0	3	0	2	1
Shrub	Juniper, undiff.	<i>Juniperus sp.</i>	1	0	0	0	0	1
Dwarf Shrub	Kinnikinnick	<i>Arctostaphylos uva-ursi</i>	5	1	2	0	1	1
Dwarf Shrub	Red Bearberry	<i>Arctostaphylos rubra</i>	2	0	0	0	1	1
Dwarf Shrub	Lingonberry	<i>Vaccinium vitis-idaea</i>	7	0	3	2	2	0
Dwarf Shrub	Bilberry	<i>Vaccinium sp.</i>	2	0	1	0	0	1
Dwarf Shrub	Crowberry	<i>Empetrum nigrum</i>	2	0	1	0	1	0
Forb	Common yarrow	<i>Achillea millefolium</i>	1	1	0	0	0	0
Forb	Northern Bastard Toadflax	<i>Comandra lividum</i>	5	1	2	2	0	0
Forb	Twin Flower	<i>Linnaea borealis</i>	5	3	0	1	1	0
Forb	Northern Bedstraw	<i>Galium boreale</i>	1	1	0	0	0	0
Forb	Arctic Lupin	<i>Lupinus arcticus</i>	2	0	1	1	0	0
Forb	Tall Bluebell	<i>Mertensia paniculata</i>	3	1	0	1	1	0
Forb	Hawk's Beard undiff.	<i>Crepis sp.</i>	1	0	1	0	0	0
Forb	Common Harebell	<i>Campanula rotundifolia</i>	1	0	0	1	0	0
Forb	Bunchberry	<i>Cornus canadensis</i>	1	0	0	0	0	1

Plant Category	Common Name	Genus	Number of Sites present in Undisturbed Station, and not in Disturbed Station					
			All Sites (n=20)	Southern Lakes (n=4 Sites)	Klondike River Basin (n=9 Sites)	Stewart Valley (n=2 Sites)	Kluane (n=4 Sites)	Haines Road (n=1 Site)
Grass	Altai Fescue	<i>Festuca altaica</i>	1	0	1	0	0	0
Grass	Purple reedgrass	<i>Calamagrostis purpurascens</i>	1	1	0	0	0	0

¹ Gray shading indicates species is reference-unique at $\geq 25\%$ of the sites

3.4 Influence of Seeded Cover

Nine of the twenty sites surveyed in 2009 were seeded upon decommissioning, and as expected and shown in Table 3-4, seeding did result in a markedly higher vegetative cover within the 0 to 2 metre layer at a site. However, the gains at seeded sites within the tree and high shrub layer where native species predominate (2 to 10 metres) are less marked, and overall, this study indicates no clear quantitative evidence that an initial seeded cover enhances or detracts from the native species richness and rates of natural recolonization. This ambiguity is possibly a reflection of a relatively small sample set of sites across a variety of ecoregions, ages, and seed treatments; a much larger database of samples could permit more definitive conclusions.

Table 3-4 Comparison of Estimated Cover between Non-Seeded and Seeded Sites

		>10m Layer Cover	2-10m Layer Cover	0-2m Layer Cover	Moss/ Lichen/ Liverwort Cover
Surveyed Stations at Non-Seeded Sites (n=32)	Median	0%	2%	25%	15%
	Mean	0%	7%	31%	20%
Surveyed Stations at Seeded Sites (n=16)	Median	0%	3%	44%	23%
	Mean	1%	11%	43%	25%

On a qualitative level, it could be seen that at some seeded sites, certain of the initial seeded cover species were still the dominant species some 10 to 20 years following seeding, and in some cases, that the seeded species were impeding the expected natural colonization. This was particularly evident where brome species (*Bromus spp.*) were included in the original seed mix and where the original seed application had taken well. One example is shown in Figure 3-8, a small borrow pit seeded in 1998. At this location smooth brome (*Bromus inermis*) became well-established along the clearing edge, a location where typically one would see the most rapid recolonization by local deciduous trees and shrubs. As a result, a thick grass fringe with very sparse colonization by trembling aspen and willow has instead developed. At one site (KL-02), the diversity of forbs and low level shrubs appeared to be lower in zones where there was thickly established alsike clover, although tree and large shrub development was not notably affected.

Some sites with a heavy seeded cover also showed a heavy thatch development of dead material. While this thatch appeared to impede colonization of native forbs as well as shrubs and trees, it did serve to foster development of certain moss and lichen species in the moist environment at the underlying soil level, and in some cases, development of organic-rich soil (Figures 3-9 and 3-10).

Figure 3-8 Site KV-04, Klondike River basin region, seeded in 1998. Along the clearing edge (arrows in main and inset photos), a thick cover of seeded smooth brome (*Bromus inermis*) is impeding natural encroachment of the surrounding tree and shrub species.



Figure 3-9 Site SL-02, agronomic cover seeded in 1988 showing substantial thatch of dead grass, as well as moss/lichen/liverwort colonization.



Figure 3-10 Site KL-02, seeded approximately 1997, showing soil development below the clover-dominated cover.



Some seeded sites show good balance between seeded and naturally colonizing species, such as is observed at site KL 02 in the Beaver Creek region of central-west Yukon (Figure 3-11). This site was decommissioned and seeded in the late 1990's, and has formed a moderate to sparse cover of grass and legumes (no brome species evident) that does not appear to impede the colonization of native species.

Figure 3-11 Site KL 03 in the Beaver Creek region of central-west Yukon, with integration of both seeded cover and spontaneous revegetation growth. This site receives just over 400mm of precipitation annually, approximately 25 percent greater than many sites in central and south-central Yukon.



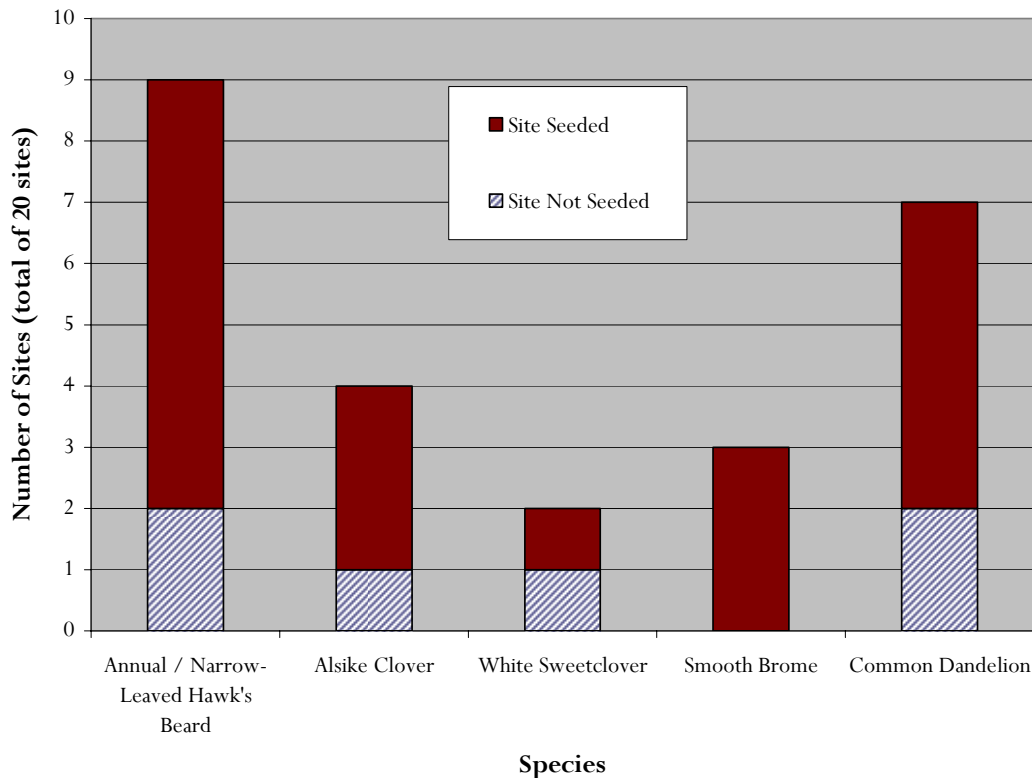
3.5 Introduced and Invasive Species Occurrence

Five species were definitively identified in the survey as introduced, including: common dandelion, annual hawk's beard, alsike clover, white sweetclover, and smooth brome (*Taraxacum officinale*, *Crepis tectorum*, *Trifolium hybridum*, *Melilotus alba*, and *Bromus inermis*). All five of these are also ranked as having invasive tendencies. Several occurrences of undifferentiated mustard family were also noted (mainly from *Arabis* genus), some of which are likely introduced. Other species such as red fescue, common plantain, and undifferentiated wheatgrass (*Festuca rubra*, *Plantago major* and *Agropyron spp.*) were noted during surveys and are recognized in Yukon as having both native and introduced origins.

Of the five invasive species identified, the most commonly observed across the Sites were the annual hawk's beard and the common dandelion, (at nine and seven of the twenty Sites respectively). All five species show a propensity to occur at Sites that had been seeded following abandonment (see

Figure 3-12). At the 16 reference stations, the common dandelion was the only invasive species observed (at two sites in the Southern Lakes area). While annual hawk’s beard was the most commonly observed across the disturbed Sites, the relative abundance of this species along with common dandelion and alsike clover tended to be ranked at the survey Stations as 0.5 to 1, indicating presence, but not having a dominating effect. On the other hand at the Stations where white sweetclover and smooth brome had colonized, relative abundance of these invasives tended to be ranked in the 2 to 3 range, indicating a dominant recolonizing species in the disturbance.

Figure 3-12 Occurrence of Invasive Species at Seeded and Non-seeded Sites



3.6 Filters to Natural Colonization

During the field surveys, any obvious factors influencing natural recolonization of the site were noted. Both these observations and the measured data were later considered in suggesting potential ‘filters’ negatively and positively affecting the rate of natural recolonization, species richness, and natural succession of the site. Common filters discussed in Polster (2009) were incorporated into the potential lists used for this study, as shown in Table 3-5.

Table 3-5 *Potential Negative and Positive Filters Considered in Site Assessments*

<p><i>Potential Negative Filters</i></p> <ul style="list-style-type: none">• excessive erosion or unstable ground• ongoing disturbance (eg. vehicular traffic)• limited availability of suitable seed sources• competing species• excessive heat absorption (eg. by dark-coloured substrate)• compacted substrate• unfavourable substrate texture (affecting moisture retention)• insufficient substrate moisture• adverse micro-climatic conditions (eg. no natural sinks to trap litter or snow)• unfavourable aspect (resulting in potentially excess heat and low moisture availability)
<p><i>Potential Positive Filters</i></p> <ul style="list-style-type: none">• adequate substrate moisture• favourable microsities• favourable substrate texture• favourable aspect (resulting in high moisture availability)

Summary

None of the sites demonstrated erosion or instability issues of note. Ongoing disturbance was considered to be a potential filter at only two of the twenty sites. Owing to the expanse of disturbances (5 ha to >20 ha), seed source availability appears to be affecting most of the larger sites.

At three of nine seeded sites, a thickly established seeded cover is considered to be out-competing native species establishment, in particular the forbs and low lying shrubs. No sites were deemed to be obviously affected by excessive heat absorption, however compaction is likely affecting colonization success in significant portions of at least five sites. Substrate texture, mainly due to a high proportion of either very coarse or very fine material, is considered to be adversely affecting recolonization at five sites.

Insufficient substrate moisture and adverse micro-climatic conditions, each occurring at six sites, were the most predominant filters identified in the study. Substrate moisture is strongly affected by micro-climatic conditions, and is logically also influenced by the site's precipitation, and the substrate's texture. Disruption of the cryptogamic layer through ongoing disturbance was observed at some sites and may also contribute to poor moisture retention.

Positive filters identified include adequate substrate moisture (six sites), favourable microsities (two sites), and favourable aspect (two sites).

At five of the six sites, adequate substrate moisture is mainly attributable to proximity of the local water table, while at the sixth, site HR-01 on the Haines Highway, local annual precipitation estimated of at

least 1000 mm has obviously contributed to colonization success. While site KV-05 located within the Klondike River's historic dredge tailings piles has obvious colonization challenges, preferential growth patterns in small and large scale depressions of the tailings features indicate successful creation of favourable micro-site conditions. Similarly, the rough and irregular surface of quarry site HR-01 has enhanced native species colonization. East and northerly aspect slopes at site KV-09 and HR-01 were also noted as creating conditions favouring recolonization.

On completion of the field surveys, there was the general sense that most sites that showed exceedingly slow rates of colonization were confronted with at least two potentially negative filters. In particular, sites with filters affecting plant moisture availability seemed to be progressing the slowest, and in some cases stagnating. While the most direct controls of plant-available moisture are precipitation and proximity of water table, other factors such as substrate texture, lack of micro-sites, and aspect appear to clearly influence the rate and success of natural recolonization. Although there are too few sites in this study to effectively demonstrate through graphical or statistical methods, this point can be illustrated by comparison of two sites within 14km of each other, KV-03 and KV-07. As shown in Figures 3-13 and 3-14, although the disturbances differ in age by almost 40 years, the younger disturbance shows areas of abundant natural recolonization which appear to be largely due to slope aspect and a higher proportion of silt to clay-sized particles in the substrate.

Figure 3-13 Sparse recolonization at site KV-07, an approximately 50-year old decommissioned borrow pit located in central Yukon. At the clearing centre, all growth is less than 2m high with less than 5 percent cover. The primary filter to natural recolonization at this site appears to be low moisture availability as influenced by: i) low precipitation (325mm annually), ii) a low proportion of silt to clay-sized particles (7 percent), iii) location at least 10m above local water table, and iv) pebble 'armouring' of the smooth surface.



Figure 3-14 Abundant natural recolonization on a gentle north-facing slope at site KV-03, a decommissioned borrow pit (13 years previous) near the closed Brewery Creek Mine. This site is approximately 14 km from and 120m higher than site KV-07 shown in Figure 1, and has similar precipitation. However, the substrate at this site is relatively high in silt to clay-sized particles (estimated at greater than 20 percent), and the north-facing aspect serves to enhance moisture availability. On the other hand, the south-facing and flat sectors in the background show much lower natural colonization.



4.0 Discussion and Conclusions

4.1 Colonization Characteristics of Key Species

Based on results highlighted in section 3.3.3, ten species were identified as being persistent colonizers across a wide variety of disturbances and geography. These key species are tabulated in Table 4-1, along with some of their associated colonization characteristics that were noted in the surveys.

The two poplar species, trembling aspen and balsam poplar are moderately prolific colonizers in the sites surveyed. Data from this study indicates that while trembling aspen tends to colonize from adjacent stands of the species, balsam poplar readily colonizes without an obvious nearby seed source.

Willow is the most prolific colonizer identified in this study, in terms of both occurrence over all study regions and ecoregions, and occurrence over the greatest number of sites. While associative data suggests that willow will readily colonize without an obvious nearby seed source, the species is nonetheless frequently present throughout mature boreal forest stands.

Both white and black spruce appear to be important colonizers in Yukon – the black spruce range tending to be more confined to central, east and north Yukon. At the sites surveyed in this study, both species tend to propagate disturbances via seed from adjacent stands, with white spruce more apt to colonize further into a disturbance and more frequently than black spruce.

While both soapberry and kinnikinnick do not typically occur uniformly across a disturbance, they are nonetheless persistent pioneer shrub species. As previously mentioned (section 3.3.4), kinnikinnick appears to colonize predominantly by encroachment from disturbance edges. Occurrences of soapberry were also noted as more frequent along disturbance fringes, and a few observations of the species in centres of larger disturbance suggests that seed may be at times transported to the site by animals (eg. bear).

Fireweed, common yarrow, and arctic lupin are three important colonizing forbs in this study. Both fireweed and yarrow are frequent, but relatively low abundance species in disturbances, and demonstrate a propensity to colonize without an obvious nearby seed source. Both species demonstrate colonizing preference towards the more open, central sector of a given disturbance. Arctic lupin is somewhat less common and abundant, and data indicates that the species colonizes through an adjacent seed source.

A few other species, while not dominant across the entire study area, appear to have localized significance at some sites. These include sheep fescue, Drummond's mountain aven, and various birch species (in this study *Betula nealaskana*, *B. glandulosa*, and *B. papyrifera*).

Sheep fescue was observed colonizing several sites in the study, and while not occurring in high abundance, is likely an early-establishing pioneer plant where there is a local seed source.

Drummond's mountain aven is mentioned previously in this report (sections 3.3.2, 3.3.3, and 3.3.4) as an aggressive colonizer of two sites in this study. Nonetheless, it was also noted that species richness

was also low where the species was well-established. With its spreading, woody habit and nitrogen-fixing properties (Lawrence et. al, 1967), this plant has been recognized as a pioneer species in glacial retreat areas, and may be a potential target restoration species in other disturbances in zones where it naturally occurs.

Species from the birch family (namely Alaska paper birch, paper birch, and dwarf birch), where locally occurring in nearby stands, were also observed in this study to be colonizing adjacent disturbances.

Given the active moss, lichen and liverwort colonization and species varieties across most all sites, coupled key role that these plants are known to play in soil stabilization and nutrient cycle establishment (U.S. Department of the Interior, 2001), more in-depth study at disturbed sites may yield valuable insights of the processes of soil development and ensuing colonization by higher plants.

4.2 Potential Colonizing Order

As shown in Table 4-1, nine of the ten key species were identified at the youngest sites in the study (5 to 6 year's estimated age), indicating that early natural colonization is feasible given appropriate conditions. Only black spruce, occurring in disturbances 13 years and older, demonstrated less tendency for rapid natural recolonization.

There is insufficient data for a rigorous statistical comparison of disturbance age and species occurrence. Nonetheless, assessment of median disturbance age for each species suggests that balsam poplar and willow, occurring at sites with a median 13 year estimated age of disturbance, may be two important early colonizers at Yukon sites. By the same token, mid-stage colonizers would include fireweed, arctic lupin, trembling aspen and yarrow (being those species with 20-year range medians, equivalent to that of the overall median age of all sites in the study). White Spruce, black spruce, kinnikinnick, and soapberry with median disturbance ages of over 30 years, appear to demonstrate later stage colonization tendencies.

Table 4-1 Summary Characteristics of Key Colonizing Species Identified in Study

Common Name	Genus / Species	Occurrence Across Study				Relative Abundance ¹		Estimated Disturbance Age as of 2009		Min. Distance to Undisturbed Vegetation		Est. Water Table Location - Median
		# of Stations Where Present	# of Sites	# of Study Regions	# of Ecoregions	Range	Median	Range	Median	Range	Median	
Trembling Aspen	<i>Populus tremuloides</i>	13	7	4	3	0.25 - 3	1	6 - 77	17	1 - 240	11	>10m
Balsam Poplar	<i>Populus balsamifera</i>	11	8	4	4	0.25 - 2	1	6 - 54	13	5 - 100	23	2.6-3.5m
Willow, undiff.	<i>Salix spp.</i>	28	15	5	5	0.25 - 3	1	6 - 77	13	1 - 250	25	>10m
White Spruce	<i>Picea glauca</i>	23	11	4	4	0.25 - 2	0.5	6 - 54	32	3 - 50	17	>10m
Black Spruce	<i>Picea mariana</i>	8	5	1	2	0.25 - 1	0.38	13 - 54	34	3 - 35	7	>10m
Kinnikinnick	<i>Arctostaphylos uva-ursi</i>	22	10	4	3	0.25 - 3	1.5	6 - 54	32	2 - 50	12	>10m
Soapberry	<i>Shepherdia canadensis</i>	19	8	4	4	0.25 - 2	0.5	5.5 - 54	32	2 - 50	20	>10m
Fireweed	<i>Epilobium angustifolium</i>	27	14	4	4	0.25 - 2	0.5	5.5 - 77	17	1 - 250	27	>10m
Common yarrow	<i>Achillea millefolium</i>	25	13	4	4	0.25 - 1	0.25	6 - 77	21	4 - 240	30	>10m
Arctic Lupin	<i>Lupinus arcticus</i>	17	9	4	4	0.25 - 1	0.25	5.5 - 54	17	2 - 250	22	>10m
ALL SITES IN STUDY		53	20	5	5	0.25 - 3	0.5	5.5 - 77	21	1 - 250	20	>10m

¹Relative Abundance Values:

Value	In Layer with More than One Species	In Layer with One Species
3	Prevalent – distinctly the most frequently occurring species	≥ 50% cover
2	Very Common – occurs more frequently than any other species	25-49% cover
1	Present but not in large numbers relative to other species	10-24% cover
0.5	Infrequent relative to other species	3-9% cover
0.25	Rare relative to other species	<1 to 2% cover
0	Does not occur in area	0% cover
-1	Species noted to occur but abundance not noted	Species noted to occur but abundance not noted

4.3 Influence of Filters

As summarized in section 3.6, factors which optimize plant available moisture are likely the key influencing aspects of natural recovery of disturbances in Yukon. While the most direct controls of plant-available moisture are precipitation and proximity of water table, other factors such as substrate texture, lack of micro-sites, and aspect appear to clearly influence the rate and success of natural recolonization.

4.4 Study Limitations

As previously stated, a study of 20 sites across several ecoregions and a varying local ecology cannot, on its own, be considered a rigorous assessment and definitive representation of all colonization tendencies and relationships. However in consideration of the resources and time available, the sites were selected to encompass a variety of substrate characteristics and age, and a reasonably broad geographical range. Because of the potential for data bias and inter-dependency from factors such as non-random site selection and inconsistent numbers of stations from site to site, the data set does not lend itself to a rigorous statistical analysis. Additional data from more sites would add to the quality of data and likely extend the interpretability of results.

5.0 Recommendations

5.1 Implications for Practice

Plant Moisture Availability

Data from the sites studied in 2009 indicates that in lower precipitation areas of Yukon (eg. less than 400mm), or at sites with lower amounts of fines (silt and clay-sized particles), site preparation measures to enhance moisture retention may be particularly important. These measures are noted below, and their effectiveness has been well-documented by other practitioners:

- the ‘rough and loose’ approach encouraged by Polster (2009) serves to provide sinks or traps for moisture and organic debris accumulation, and provides shelter for emerging seedlings. In higher precipitation areas or sites with excess clay and silt sized particles, this ‘rough and loose’ approach can also reduce erosion.
- woody debris placement on surfaces also creates moisture pockets as well as protection of emerging seedlings.

Target Species

The study highlighted ten target species in the study regions that are most likely to colonize a disturbance over time (see section 4.1), and the primary colonization mechanisms indicated by their associative relationship between the disturbance and in the adjacent forest stands. These species and factors could be utilized to derive target species for any direct seeding and planting efforts for a given site. In addition, incorporation of other locally-occurring species such as birch, various native grasses, and Drummond’s mountain aven could also be considered.

Use of Seeded Cover

The 2009 results demonstrate the increased potential for the occurrence of invasive species at sites where a seeded cover has been introduced. This issue should be carefully weighed into the decision when considering use of seed sourced from outside the immediate site, regardless of whether the seed is a ‘native’ or agronomic blend. As well, a thick seeded cover appears to have a negative effect on natural colonization particularly by forb and low shrub, at least within the 10 to 20 year age range where the practice of seeding disturbances has been carried out.

5.1.1 Additional Information

Analyses of the 2009 data will continue as time and resources permit. As possible, data from other disturbed sites in Yukon should be incorporated, in particular, those sites in the 400 to 600mm precipitation range such as in the south to southeast region of the territory. Natural recolonization processes in Yukon are also under study by others, and more strength in the information will be achieved through the addition of data from more sites – not just those recorded by this study. Ultimately, it is the goal to collaborate with other groups to compile other existing natural re-

colonization data from the North and assist in development of a spontaneous natural re-colonization database.

6.0 Acknowledgements

I'm very grateful to many organizations and individuals for their assistance in this study, to mention a few: i) the Mining and Petroleum Environmental Research Group and Northern Research Institute for assisting with project funding; ii) the Yukon Department of Highways and Public Works for providing access to their quarry database, providing suggestions of potential survey sites and performing grain size analyses; iii) Bruce Bennett of Environment Yukon for assistance with invasive species identification, iv) Stu Withers for plant taxonomy assistance, and v) Alexco Resource Corp. for providing accommodation during work at the Klondike valley sites, and for providing a tour and access to the Brewery Creek Mine site.

I am also grateful to the various Yukon First Nation governments for expressing interest in this study and where necessary, granting permission to enter their designated lands to complete surveys on certain sites.

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**Appendix A Table of Common and Scientific Names for Plants
Referenced in this Study**

Appendix A
Plant Common and Scientific Names

Common Name	Genus	Species Name	Native or Introduced
Trembling Aspen	<i>Populus</i>	<i>tremuloides</i>	Native
Balsam Poplar	<i>Populus</i>	<i>balsamifera</i>	Native
White Spruce	<i>Picea</i>	<i>glauca</i>	Native
Black Spruce	<i>Picea</i>	<i>mariana</i>	Native
Lodgepole Pine	<i>Pinus</i>	<i>contorta ssp. Latifolia</i>	Native
Alpine Fir	<i>Abies</i>	<i>lasiocarpa</i>	Native
Alaska Paper Birch	<i>Betula</i>	<i>neolaskana</i>	Native
Dwarf / Shrub Birch	<i>Betula</i>	<i>glandulosa</i>	Native
Paper Birch	<i>Betula</i>	<i>papyrifera</i>	Native
Shrubby Willow	<i>Salix</i>	<i>arbusculoides</i>	Native
Willow, undifferentiated	<i>Salix</i>	<i>sp.</i>	Native
Green Alder	<i>Alnus</i>	<i>crispa</i>	Native
Speckled Alder	<i>Alnus</i>	<i>incana</i>	Native
Wolf Willow	<i>Eleagnus</i>	<i>commutata</i>	Native
Prickly Rose	<i>Rosa</i>	<i>acicularis</i>	Native
Highbush Cranberry	<i>Viburnum</i>	<i>edule</i>	Native
Soapberry	<i>Shepherdia</i>	<i>canadensis</i>	Native
Wild Red Raspberry	<i>Rubus</i>	<i>idaeus</i>	Native
Labrador Tea	<i>Ledum</i>	<i>groenlandicum</i>	Native
Norwegian / Rough Cinqu	<i>Potentilla</i>	<i>norvegica</i>	Native
Pennsylvania Cinquefoil	<i>Potentilla</i>	<i>litoralis</i>	Native
Common Juniper	<i>Juniperus</i>	<i>communis</i>	Native
Juniper, undifferentiated	<i>Juniperus</i>	<i>sp.</i>	Native
Shrub, undifferentiated			Native
Kinnikinnick / Common B	<i>Arctostaphylos</i>	<i>uva-ursi</i>	Native
Red Bearberry	<i>Arctostaphylos</i>	<i>rubra</i>	Native
Lingonberry / Low-bush c	<i>Vaccinium</i>	<i>vitis-idaea</i>	Native
Bilberry	<i>Vaccinium</i>	<i>sp.</i>	Native
Crowberry	<i>Empetrum</i>	<i>nigrum</i>	Native
Drummond's Mountain A	<i>Dryas</i>	<i>drummondii</i>	Native
Dwarf Heather, undiffere	<i>Cassiope</i>	<i>sp.</i>	Native
Common yarrow	<i>Achillea</i>	<i>millefolium</i>	Native
Northern Bastard Toadfla	<i>Comandra</i>	<i>lividum</i>	Native
Twin Flower	<i>Linnaea</i>	<i>borealis</i>	Native
Northern Bedstraw	<i>Galium</i>	<i>boreale</i>	Native
Arctic Lupin	<i>Lupinus</i>	<i>arcticus</i>	Native
Fireweed	<i>Epilobium</i>	<i>angustifolium</i>	Native
Dwarf Fireweed	<i>Epilobium</i>	<i>latifolium</i>	Native
Horned Dandelion	<i>Taraxacum</i>	<i>ceratophorum</i>	Native
Common Dandelion	<i>Taraxacum</i>	<i>officinale</i>	Introduced
Dune Golden Rod	<i>Solidago</i>	<i>simplex</i>	Native
Golden Rod, undifferentia	<i>Solidago</i>	<i>sp.</i>	Native
Wild Strawberry	<i>Fragaria</i>	<i>virginiana</i>	Native
Purple Rock Cress	<i>Arabis</i>	<i>divaricarpa</i>	Native
Holboell's Rock Cress	<i>Arabis</i>	<i>holboellii</i>	Native
Rock Cress, undifferentiat	<i>Arabis</i>	<i>sp.</i>	Unknown
Early Yellow Locoweed	<i>Oxytropis</i>	<i>campestris</i>	Native

Appendix A
Plant Common and Scientific Names

Common Name	Genus	Species Name	Native or Introduced
Locoweed, undifferentiated	<i>Oxytropis</i>	<i>sp.</i>	Native
Showy Jacob's Ladder	<i>Polemonium</i>	<i>pulcherrimum</i>	Native
Tall Bluebell	<i>Mertensia</i>	<i>paniculata</i>	Native
Elegant Hawk's Beard	<i>Crepis</i>	<i>elegans</i>	Native
Dwarf Alpine Hawksbeard	<i>Crepis</i>	<i>nana</i>	Native
Annual / Narrow-Leaved Hawk's Beard	<i>Crepis</i>	<i>tectorum</i>	Introduced
Hawk's Beard undifferentiated	<i>Crepis</i>	<i>sp.</i>	Unknown
Common Pepper-grass	<i>Lepidium</i>	<i>densiflorum</i>	Native
Common Horsetail	<i>Equisetum</i>	<i>arvense</i>	Native
Horsetail, undifferentiated	<i>Equisetum</i>	<i>sp.</i>	Native
Common plantain	<i>Plantago</i>	<i>major</i>	Unknown
Three-toothed Saxifrage	<i>Saxifraga</i>	<i>tricuspidata</i>	Native
Fragrant Fern	<i>Dropteris</i>	<i>fragrans</i>	Native
Cutleaf Fleabane	<i>Erigeron</i>	<i>compositus</i>	Native
Labrador Lousewort	<i>Pedicularis</i>	<i>labradorica</i>	Native
Alsike Clover	<i>Trifolium</i>	<i>hybridum</i>	Introduced
Introduced clover, undifferentiated	<i>Trifolium</i>	<i>sp.</i>	Introduced
White Sweetclover	<i>Melilotus</i>	<i>alba</i>	Introduced
Mountain Harebell	<i>Campanula</i>	<i>lasiocarpa</i>	Native
Common Harebell	<i>Campanula</i>	<i>rotundifolia</i>	Native
Field Sagewort	<i>Artemesia</i>	<i>campestris</i>	Native
Pasture Sage	<i>Artemesia</i>	<i>frigida</i>	Native
Boreal Sagebrush	<i>Artemesia</i>	<i>norvegica</i>	Native
Williams' Milkvetch	<i>Astragalus</i>	<i>williamsii</i>	Native
Tufted Milk Vetch	<i>Astragalus</i>	<i>adsurgens</i>	Native
Vetch, undifferentiated	<i>Astragalus</i>	<i>sp.</i>	Unknown
Hemlock Parsley	<i>Conioselinum</i>	<i>scopulorum</i>	Native
Alpine Sweet Vetch	<i>Hedysarum</i>	<i>alpinum</i>	Native
Mackenzie's Hedysarum / Hedysarum	<i>Hedysarum</i>	<i>mackenzii</i>	Native
Hedysarum, undifferentiated	<i>Hedysarum</i>	<i>sp.</i>	Native
Arctic Aster	<i>Aster</i>	<i>sibiricus</i>	Native
Cut-leaved Anemone	<i>Anemone</i>	<i>multifida</i>	Native
Blue Flax	<i>Linum</i>	<i>lewisii</i>	Native
Bunchberry	<i>Cornus</i>	<i>canadensis</i>	Native
Pearly Everlasting	<i>Anaphalis</i>	<i>margaritacae</i>	Native
Pussytoes, undifferentiated	<i>Antennaria</i>	<i>sp.</i>	Native
Foxtail barley	<i>Hordeum</i>	<i>jubatum</i>	Native
Hair grass, undifferentiated	<i>Deschampsia</i>	<i>sp.</i>	Unknown
Tufted hair grass	<i>Deschampsia</i>	<i>caespitosa</i>	Native
Altai Fescue	<i>Festuca</i>	<i>altaica</i>	Native
Sheep fescue	<i>Festuca</i>	<i>ovina</i>	Native
Red Fescue	<i>Festuca</i>	<i>rubra</i>	Unknown
Purple reedgrass	<i>Calamagrostis</i>	<i>purpurascens</i>	Native
Blue-joint Grass	<i>Calamagrostis</i>	<i>canadensis</i>	Native
Wheatgrass - common narrow-leaved	<i>Agropyron</i>	<i>pauciflorum</i>	Native
Bluebunch Wheat Grass	<i>Agropyron</i>	<i>spicatum</i>	Native
Slender Wheatgrass	<i>Agropyron</i>	<i>trachycaulum</i>	Native

Appendix A
Plant Common and Scientific Names

Common Name	Genus	Species Name	Native or Introduced
Wheatgrass	<i>Agropyron</i>	<i>sp.</i>	Unknown
Glaucous Bluegrass	<i>Poa</i>	<i>glauca</i>	Native
Kentucky bluegrass	<i>Poa</i>	<i>pratensis</i>	Introduced
Pine Bluegrass	<i>Poa</i>	<i>secunda</i>	Native
Smooth Brome	<i>Bromus</i>	<i>inermis</i>	Introduced
Brome, undifferentiated	<i>Bromus</i>	<i>sp.</i>	Unknown
Tickle Grass / Hair Bentgr	<i>Agrostis</i>	<i>scabra</i>	Native
Spike trisetum	<i>Trisetum</i>	<i>spicatum</i>	Native

Appendix B Photographs of Study Sites

Appendix B
Photographs of Study Sites

HR-01 – View A



HR-01 – View B



Appendix B
Photographs of Study Sites

KL-01



Appendix B
Photographs of Study Sites

KL-02



KL-03



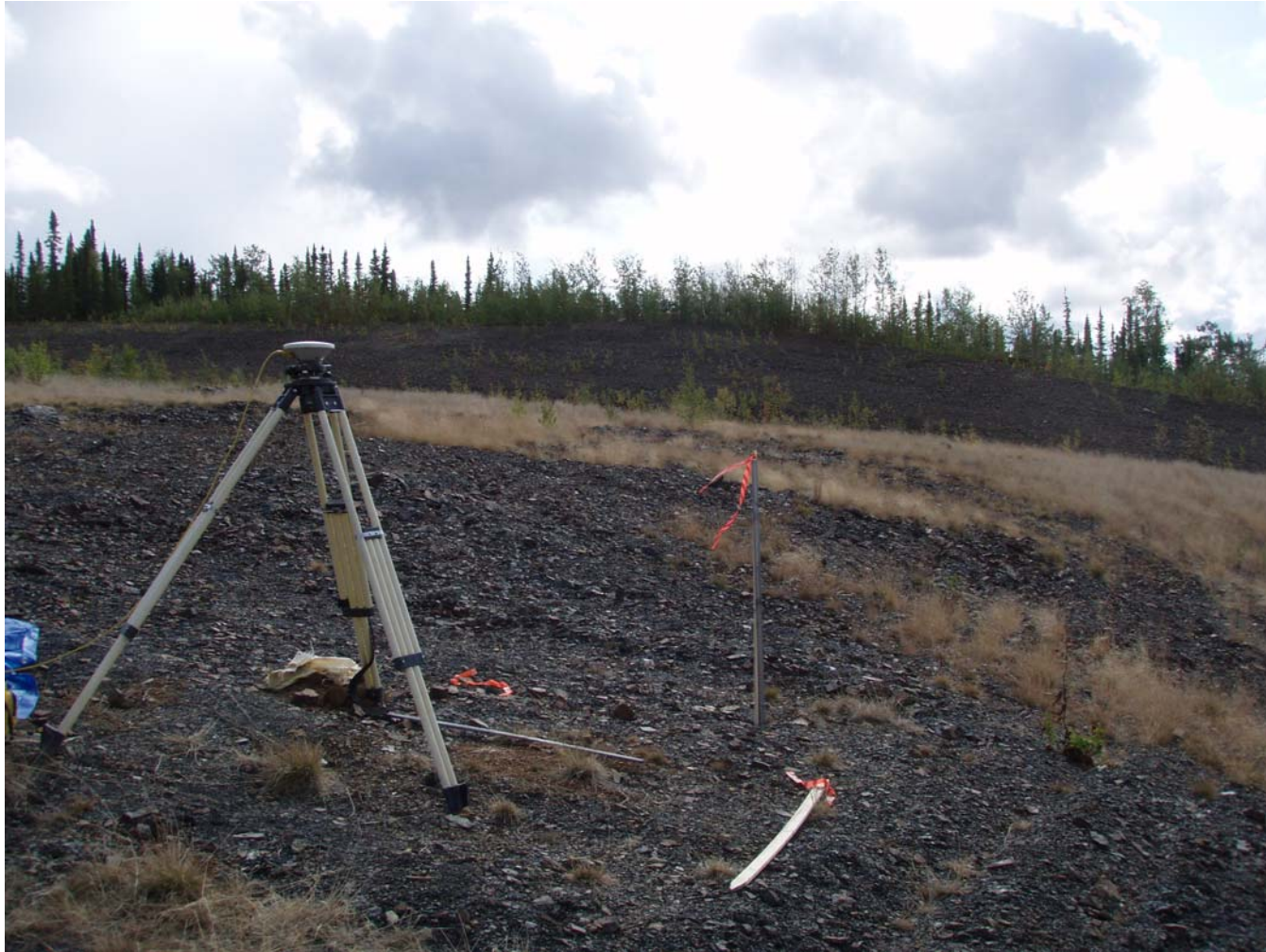
Appendix B
Photographs of Study Sites

KL-04



Appendix B
Photographs of Study Sites

KV-01



Appendix B
Photographs of Study Sites

KV-02



Appendix B
Photographs of Study Sites

KV-03



KV-04



Appendix B
Photographs of Study Sites

KV-05



Appendix B
Photographs of Study Sites

KV-06



KV-07



Appendix B
Photographs of Study Sites

KV-08



KV-09



Appendix B
Photographs of Study Sites

SL-01



SL-02



Appendix B
Photographs of Study Sites

SL-03



Appendix B Photographs of Study Sites

SL-04



Appendix C Compiled Study Data

Appendix C
Site Information

Site #	Region	Site Descriptor or Alterate ID	General Description	Surface Tenure (other than crown land)			Min Elevation	Max Elevation	Average Elevation	Photo Point Waypoint	Photo Point Latitude	Photo Point Longitude	Photo Point Elevation	Photo Point Azimuth	Photo Numbers	Photo Point Photos	Disturbance Type	Size of Disturbance (ha)	Disturbance Date Earliest
				Longitude	Latitude														
KV-01	Klondike Valley		Brewery Creek Mine, shale cut and knob, in vicinity of old repeater site						none					130480		cut into shale material	1	1995	
KV-02	Klondike Valley	LP-3?	Brewery Creek Mine, reclaimed leach pad area, area of site 'LP-3' of Withers and Burns						226	64.04247	-138.27895	854	270	482		decommissioned heap leach pad, large fill, capped with soil cover and seeded	>20	1995	
KV-03	Klondike Valley		Borrow area on Brewery Creek mine access road, lhs, approx 2km northeast of Lee Creek						234	64.02015	-138.36410	646	350	494-497		decommissioned borrow pit	1	1995	
KV-04	Klondike Valley		Borrow area on Brewery Creek mine access road, rhs, approx 0.5km northeast of Lee Creek						none	64.008301	-138.37104	537	180	502-504		decommissioned borrow pit	2.5	1995	
KV-05	Klondike Valley		Old dredge tailings pile, Klondike River valley south of Dawson City.						240	64.03763	-139.31396	343	315	533		abandoned dredge tailings pile	10	1915	
KV-06	Klondike Valley		Dempster Highway, approx km7.5, lhs						243	64.0114	-138.62212	535	190	542-545		decommissioned borrow pit	0.5	1950	
KV-07	Klondike Valley		Dempster Highway, approx km6, rhs						245	64.00889	-138.62557	529	260	554-557		decommissioned borrow pit	0.5	1950	
KV-08	Klondike Valley		Dempster Highway, approx km6.5, lhs						246	64.00652	-138.63461	512	45	564-566		decommissioned borrow pit	0.5	1950	
KV-09	Klondike Valley		Dempster Highway, approx km4, rhs						247	63.99465	-138.66098	498	260	571-574		decommissioned borrow pit	1	1950	
SV-01	Stewart Valley	Quarry #115-P-15	Silver Trail Highway, approx km14, rhs						249	63.45533	-136.43992	501	120	596-598		decommissioned borrow pit	1	1988	

Appendix C
Site Information

Site #	Region	Site Descriptor or Alterate ID	General Description	Surface Tenure (other than crown land)		Longitude	Latitude	Min Elevation	Max Elevation	Average Elevation	Photo Point Waypoint	Photo Point Latitude	Photo Point Longitude	Photo Point Elevation	Photo Point Azimuth	Photo Point Numbers	Photo Point Photos	Disturbance Type	Size of Disturbance (ha)	Disturbance Date Earliest
SV-02	Stewart Valley		Silver Trail Highway, approx 40m long road cut rhs, approx 0.5km west of Mayo River								261	63.61143	-135.90631	531	190	031		large road cut	0.5	1965
KL-01	Kluane Lake		Alaska Highway, lhs, approx km1665.8, north of Congdon Creek. Material appears to have been used for training the right bank of Congdon Creek stream course to control flooding of tributary leading to 115-G-23 quarry. Possibly other uses. Appears to be a relatively shallow excavation.								264	61.14223	-138.58631	870	85	055		decommissioned borrow pit	1	1989
KL-02	Kluane Lake	115-F-03	Alaska Highway, lhs, approx km1782.5, Edith Creek								265	61.79969	-140.04746	743	260	064-066		decommissioned borrow pit	6	1996
KL-03	Kluane Lake	Quarry #115-K-01	Alaska Highway, rhs, approx km1877.9, '1741' Pelly Camp pit								269	62.44339	-140.84891	635	80	079-082		decommissioned borrow pit	10	2003
KL-04	Kluane Lake	unknown - quarry does not appear to be indicated in YG database	Alaska Highway, approx km 1691, 6.5 km north of Talbot Arm Motel, LHS of highway.								272	61.29947	-138.88640	826	225	094-097		decommissioned borrow pit	5	2003

Appendix C
Site Information

Site #	Region	Site Descriptor or Alterate ID	General Description	Surface Tenure (other than crown land)	Longitude	Latitude	Min Elevation	Max Elevation	Average Elevation	Photo Point Waypoint	Photo Point Latitude	Photo Point Longitude	Photo Point Elevation	Photo Point Azimuth	Photo Numbers	Photo Point Photos	Disturbance Type	Size of Disturbance (ha)	Disturbance Date Earliest
HR-01	Haines Road	114-P-04	Haines Highway, lhs, approx km95.5, Stonehouse Creek quarry. Note: site is in northern B.C.							280	59.63596	-136.46651	903	45	114-117		decommissioned borrow pit	5	1998
SL-01	Southern Lakes		Abandoned clearing approximately 100m to northeast of Alaska Highway, km 1369	KDFN R8A						none	60.509557	-134.31374	686	315	399-402		abandoned cut/fill clearing	1	1969
SL-02	Southern Lakes		Alaska Highway, rhs, approx km 1403.7 lhs, old 1988 Quarry Reclamation site							288	60.59941	-134.86538	741	36	187-191		decommissioned borrow pit	1	1988
SL-03	Southern Lakes		Alaska Highway, lhs, approx km1382.5 lhs, old road section approx 1km northwest of Swan Haven Road							293	60.55534	-134.50772	671	250	234-235		abandoned highway section	0.5	1972
SL-04	Southern Lakes		Alaska Highway, rhs, approx km 1406.4 rhs, old 1988 Quarry Reclamation site							296	60.6031	-134.91363	711	342	244-246		decommissioned borrow pit	2	1988

Appendix C
Site Information

Site #	Region	Disturbance Date Latest	Estimated Disturbance Age as of 2009	Dating Method	Distance from Active Highway	Active Facilities w_in 1km	Ecozone	Ecoregion	Climate Mean Annual Precipitation	Climate Mean Annual Temperature	Climate Source of Data	Reclamation: Site Preparation Performed	Reclamation: Seeding Performed	Reclamation: other work	Reclamation: references	General Notes	Possible Factors Controlling Re	Other Comments
KV-01	Klondike Valley	1997?	13	historical records	>15 km	none	Boreal Cordillera	Yukon Plateau - North	329	-1.7	Brewery Crk Updated Soln Mgmt Plan, 1998	1998?	1998?		BCM Water License Reports	reference photo shows 'shale hill' survey control point in foreground, azimuth approximate.	1) looseness of substrate positive factor	
KV-02	Klondike Valley	2000?	12	historical records	>15 km	none	Boreal Cordillera	Yukon Plateau - North	329	-1.7	Brewery Crk Updated Soln Mgmt Plan, 1998	2004?	yes, circa 2004	soil cover	BCM Water License Reports	Withers/Burns plot on slope in reference photo (LP-3)	1) distance from undisturbed vegetation (seed sources), 2) competition where seeded cover is thickly established	
KV-03	Klondike Valley	1997	13	historical records	>15 km	none	Boreal Cordillera	Yukon Plateau - North	329	-1.7	Brewery Crk Updated Soln Mgmt Plan, 1998		none				1) soil texture (siltier on south side, hence more growth than on coarser north material) and 2) aspect (less growth on south-facing slopes) are controlling the colonization success.	good to see balsam poplar at this site
KV-04	Klondike Valley	1998	11	historical records	>15 km	none	Boreal Cordillera	Yukon Plateau - North	329	-1.7	Brewery Crk Updated Soln Mgmt Plan, 1998	1998?	May 1998 - seeded and fertilized			seeding: 75 kg/ha with BCM 1997 seed mix, fertilizing 300 kg/ha	1) coarseness of material in main pit bottom is limiting recolonization (slightly finer material noted on slopes), 2) dominant seeded grass is inhibiting re-colonization	
KV-05	Klondike Valley	1949	77	airphotos and archives photos (Dredge No.3)	<100m	rural residential, light industrial	Boreal Cordillera	Klondike Plateau	324.3	-4.4	Dawson Airport 1971-2000		none				1) moisture, 2) particle size, 3) limited seed sources	Mature community of pioneering plants in depression to southwest is possibly now providing seed sources?
KV-06	Klondike Valley	1960	54	airphotos	<100m	none	Boreal Cordillera	Klondike Plateau	324.3	-4.4	Dawson Airport 1971-2000	yes	none			sites graded prior to abandonment	1) moisture, 2) lack of microsites/shelter from elements, 3) compaction	
KV-07	Klondike Valley	1960	54	airphotos	<100m	none	Boreal Cordillera	Klondike Plateau	324.3	-4.4	Dawson Airport 1971-2000	yes	none			sites graded prior to abandonment	1) moisture, 2) lack of microsites/shelter from elements, 3) compaction.	
KV-08	Klondike Valley	1960	54	airphotos	<100m	none	Boreal Cordillera	Klondike Plateau	324.3	-4.4	Dawson Airport 1971-2000	yes	none			sites graded prior to abandonment	1) moisture, 2) lack of microsites/shelter from elements, 3) compaction.	
KV-09	Klondike Valley	1960	54	airphotos	<100m	none	Boreal Cordillera	Klondike Plateau	324.3	-4.4	Dawson Airport 1971-2000	yes	none			sites graded prior to abandonment	1) aspect (positive and negative controls), 2) screened gravel with minor fines at pit bottom, 3) compaction	Good example of differences in north and south aspects. Interesting concentration of Dryas sp. and how well it is colonizing. Elev 885 and below -- start to see <i>Populus balsamifera</i> and <i>Epilobium latifolium</i>
SV-01	Stewart Valley	1996	17	airphotos	<100m	none	Boreal Cordillera	Yukon Plateau - North	312.9	-3.1	Mayo Airport 1971-2000	yes	yes				1) water table appears to be close to pit bottom (ponded water in ditch across highway)	

Appendix C
Site Information

Site #	Region	Disturbance Date Latest	Estimated Disturbance Age as of 2009	Dating Method	Distance from Active Highway	Active Facilities w_in 1km	Ecozone	Ecoregion	Climate Mean Annual Precipitation	Climate Mean Annual Temperature	Climate Source of Data	Reclamation: Site Preparation Performed	Reclamation: Seeding Performed	Reclamation: other work	Reclamation: references	General Notes	Possible Factors Controlling Re	Other Comments
SV-02	Stewart Valley	1965	44	airphotos	<100m	active borrow pit, 200m	Boreal Cordillera	Yukon Plateau - North	312.9	-3.1	Mayo Airport 1971-2000	none	none				1) limited moisture retention due to slope, 2) loose soil (positive factor), 3) smooth slope, limited micro-sites	impressive abundance of <i>D. drummondii</i> ; tough shrubby nature and spreading habit of plant makes it encouraging species for colonization. Does not appear to show allelopathic tendencies.
KL-01	Kluane Lake	2003	13	airphotos, quarry production database	1400	none	Boreal Cordillera	Ruby Ranges	279.7	-3.8	Burwash Airport 1971-2000	yes	none				1) water table may be relatively close to surface, based on proximity to Congdon Creek, 2) significant fraction of pebble to cobble-sized fragments (70%) - negative factor	potentially good example of <i>D. drummondii</i> succession. Soapberry presence in clearing centre may be indication of advanced succession and stability, or possibly owing to shallow disturbance depth, self-propagated from remnant root fragments?
KL-02	Kluane Lake	1998	12	quarry production database, airphotos	500	none	Boreal Cordillera	Ruby Ranges	279.7	-3.8	Burwash Airport 1971-2000	yes	yes				1) competition by seeded cover, mainly alsike clover (few native forbs and low shrubs in centre of disturbance), 2) centre of clearing relatively compacted	see notes
KL-03	Kluane Lake	2003	6	estimated from quarry reports	150	none	Boreal Cordillera	Klondike Plateau	416.3	-5.5	Beaver Creek 1971-2000	yes	yes				proximal water table; elevated local precipitation; relatively shallow excavation (presumably due to close water table)	Less abundance of clover here than at KL-02 site, good diversity of species at herb level. Kinnikinnick observed in recolonized disturbance but not at reference site. Looks like <i>Picea glauca</i> seedlings in disturbance but <i>P. mariana</i> at reference site? Little diversity in reference site but tremendous diversity in clearing. Overall, site appears to be doing well.
KL-04	Kluane Lake	2004	6	HPW records (assuming typical year for abandonment as 2003-2004)	250	none	Boreal Cordillera	Ruby Ranges	279.7	-3.8	Burwash Airport 1971-2000	yes	yes				1) disturbance size (distance from potential seed sources)	

Appendix C
Site Information

Site #	Region	Disturbance Date Latest	Estimated Disturbance Age as of 2009	Dating Method	Distance from Active Highway	Active Facilities w_in 1km	Ecozone	Ecoregion	Climate Mean Annual Precipitation	Climate Mean Annual Temperature	Climate Source of Data	Reclamation: Site Preparation Performed	Reclamation: Seeding Performed	Reclamation: other work	Reclamation: references	General Notes	Possible Factors Controlling Re	Other Comments
HR-01	Haines Road	2003	9	site photos (HPW, 2008)	<100m	none	Boreal Cordillera	Yukon-Stikine Highlands	1416.3	2.7	Pleasant Camp 1971-2000	yes	none		HPW, 2008		1) presence of microsites/moist depressions positively influence growth (photo 130), possibly snow accumulation area? 2) aspect - 350-040 deg aspects show low growth, while 060 aspect shows some areas of dense growth 3) higher precipitation may account for some of the success at this site	Some moisture pockets/microsites support more growth than other areas - SEE ALSO NOTES
SL-01	Southern Lakes	1986	32	airphotos	<100m	rural residences	Boreal Cordillera	Yukon Southern Lakes	267.4	-0.7	Whitehorse 1971-2000	none	none				1) very low plant available moisture (well-draining substrate texture, low precipitation, deep water table), 2) ongoing disturbance in certain sectors of clearing; 3) lack of micro-sites	see term paper by D. Lister (2009)
SL-02	Southern Lakes	1988	21	sign posted at site	<100m	rural residences, light industrial	Boreal Cordillera	Yukon Southern Lakes	267.4	-0.7	Whitehorse 1971-2000	yes	yes				1) competition where seeded cover is thickly established	
SL-03	Southern Lakes	1986	30	airphotos	<100m	none	Boreal Cordillera	Yukon Southern Lakes	267.4	-0.7	Whitehorse 1971-2000	none	none				1) proximity to moisture, 2) relatively narrow disturbance, 3) compaction on centre of old roadbed (not surveyed due to ongoing recreational traffic)	
SL-04	Southern Lakes	1988	21	sign posted at site	<100m	rural residences	Boreal Cordillera	Yukon Southern Lakes	267.4	-0.7	Whitehorse 1971-2000	yes	yes			two reference photo sets for this site (second set from wpt 297, azimuth 342, photo 244-246	1) periodic recreational vehicle and foot traffic, other factors unknown.	

Appendix C
Site Information

Site #	Region	Negative Filters											Positive Filters					TOTAL	TOTAL POSITIVE - NEGATIVE	0-2m Richness Grass
		excessive erosion or unstable ground	ongoing disturbance (eg: vehicular traffic)	limited availability of suitable seed sources	competing species	excessive heat absorption (eg. by dark coloured substrate)	compact substrate	unfavourable substrate texture	insufficient substrate moisture	adverse micro-climatic conditions	unfavourable aspect (potentially excess heat, low moisture availability, other)	TOTAL	adequate moisture	favourable microsites	favourable substrate texture	favourable aspect	TOTAL			
KV-01	Klondike Valley										0					0	0	7		
KV-02	Klondike Valley			1	1						2					0	-2	8		
KV-03	Klondike Valley							1			2					0	-2	12		
KV-04	Klondike Valley				1			1			2					0	-2	8		
KV-05	Klondike Valley			1				1	1		3		1			1	-2	9		
KV-06	Klondike Valley						1	1	1		3					0	-3	10		
KV-07	Klondike Valley						1	1	1		3					0	-3	13		
KV-08	Klondike Valley						1	1	1		3					0	-3	12		
KV-09	Klondike Valley						1	1		1	3				1	1	-2	13		
SV-01	Stewart Valley										0	1				1	1	18		

Appendix C
Site Information

Site #	Region	Negative Filters											Positive Filters							TOTAL POSITIVE - NEGATIVE	0-2m Richness
		excessive erosion or unstable ground	ongoing disturbance (eg. vehicular traffic)	limited availability of suitable seed sources	competing species	excessive heat absorption (eg. by dark coloured substrate)	compacted substrate	unfavourable substrate texture	insufficient substrate moisture	adverse micro-climatic conditions	unfavourable aspect (potentially excess heat, low moisture availability, other)	TOTAL	adequate moisture	favourable microsites	favourable substrate texture	favourable aspect	TOTAL				
SV-02	Stewart Valley							1	1			2				0	-2	3			
KL-01	Kluane Lake						1		1			2	1			1	-1	7			
KL-02	Kluane Lake				1		1					2	1			1	-1	13			
KL-03	Kluane Lake											0	1			1	1	13			
KL-04	Kluane Lake			1								1				0	-1	18			

Appendix C
Site Information

Site #	Region	Negative Filters											Positive Filters						TOTAL POSITIVE - NEGATIVE	0-2m Richness Grass
		excessive erosion or unstable ground	ongoing disturbance (eg: vehicular traffic)	limited availability of suitable seed sources	competing species	excessive heat absorption (eg. by dark coloured substrate)	compacted substrate	unfavourable substrate texture	insufficient substrate moisture	adverse micro-climatic conditions	unfavourable aspect (potentially excess heat, low moisture availability, other)	TOTAL	adequate moisture	favourable microsites	favourable substrate texture	favourable aspect	TOTAL			
HR-01	Haines Road									1	1	1	1		1	3	2	13		
SL-01	Southern Lakes		1					1	1		3					0	-3	15		
SL-02	Southern Lakes										0					0	0	16		
SL-03	Southern Lakes										0	1			1	1	1	11		
SL-04	Southern Lakes		1								1				0	-1	5			

Appendix C
Station Information

Site #	Station #	General Description	Date Assessed	Assessed By	Station Type	Associated Reference Station	Assessment Type	Assessment Area (m2)	Station Waypoint	Latitude	Longitude	Elevation	Slope	Aspect
KV-01	KV-01-Ref South		19-Aug-09	Lister, 2009	reference	NA	releve	5	221	64.03935	-138.27639	863	8%	196
KV-01	KV-01-0+03	approx 3m inside disturbance	19-Aug-09	Lister, 2009	recolonized disturbance	KV-01-Ref South	releve	5	223	64.0395	-138.27643	859	<2%	flat
KV-01	KV-01-0+09	down from shale cutslope crest	19-Aug-09	Lister, 2009	recolonized disturbance	KV-01-Ref South	releve	5	224	64.03957	-138.27650	858	<2%	flat
KV-01	KV-01-0+20	toe of shale cutslope	19-Aug-09	Lister, 2009	recolonized disturbance	KV-01-Ref South	releve	5	225	64.0396	-138.27646	855	35%	350
KV-02	KV-02-A	Site LP-3 (Burns and Withers) and immediate surrounding area	19-Aug-09	Lister, 2009	recolonized disturbance	KV-02-B	releve	10	226	64.04247	-138.27895	854	35%	86
KV-02	KV-02-B	reference site, approx 3m from disturbance edge	19-Aug-09	Lister, 2009	reference	NA	releve	10	227	64.04247	-138.27713	845	<2%	flat
KV-02	KV-02-C	mid-disturbance on top of leach pad, approx 250m from edge of disturbance	19-Aug-09	Lister, 2009	recolonized disturbance		releve	20	229	64.0414	-138.28116	859	3%	90
KV-03	KV-03-Ref	2004 burn area (eg. post-disturbance)	19-Aug-09	Lister, 2009	reference	NA	releve	75	230	64.01941	-138.36397	643	5%	270
KV-03	KV-03-B	edge of disturbance - appears to be berm of organics pushed up, very dense young growth	19-Aug-09	Lister, 2009	recolonized disturbance	KV-03-Ref	releve	10	231	64.01949	-138.36394	644	<2%	flat
KV-03	KV-03-C	just into disturbance, approx 4m from edge organics berm	19-Aug-09	Lister, 2009	recolonized disturbance	KV-03-Ref	releve	10	232	64.01959	-138.36392	642	<2%	flat
KV-03	KV-03-D	open area	19-Aug-09	Lister, 2009	recolonized disturbance	KV-03-Ref	releve	10	233	64.0198	-138.36400	646	5%	150
KV-03	KV-03-E	slope, south sector of borrow pit	19-Aug-09	Lister, 2009	recolonized disturbance	KV-03-Ref	releve	75	234	64.02015	-138.36410	646	28%	0
KV-03	KV-03-F	south-facing slope, north sector of borrow pit	19-Aug-09	Lister, 2009	recolonized disturbance	KV-03-Ref	releve	75	235	64.02086	-138.36403	643	25%	180
KV-04	KV-04-Ref	mature pop. Tremuloides >20m, white spruce	19-Aug-09	Lister, 2009	reference	NA	releve	20	none	64.007979	-138.36962	541	<2%	flat
KV-04	KV-04-A	edge area of disturbance, mainly dominated by seeded grass	19-Aug-09	Lister, 2009	recolonized disturbance	KV-03-Ref	releve	10	237	64.00805	-138.37005	541	<2%	flat
KV-04	KV-04-B	well mossed-over recolonized area, approx 10m from toe of main cut	19-Aug-09	Lister, 2009	recolonized disturbance	KV-03-Ref	releve	10	238	64.008	-138.37034	537	<2%	flat

Appendix C
Station Information

Site #	Station #	General Description	Date Assessed	Assessed By	Station Type	Associated Reference Station	Assessment Type	Assessment Area (m2)	Station Waypoint	Latitude	Longitude	Elevation	Slope	Aspect
KV-05	KV-05-A	dredge tailings pile crest	20-Aug-09	Lister, 2009	recolonized disturbance	none - no undisturbed area within 200m	releve	300	240	64.03763	-139.31396	343	<2%	flat
KV-06	KV-06-Ref	old burn area	20-Aug-09	Lister, 2009	reference	NA	releve	20	241	64.01142	-138.62178	535	<2%	flat
KV-06	KV-06-A	centre of clearing (approx 3m below original surface)	20-Aug-09	Lister, 2009	recolonized disturbance	KV-06-Ref	releve	75	244	64.011	-138.62257	532	<2%	flat
KV-07	KV-07-A	margin area of disturbance, approx 8m from disturbance edge, not excavated to full depth of pit	20-Aug-09	Lister, 2009	recolonized disturbance	KV-06-Ref	releve	75	245	64.00889	-138.62557	529	<2%	flat
KV-07	KV-07-B	centre of clearing (approx 1.5m below original surface)	20-Aug-09	Lister, 2009	recolonized disturbance	KV-06-Ref	releve	75	254	64.00872	-138.62634	527	<2%	flat
KV-08	KV-08-A	disturbed margin area, similar to KV-07-A	20-Aug-09	Lister, 2009	recolonized disturbance	KV-06-Ref	releve	75	246	64.00652	-138.63461	512	<2%	flat
KV-08	KV-08-B	centre of clearing (approx 25m to nearest edge)	20-Aug-09	Lister, 2009	recolonized disturbance	KV-06-Ref	releve	75	255	64.00680	-138.63405	517	<2%	flat
KV-09	KV-09-Ref	adjacent to disturbance, approx 20m from wpt 247 (photo point site). Some logging in past; tree stumps throughout.	20-Aug-09	Lister, 2009	reference	NA	releve	75	none	63.994741	-138.66060	498	<2%	flat
KV-09	KV-09-A	north aspect slope	20-Aug-09	Lister, 2009	recolonized disturbance	KV-09-Ref	releve	75	248	63.9944	-138.66188	489	30	350
KV-09	KV-09-B	centre of clearing	20-Aug-09	Lister, 2009	recolonized disturbance	KV-09-Ref	releve	175	257	63.99456	-138.66226	488	<2%	flat
KV-09	KV-09-C	south aspect slope	20-Aug-09	Lister, 2009	recolonized disturbance	KV-09-Ref	releve	175	none	63.994636	-138.66253	489	30	180
SV-01	SV-01-Ref	adjacent to disturbance, approx 15m to NW of wpt 249.	21-Aug-09	Lister, 2009	reference	NA	releve	75	262	63.45538	-136.44005	489	<2%	flat

Appendix C
Station Information

Site #	Station #	General Description	Date Assessed	Assessed By	Station Type	Associated Reference Station	Assessment Type	Assessment Area (m2)	Station Waypoint	Latitude	Longitude	Elevation	Slope	Aspect
SV-01	SV-01-A	mid-slope on cut at north end of pit	21-Aug-09	Lister, 2009	recolonized disturbance	SV-01-Ref	releve	75	250	63.45534	-136.43947	490	25%	120
SV-01	SV-01-B	bottom of pit, slightly moist appearance	21-Aug-09	Lister, 2009	recolonized disturbance	SV-01-Ref	releve	200	251	63.45533	-136.43924	491	<2%	flat
SV-02	SV-02-Ref	approx 6m wide fringe between cut slope and borrow pit	2-Sep-09	Lister, 2009	reference	NA	releve	75	259	63.6107	-135.90650	531	<2%	flat
SV-02	SV-02-A	mid-slope	2-Sep-09	Lister, 2009	recolonized disturbance	SV-02-Ref	releve	75	260	63.61068	-135.90620	526	45%	102
KL-01	KL-01-Ref	Mature picea glauca, willow understory. No detailed species inventory completed	5-Sep-09	Lister, 2009	reference	NA	NA	NA	none	61.1415	-138.58533	872	5%	60
KL-01	KL-01-A	fringe area, 0 to 15m from disturbance edge	5-Sep-09	Lister, 2009	recolonized disturbance	KL-01-Ref	releve	75	none	61.141582	-138.58543	871	5%	60
KL-01	KL-01-B	clearing centre	5-Sep-09	Lister, 2009	recolonized disturbance	KL-01-Ref	releve	75	263	61.14191	-138.58582	869	5%	60
KL-02	KL-02-Ref	approx 15m into bush from disturbed edge, appears to be moist judging by thick hummocky moss cover	6-Sep-09	Lister, 2009	reference	NA	releve	75	266	61.80023	-140.05163	746	<2%	flat
KL-02	KL-02-A	fringe area	6-Sep-09	Lister, 2009	recolonized disturbance	KL-02-Ref	releve	75	267	61.80018	-140.05106	742	<2%	flat
KL-02	KL-02-B	centre of clearing	6-Sep-09	Lister, 2009	recolonized disturbance	KL-02-Ref	releve	75	268	61.79965	-140.04963	744	<2%	flat
KL-03	KL-03-Ref	reference site, approx 15m from SW disturbance edge	6-Sep-09	Lister, 2009	reference	NA	releve	75	270	62.44074	-140.84917	639	<2%	flat

Appendix C
Station Information

Site #	Station #	General Description	Date Assessed	Assessed By	Station Type	Associated Reference Station	Assessment Type	Assessment Area (m2)	Station Waypoint	Latitude	Longitude	Elevation	Slope	Aspect
KL-03	KL-03-A	approx 15m from edge of disturbance, gentle short slope	6-Sep-09	Lister, 2009	recolonized disturbance	KL-03-Ref	releve	75	271	62.44072	-140.84882	637	15%	55
KL-03	KL-03-B	general observations along west edge of clearing	6-Sep-09	Lister, 2009	recolonized disturbance	KL-03-Ref	releve	300	none	62.442467	-140.84862	635	5%	90
KL-04	KL-04-Ref	approx 15m from edge of disturbance	6-Sep-09	Lister, 2009	reference	NA	releve	75	276	61.29784	-138.88891	839	<2%	flat
KL-04	KL-04-A	clearing centre	6-Sep-09	Lister, 2009	recolonized disturbance	KL-04-Ref	releve	75	273	61.29896	-138.88717	823	<2%	flat
KL-04	KL-04-B	zone 20-40m from disturbance edge	6-Sep-09	Lister, 2009	recolonized disturbance	KL-04-Ref	releve	300	275	61.29814	-138.88846	830	10%	40
HR-01	HR-01-Ref	above quarry cut	6-Sep-09	Lister, 2009	reference	NA	releve	75	280	59.63596	-136.46651	903	5%	60
HR-01	HR-01-A	fringe area of disturbance	7-Sep-09	Lister, 2009	recolonized disturbance	HR-01-Ref	releve	75	282	59.63643	-136.46558	889	5%	50
HR-01	HR-01-B	lower end of pit	7-Sep-09	Lister, 2009	recolonized disturbance	HR-01-Ref	releve	200	286	59.63720	-136.46452	880	3%	50
SL-01	SL-01-Ref1	trembling aspen-dominated area, below disturbance (station 0+00)	6-Jun-09	Lister, 2009	reference	NA	plot	4	142	60.50946	-134.31521	678	41%	224
SL-01	SL-01-Ref2	white spruce-dominated area, above disturbance (station 0+84), ~3 m into undisturbed forest	6-Jun-09	Lister, 2009	reference	NA	releve	20	none	60.509884	-134.31403	689	<2%	flat
SL-01	SL-01-A	station 0+005	6-Jun-09	Lister, 2009	recolonized disturbance	SL-01-Ref1	plot	4	none	60.509467	-134.31517	680	15%	220
SL-01	SL-01-B	station 0+010; face of fill slope	6-Jun-09	Lister, 2009	recolonized disturbance	SL-01-Ref1	plot	4	144	60.509490	-134.31509	682	36%	210
SL-01	SL-01-C	station 0+015	6-Jun-09	Lister, 2009	recolonized disturbance	SL-01-Ref1	plot	4	none	60.509510	-134.31503	683	2%	224
SL-01	SL-01-D	station 0+020	6-Jun-09	Lister, 2009	recolonized disturbance	SL-01-Ref1	plot	4	none	60.509530	-134.31497	684	5%	224
SL-01	SL-01-E	station 0+025	6-Jun-09	Lister, 2009	recolonized disturbance	SL-01-Ref1	plot	4	145	60.509570	-134.31488	685	5%	224

Appendix C
Station Information

Site #	Station #	General Description	Date Assessed	Assessed By	Station Type	Associated Reference Station	Assessment Type	Assessment Area (m2)	Station Waypoint	Latitude	Longitude	Elevation	Slope	Aspect
SL-01	SL-01-F	station 0+030	6-Jun-09	Lister, 2009	recolonized disturbance	SL-01-Ref1	plot	4	none	60.509563	-134.31484	685	2%	224
SL-01	SL-01-G	station 0+035	6-Jun-09	Lister, 2009	recolonized disturbance	SL-01-Ref1	plot	4	none	60.509604	-134.31475	685	<2%	flat
SL-01	SL-01-H	station 0+040	6-Jun-09	Lister, 2009	recolonized disturbance	SL-01-Ref1	plot	4	none	60.509645	-134.31476	686	7%	224
SL-01	SL-01-I	station 0+048	6-Jun-09	Lister, 2009	recolonized disturbance	SL-01-Ref2	releve	20	none	60.509683	-134.31469	686	3%	224
SL-01	SL-01-J	station 0+056, 5 m west of trail	6-Jun-09	Lister, 2009	recolonized disturbance	SL-01-Ref2	releve	20	none	60.509762	-134.31460	686	3%	224
SL-01	SL-01-K	station 0+067, toe of cut slope	6-Jun-09	Lister, 2009	recolonized disturbance	SL-01-Ref2	releve	20	none	60.509837	-134.31446	686	7%	224
SL-01	SL-01-L	station 0+070, midway on cutslope	6-Jun-09	Lister, 2009	recolonized disturbance	SL-01-Ref2	releve	20	none	60.509926	-134.31430	687	46%	224
SL-01	SL-01-M	station 0+073, crest of cutslope	6-Jun-09	Lister, 2009	recolonized disturbance	SL-01-Ref2	releve	20	none	60.509957	-134.31430	688	5%	224
SL-01	SL-01-N	station 0+079, edge of tree-cleared area	6-Jun-09	Lister, 2009	recolonized disturbance	SL-01-Ref2	releve	20	none	60.509974	-134.31421	689	<2%	flat
SL-02	SL-02-Ref	semi-mature' lodgepole pine/spruce stand, very old burn area	17-Sep-09	Lister, 2009	reference	NA	releve	75	289	60.60006	-134.86483	740	<2%	flat
SL-02	SL-02-A	mid-slope	17-Sep-09	Lister, 2009	recolonized disturbance	SL-02-Ref	releve	75	291	60.5996	-134.86394	737	12%	290
SL-02	SL-02-B	base of pit	19-Sep-09	Lister, 2009	recolonized disturbance	SL-02-Ref	releve	75	292	60.5996	-134.86432	738	<2%	flat
SL-02	SL-02-C	area of less grass cover	19-Sep-09	Lister, 2009	recolonized disturbance	SL-02-Ref	releve	75		60.599557	-134.86481	737	<2%	flat
SL-03	SL-03-Ref	moist area approx 2m lower than road bed	3-Oct-09	Lister, 2009	reference	NA	releve	75	295	60.55516	-134.50790	666	<2%	flat
SL-03	SL-03-A	shoulder of old road bed, approx 5m from disturbance edge	3-Oct-09	Lister, 2009	recolonized disturbance	SL-03-Ref	releve	75	294	60.5553	-134.50799	670	<2%	flat
SL-04	SL-04-Ref	edge of clearing, not inventoried in detail	7-Oct-09	Lister, 2009	reference	NA	releve	75	298	60.6049	-134.91471	721	<2%	flat

Appendix C
Station Information

Site #	Station #	General Description	Date Assessed	Assessed By	Station Type	Associated Reference Station	Assessment Type	Assessment Area (m2)	Station Waypoint	Latitude	Longitude	Elevation	Slope	Aspect
SL-04	SL-04-A	approx 18m from edge of clearing	7-Oct-09	Lister, 2009	recolonized disturbance	SL-04-Ref	releve	75	299	60.60479	-134.91471	718	15%	150

Appendix C
Station Information

Site #	Station #	Soil General Description	Estimated Water Table Location	Water Table Assmt based on	Min Distance to Undisturbed Vegetation	Disturbance Degree	Ongoing Disturbance Evidence	Wildlife Evidence	Evidence of Erosion	Compaction Rating (cm)	Photo #'s
KV-01	KV-01-Ref South	well-drained	>10m	local measured data		0 none	minimal	moose pellets, sparrows, juncos	minimal		462
KV-01	KV-01-0+03	well drained shale/soil	>10m	local measured data		3 <0.5 m cut or fill	minimal	moose pellets, sparrows, juncos	minimal		463
KV-01	KV-01-0+09	well drained shale/soil	>10m	local measured data		9 cut 0.5-1.5m	minimal	moose pellets, sparrows, juncos	minimal	"loose"	466
KV-01	KV-01-0+20	slightly moist shale/soil	>10m	local measured data		20 cut >3m	minimal	moose pellets, sparrows, juncos	minimal		467
KV-02	KV-02-A	not described	>10m	local measured data		80 fill >3m	minimal	no observations	minimal		482
KV-02	KV-02-B	not described	>10m	local measured data		0 none	minimal	no observations	minimal		483
KV-02	KV-02-C	not described	>10m	local measured data		250 fill >3m	minimal	no observations	minimal		none
KV-03	KV-03-Ref		>10m	topographic inference		0 none	minimal	no observations	minimal		489
KV-03	KV-03-B	organics berm	>10m	topographic inference		1 fill 0.5-1.5m	minimal	no observations	minimal		490
KV-03	KV-03-C		>10m	topographic inference		5 <0.5 m cut or fill	minimal	no observations	minimal		491
KV-03	KV-03-D	fine-grained, silt-like with some rounded rocks	>10m	topographic inference		35 cut 1.5-3m	minimal	no observations	minimal		492
KV-03	KV-03-E		>10m	topographic inference		65 cut >3m	minimal	no observations	minimal		493
KV-03	KV-03-F	approx 60% rounded pebbles to coarse sand, <40% fines. Less silty relative to south side of pit (eg. sites KV-03D and E)	>10m	topographic inference		25 cut >3m	minimal	no observations	minimal		498
KV-04	KV-04-Ref		3.6-10m	topographic inference		0 none	minimal	no observations	minimal		506
KV-04	KV-04-A	not described	3.6-10m	topographic inference		3 <0.5 m cut or fill	minimal	no observations	minimal		505
KV-04	KV-04-B	well drained sand and gravel with <30% fines	3.6-10m	topographic inference		30 cut 1.5-3m	minimal	no observations	minimal		507

Appendix C
Station Information

Site #	Station #	Soil General Description	Estimated Water Table Location	Water Table Assmt based on	Min Distance to Undisturbed Vegetation	Disturbance Degree	Ongoing Disturbance Evidence	Wildlife Evidence	Evidence of Erosion	Compaction Rating (cm)	Photo #'s
KV-05	KV-05-A	approx 90% pebble to cobble size; 10% fines consisting of slightly silty sand with organics	3.6-10m	topographic inference	240	other	minimal	no observations	minimal		523-533
KV-06	KV-06-Ref		>10m	topographic inference	0	none	minimal	no observations	minimal	20	536
KV-06	KV-06-A	approx 50% pebble to cobble, with fines consisting of silty sand	>10m	topographic inference	30	cut 1.5-3m	minimal	no observations	minimal	10	546
KV-07	KV-07-A	approx 50% pebble to cobble, with fines consisting of silty sand	>10m	topographic inference	8	<0.5 m cut or fill	minimal	no observations	minimal	8	554
KV-07	KV-07-B	approx 50% pebble to cobble, with fines consisting of silty sand	>10m	topographic inference	30	cut 0.5-1.5m	minimal	no observations	minimal	6	555
KV-08	KV-08-A	approx 40% pebble to cobble, fines consisting of sandy silt (seems slightly more fine-grained than KV-06 and KV-07.	>10m	topographic inference	8	<0.5 m cut or fill	minimal	no observations	minimal	23	564
KV-08	KV-08-B	approx 40% pebble to cobble, fines consisting of sandy silt (seems slightly more fine-grained than KV-06 and KV-07.	>10m	topographic inference	25	cut 0.5-1.5m	minimal	no observations	minimal	9	565
KV-09	KV-09-Ref		>10m	topographic inference	0	none	minimal	no observations	minimal	15	575
KV-09	KV-09-A	approx 50% pebble to cobble, with fines consisting of silty sand	>10m	topographic inference	4	cut 1.5-3m	minimal	no observations	minimal		579
KV-09	KV-09-B	approx 60% remnant crush (1" angular pieces), fines consisting of slightly silty sand	>10m	topographic inference	40	cut >3m	sporadic vehicle traffic	no observations	minimal	8	573
KV-09	KV-09-C		>10m	topographic inference	4	cut 1.5-3m	minimal	no observations	minimal		573
SV-01	SV-01-Ref		3.6-10m	waterbody location w/in 100m	0	none	minimal	no observations	minimal	20	599

Appendix C
Station Information

Site #	Station #	Soil General Description	Estimated Water Table Location	Water Table Assmt based on	Min Distance to Undisturbed Vegetation	Disturbance Degree	Ongoing Disturbance Evidence	Wildlife Evidence	Evidence of Erosion	Compaction Rating (cm)	Photo #'s
SV-01	SV-01-A	soil pit to 0.15m: <0.05m veneer of humus/moss, underlain by approx 40% rounded cobbles/pebbles, fines medium grained and sandy, minor silt, no roots seen	3.6-10m	waterbody location w/in 100m	23	cut 1.5-3m	minimal	no observations	minimal	17	600
SV-01	SV-01-B	soil pit to 0.1m: 1.5cm veneer of humus/moss, underlain by approx 40% rounded cobbles/pebbles, fines medium grained and sandy, moderate silt, fine root hairs seen	0.5-1.5m	waterbody location w/in 100m	30	cut >3m	minimal	no observations	minimal	13	607
SV-02	SV-02-Ref	not described	>10m	topographic inference	0	none	minimal	no observations	minimal	16	25
SV-02	SV-02-A	approx 5cm thick surface armouring of well-rounded cobbles and pebbles, underlain by 40% pebble/cobbles, with fines of sand with trace silt			10	cut >3m	minimal	no observations	minimal	15	26
KL-01	KL-01-Ref		2.6-3.5m	waterbody location w/in 100m	0	none	minimal	no observations	minimal		55
KL-01	KL-01-A	approx 70% pebble/cobble sized material, fines consisting of silty sand	2.6-3.5m	waterbody location w/in 100m	8	cut 0.5-1.5m	minimal	no observations	minimal	9	56
KL-01	KL-01-B	approx 70% pebble/cobble sized material, fines consisting of silty sand	2.6-3.5m	waterbody location w/in 100m	40	cut 0.5-1.5m	minimal	no observations	minimal	9	58
KL-02	KL-02-Ref		1.6-2.5m	topographic inference	0	none	minimal	moose pellets	minimal		68
KL-02	KL-02-A		1.6-2.5m	topographic inference	10	cut 1.5-3m	minimal	no observations	minimal		70-71
KL-02	KL-02-B	dark soil with visually elevated organics content, approx 30% cobble sized fragments	1.6-2.5m	topographic inference	100	cut 1.5-3m	minimal	no observations	minimal	5	73
KL-03	KL-03-Ref		3.6-10m	waterbody location w/in 100m	0	none	minimal	no observations	minimal		83, 87

Appendix C
Station Information

Site #	Station #	Soil General Description	Estimated Water Table Location	Water Table Assmt based on	Min Distance to Undisturbed Vegetation	Disturbance Degree	Ongoing Disturbance Evidence	Wildlife Evidence	Evidence of Erosion	Compaction Rating (cm)	Photo #'s
KL-03	KL-03-A		2.6-3.5m	waterbody location w/in 100m	15	cut 1.5-3m	minimal	no observations	minimal		84
KL-03	KL-03-B		1.6-2.5m	waterbody location w/in 100m	5	cut 1.5-3m	minimal	no observations	minimal		87
KL-04	KL-04-Ref		3.6-10m	topographic inference	0	none	minimal	no observations	minimal		108
KL-04	KL-04-A		3.6-10m	topographic inference	100	cut >3m	minimal	no observations	minimal		98
KL-04	KL-04-B		3.6-10m	topographic inference	20	cut >3m	minimal	no observations	minimal		107
HR-01	HR-01-Ref	substrate very blocky underfoot	>10m	topographic inference	0	none	minimal	no observations	minimal		118
HR-01	HR-01-A	approx 60% pebble/cobble (granite/granodiorite), sandy-textured fines with minimal silt	>10m	topographic inference	18	cut >3m	minimal	no observations	minimal		124
HR-01	HR-01-B		>10m	topographic inference	60	cut >3m	minimal	no observations	minimal		137
SL-01	SL-01-Ref1	well-drained	>10m	topographic inference	0	none	minimal	no observations	minimal		339
SL-01	SL-01-Ref2	well-drained	>10m	topographic inference	0	none	minimal	no observations	minimal		396
SL-01	SL-01-A	well-drained	>10m	topographic inference	3	fill 0.5-1.5m	minimal	no observations	minimal		344-345
SL-01	SL-01-B	approx 20% rounded cobbles with fine sand	>10m	topographic inference	7	fill 0.5-1.5m	minimal	no observations	minimal		346
SL-01	SL-01-C	fine sand	>10m	topographic inference	12	fill 1.5m-3m	minimal	no observations	minimal		348
SL-01	SL-01-D	fine sand	>10m	topographic inference	17	fill 0.5-1.5m	minimal	no observations	minimal		352
SL-01	SL-01-E	fine sand w/ 30% pebble to small cobbles	>10m	topographic inference	22	fill 0.5-1.5m	minimal	no observations	minimal		354

Appendix C
Station Information

Site #	Station #	Soil General Description	Estimated Water Table Location	Water Table Assmt based on	Min Distance to Undisturbed Vegetation	Disturbance Degree	Ongoing Disturbance Evidence	Wildlife Evidence	Evidence of Erosion	Compaction Rating (cm)	Photo #'s
SL-01	SL-01-F	fine sand w/ 30% pebble to small cobbles	>10m	topographic inference	27	fill 0.5-1.5m	minimal	no observations	minimal		356
SL-01	SL-01-G	slightly sandy silt with approx 15% angular pebbles and occasional cobbles	>10m	topographic inference	32	<0.5 m cut or fill	occasional off-road vehicle traffic, foot traffic	no observations	minimal		367
SL-01	SL-01-H	silty sand, surface amouring with 5% pebble/cobbles	>10m	topographic inference	37	<0.5 m cut or fill	occasional off-road vehicle traffic, foot traffic	no observations	minimal		369
SL-01	SL-01-I	silty sand, surface amouring with 5% pebble/cobbles	>10m	topographic inference	31	cut 0.5-1.5m	occasional off-road vehicle traffic, foot traffic	no observations	minimal		380
SL-01	SL-01-J	silty sand, surface amouring with 5% pebble/cobbles	>10m	topographic inference	25	cut 0.5-1.5m	occasional off-road vehicle traffic, foot traffic	no observations	minimal		381
SL-01	SL-01-K	slightly indurated silty sand with 15% gravel to small cobbles	>10m	topographic inference	14	cut 1.5-3m	occasional off-road vehicle traffic, foot traffic	no observations	minimal		389
SL-01	SL-01-L	slightly indurated silty sand with 15% gravel to small cobbles	>10m	topographic inference	11	cut 0.5-1.5m	minimal	no observations	minimal		390
SL-01	SL-01-M	well-drained	>10m	topographic inference	8	<0.5 m cut or fill	minimal	no observations	minimal		394
SL-01	SL-01-N	well-drained	>10m	topographic inference	2	<0.5 m cut or fill	minimal	no observations	minimal		395
SL-02	SL-02-Ref		>10m	topographic inference	0	none	none	no observations	minimal		192
SL-02	SL-02-A		>10m	topographic inference	20	cut 1.5-3m	occasional off-road vehicle traffic, foot traffic	no observations	minimal	9	205
SL-02	SL-02-B	sandy silt with 30% pebble to cobble-sized fragments	>10m	topographic inference	34	cut 1.5-3m	occasional off-road vehicle traffic, foot traffic	no observations	minimal	9	212
SL-02	SL-02-C		>10m	topographic inference	50	cut 1.5-3m	occasional off-road vehicle traffic, foot traffic	no observations	minimal		218
SL-03	SL-03-Ref		<0.5m	visible moisture	0	none	none	no observations	minimal		237
SL-03	SL-03-A		0.5-1.5m	topographic inference	5	fill 1.5m-3m	occasional off-road vehicle traffic, foot traffic	no observations	minimal	13	236
SL-04	SL-04-Ref		>10m	topographic inference	0	none	none	no observations	minimal		250

Appendix C
Station Information

Site #	Station #	Soil General Description	Estimated Water Table Location	Water Table Assmt based on	Min Distance to Undisturbed Vegetation	Disturbance Degree	Ongoing Disturbance Evidence	Wildlife Evidence	Evidence of Erosion	Compaction Rating (cm)	Photo #'s
SL-04	SL-04-A	pebbly sand: approx 50% fine to medium pebbles, fines consist of a medium-grained sand, virtually no silt	>10m	topographic inference	18	cut >3m	occasional off-road vehicle traffic, foot traffic	no observations	minimal	15	251

Appendix C
Plant Layer Assessment

Site	Station	Additional Description	>10m Layer Cover	2-10m Layer Cover	0-2m Layer Cover	Moss/ Lichen/ Liverwort Cover	Layer Comments
KV-01	KV-01-Ref South		0%	26%	10%	95%	Very low abundance of low shrub layer species (0.3 - 1.5m)
KV-01	KV-01-0+03		0%	50%	42%	35%	
KV-01	KV-01-0+09		0%	0%	6%	1%	
KV-01	KV-01-0+20		0%	0%	7%	5%	
KV-02	KV-02-A						no layer data recorded
KV-02	KV-02-B		0%	69%	17%	70%	
KV-02	KV-02-C						no layer data recorded
KV-03	KV-03-Ref		0%	25%	70%	20%	
KV-03	KV-03-B		0%	50%	60%	25%	
KV-03	KV-03-C		0%	25%	15%	80%	
KV-03	KV-03-D		0%	5%	15%	40%	
KV-03	KV-03-E		0%	30%	30%	40%	
KV-03	KV-03-F		0%	0%	20%		no ground layer data recorded
KV-04	KV-04-Ref		30%	20%	80%	10%	layer data estimated from photo
KV-04	KV-04-A		0%	0%	80%		A, B1, B2 layer data estimated from photo, ground layer data not estimated nor recorded
KV-04	KV-04-B		0%	10%	45%	20%	A, B1, B2 and ground layer data estimated from photo and field notes
KV-05	KV-05-A		0%	1%	5%	2%	
KV-06	KV-06-Ref		0%	25%	25%	80%	
KV-06	KV-06-A		0%	0%	1%	3%	
KV-07	KV-07-A					30%	no layer data recorded, ground layer data estimated from photo
KV-07	KV-07-B		0%	0%	2%	5%	ground layer data estimated from photo
KV-08	KV-08-A		0%	2%	20%	30%	layer data estimated from photo
KV-08	KV-08-B		0%	1%	15%		layer data estimated from photo (could not discern ground layer cover)
KV-09	KV-09-Ref		0%	50%	30%	90%	
KV-09	KV-09-A		0%	0%	25%	5%	
KV-09	KV-09-B		0%	0%	15%	5%	
KV-09	KV-09-C						no layer data recorded

Appendix C
Plant Layer Assessment

Site	Station	Additional Description	>10m Layer Cover	2-10m Layer Cover	0-2m Layer Cover	Moss/ Lichen/ Liverwort Cover	Layer Comments
SV-01	SV-01-Ref		35%	10%	25%	95%	
SV-01	SV-01-A		10%	20%	40%	40%	
SV-01	SV-01-B		1%	5%	50%	35%	tree and shrub layer data estimated from photo
SV-02	SV-02-Ref		15%	20%	30%	80%	ground layer data estimated from photo and field notes
SV-02	SV-02-A		0%	2%	30%	20%	ground layer data estimated from photo and field notes
KL-01	KL-01-Ref		20%	10%			tree and shrub layer data estimated from photo
KL-01	KL-01-A		0%	5%	70%	5%	layer data estimated from photo ground layer cover from notes)
KL-01	KL-01-B		0%	5%	40%	15%	ground layer data estimated from photo and field notes
KL-02	KL-02-Ref		30%	10%	40%	80%	
KL-02	KL-02-A		0%	40%	70%	15%	
KL-02	KL-02-B		0%	25%	70%	25%	low shrub/herb layer data estimated from photo
KL-03	KL-03-Ref		25%	20%	5%	92%	low shrub/herb layer data estimated from photo
KL-03	KL-03-A		0%	5%	30%	30%	low shrub/herb layer data estimated from photo
KL-03	KL-03-B						no layer data recorded
KL-04	KL-04-Ref		25%	15%	20%	75%	
KL-04	KL-04-A		0%	0%	60%	5%	
KL-04	KL-04-B		0%	0%	60%		low shrub/herb layer data estimated from photo (could not discern ground layer cover)
HR-01	HR-01-Ref		0%	0%	30%	70%	
HR-01	HR-01-A		0%	0%	10%	20%	
HR-01	HR-01-B		0%	0%	15%	55%	impressive moss/lichen cover for a recolonizing area!
SL-01	SL-01-Ref1		15%	5%	100%	0%	No notable presence of moss or lichen -- extensive groundcover of kinnikinnick and litter. Tree and tall shrub layer data interpreted from tree height information along with cover information, certain information using photos
SL-01	SL-01-Ref2		40%	10%	45%		Tree and tall shrub layer data interpreted from tree height information along with cover information, certain information using photos. Moss/lichen/liverwort data appears inconsistent with photo so was not entered.
SL-01	SL-01-A	station 0+005	0%	5%	80%	1%	Tree and tall shrub layer data interpreted from tree height information along with cover information, certain information using photos

Appendix C
Plant Layer Assessment

Site	Station	Additional Description	>10m Layer Cover	2-10m Layer Cover	0-2m Layer Cover	Moss/ Lichen/ Liverwort Cover	Layer Comments
SL-01	SL-01-B	station 0+010; face of fill slope	0%	25%	35%	0%	Tree and tall shrub layer data interpreted from tree height information along with cover information, certain information using photos
SL-01	SL-01-C	station 0+015	0%	5%	50%	1%	Tree and tall shrub layer data interpreted from tree height information along with cover information, certain information using photos
SL-01	SL-01-D	station 0+020	0%	0%	70%	1%	Tree and tall shrub layer data interpreted from tree height information along with cover information, certain information using photos
SL-01	SL-01-E	station 0+025	0%	10%	40%	1%	Tree and tall shrub layer data interpreted from tree height information along with cover information, certain information using photos
SL-01	SL-01-F	station 0+030	0%	15%	25%	3%	Tree and tall shrub layer data interpreted from tree height information along with cover information, certain information using photos
SL-01	SL-01-G	station 0+035	0%	2%	60%	4%	Tree and tall shrub layer data interpreted from tree height information along with cover information, certain information using photos
SL-01	SL-01-H	station 0+040	0%	0%	1%	53%	Tree and tall shrub layer data interpreted from tree height information along with cover information, certain information using photos
SL-01	SL-01-I	station 0+048	0%	1%	7%	48%	Tree and tall shrub layer data interpreted from tree height information along with cover information, certain information using photos
SL-01	SL-01-J	station 0+056, 5 m west of trail	0%	0%	1%	40%	Tree and tall shrub layer data interpreted from tree height information along with cover information, certain information using photos
SL-01	SL-01-K	station 0+067, toe of cut slope	0%	0%	35%	21%	Tree and tall shrub layer data interpreted from tree height information along with cover information, certain information using photos
SL-01	SL-01-L	station 0+070, midway on cutslope	0%	3%	22%	7%	Tree and tall shrub layer data interpreted from tree height information along with cover information, certain information using photos

**Appendix C
Plant Layer Assessment**

Site	Station	Additional Description	>10m Layer Cover	2-10m Layer Cover	0-2m Layer Cover	Moss/ Lichen/ Liverwort Cover	Layer Comments
SL-01	SL-01-M	station 0+073, crest of cutslope	0%	10%	80%	15%	Tree and tall shrub layer data interpreted from tree height information along with cover information, certain information using photos
SL-01	SL-01-N	station 0+079, edge of tree- cleared area	0%	10%	45%	25%	Tree and tall shrub layer data interpreted from tree height information along with cover information, certain information using photos
SL-02	SL-02-Ref		50%	20%	30%	40%	low moss/lichen cover for a reference site -- owing to litter?
SL-02	SL-02-A		0%	1%	25%	55%	
SL-02	SL-02-B		0%	20%	75%	5%	
SL-02	SL-02-C		0%	0%	10%	60%	
SL-03	SL-03-Ref		0%	35%	30%	20%	
SL-03	SL-03-A		0%	25%	60%	28%	
SL-04	SL-04-Ref						no layer data recorded
SL-04	SL-04-A		0%	0%	20%	15%	

**Appendix C
Plant Species Assessment**

Layer	Plant Category	Common Name	Genus	Species Name	Native or Introduced	Possible Seed Mix Species?	Invasive Rank	KV-01-Ref South	KV-01-0+03	KV-01-0+09	KV-01-0+20	KV-02-A	KV-02-B	KV-02-C	KV-03-Ref	KV-03-B
0-2m	Forb	Cut-leaved Anemone	<i>Anemone</i>	<i>multifida</i>	Native											
0-2m	Forb	Blue Flax	<i>Linum</i>	<i>lewisii</i>	Native											
0-2m	Forb	Bunchberry	<i>Cornus</i>	<i>canadensis</i>	Native											
0-2m	Forb	Pearly Everlasting	<i>Anaphalis</i>	<i>margaritacea</i>	Native											
0-2m	Forb	Pussytoes, undifferentiated	<i>Antennaria</i>	<i>sp.</i>	Native											
0-2m	Forb	Forb, taxonomy undetermined														
0-2m	Grass	Foxtail barley	<i>Hordeum</i>	<i>jubatum</i>	Native							0.25			-1	
0-2m	Grass	Hair grass, undifferentiated	<i>Deschampsia</i>	<i>sp.</i>	Unknown											
0-2m	Grass	Tufted hair grass	<i>Deschampsia</i>	<i>caespitosa</i>	Native	Yes					1				0.25	
0-2m	Grass	Altai Fescue	<i>Festuca</i>	<i>altaica</i>	Native											
0-2m	Grass	Sheep fescue	<i>Festuca</i>	<i>ovina</i>	Native											
0-2m	Grass	Red Fescue	<i>Festuca</i>	<i>rubra</i>	Unknown	Yes										
0-2m	Grass	Purple reedgrass	<i>Calamagrostis</i>	<i>purpurascens</i>	Native											
0-2m	Grass	Blue-joint Grass	<i>Calamagrostis</i>	<i>canadensis</i>	Native											
0-2m	Grass	Wheatgrass - common	<i>Agropyron</i>	<i>pauciflorum</i>	Native											
0-2m	Grass	Bluebunch Wheat	<i>Agropyron</i>	<i>spicatum</i>	Native											
0-2m	Grass	Slender Wheatgrass	<i>Agropyron</i>	<i>trachycaulum</i>	Native	Yes					0.25					
0-2m	Grass	Wheatgrass	<i>Agropyron</i>	<i>sp.</i>	Unknown	Yes					0.25					
0-2m	Grass	Glaucous Bluegrass	<i>Poa</i>	<i>glauca</i>	Native											
0-2m	Grass	Kentucky bluegrass	<i>Poa</i>	<i>pratensis</i>	Introduced		7									
0-2m	Grass	Pine Bluegrass	<i>Poa</i>	<i>secunda</i>	Native											
0-2m	Grass	Smooth Brome	<i>Bromus</i>	<i>inermis</i>	Introduced	Yes	1									
0-2m	Grass	Brome, undifferentiated	<i>Bromus</i>	<i>sp.</i>	Unknown											
0-2m	Grass	Tickle Grass / Hair Grass	<i>Agrostis</i>	<i>scabra</i>	Native											
0-2m	Grass	Spike trisetum	<i>Trisetum</i>	<i>spicatum</i>	Native											
0-2m	Grass	Introduced Grass, undifferentiated			Introduced	Yes						3				0.25
0-2m	Grass	Native Grass, undifferentiated			Native											
0-2m	Fungi	Mushroom-like fungus, undifferentiated			Native											
Ground		Rock/Cobbles/Pebbles						0%	15%		50%					
Ground		Exposed Fines						0%	10%		10%				45%	
Ground		Plant Litter						5%	20%		30%		30%		35%	75%
Ground		Thick Moss/Lichen						95%	35%		5%		70%		20%	25%
Ground		Crustal Moss/Lichen / Cryptogram Layer						0%	20%		1%					
Ground		Tripe-like Lichen / Liverwort						1%	0%		0%					

Appendix C
Plant Species Assessment

Layer	Plant Category	Common Name	Genus	Species Name	Native or Introduced	Possible Seed Mix Species?	Invasive Rank	KV-03-C	KV-03-D	KV-03-E	KV-03-F	KV-04-Ref	KV-04-A	KV-04-B	KV-05-A	KV-06-Ref
>10m	Tree	Trembling Aspen	<i>Populus</i>	<i>tremuloides</i>	Native							2				
>10m	Tree	Balsam Poplar	<i>Populus</i>	<i>balsamifera</i>	Native											
>10m	Tree	White Spruce	<i>Picea</i>	<i>glauca</i>	Native							1				
>10m	Tree	Black Spruce	<i>Picea</i>	<i>mariana</i>	Native											
>10m	Tree	Lodgepole Pine	<i>Pinus</i>	<i>contorta ssp. L</i>	Native											
2-10m	Tree	Trembling Aspen	<i>Populus</i>	<i>tremuloides</i>	Native			1	3	0.25		0.5			0.5	3
2-10m	Tree	Balsam Poplar	<i>Populus</i>	<i>balsamifera</i>	Native				1							
2-10m	Tree	White Spruce	<i>Picea</i>	<i>glauca</i>	Native							2				
2-10m	Tree	Black Spruce	<i>Picea</i>	<i>mariana</i>	Native											0.5
2-10m	Tree	Lodgepole Pine	<i>Pinus</i>	<i>contorta ssp. L</i>	Native											
2-10m	Tree	Alaska Paper Birch	<i>Betula</i>	<i>neolaskana</i>	Native			3		1					0.5	0.5
2-10m	Shrub	Shrubby Willow	<i>Salix</i>	<i>arbusuloides</i>	Native											
2-10m	Shrub	Willow, undifferent	<i>Salix</i>	<i>sp.</i>	Native			0.5		3		1			3	
2-10m	Shrub	Green Alder	<i>Alnus</i>	<i>crispa</i>	Native											
0-2m	Tree	Trembling Aspen	<i>Populus</i>	<i>tremuloides</i>	Native			2	2		0.5		0.25	1		0.5
0-2m	Tree	Balsam Poplar	<i>Populus</i>	<i>balsamifera</i>	Native					1	0.5					
0-2m	Tree	White Spruce	<i>Picea</i>	<i>glauca</i>	Native						0.25					
0-2m	Tree	Black Spruce	<i>Picea</i>	<i>mariana</i>	Native			0.25	0.25							2
0-2m	Tree	Lodgepole Pine	<i>Pinus</i>	<i>contorta ssp. L</i>	Native											
0-2m	Tree	Alpine Fir	<i>Abies</i>	<i>lasiocarpa</i>	Native											
0-2m	Tree	Alaska Paper Birch	<i>Betula</i>	<i>neolaskana</i>	Native			1	0.25	0.25	2				0.5	
0-2m	Tree	Dwarf / Shrub Birch	<i>Betula</i>	<i>glandulosa</i>	Native											
0-2m	Tree	Paper Birch	<i>Betula</i>	<i>papyrifera</i>	Native											
0-2m	Shrub	Shrubby Willow	<i>Salix</i>	<i>arbusuloides</i>	Native											
0-2m	Shrub	Willow, undifferent	<i>Salix</i>	<i>sp.</i>	Native			0.5	0.5	1	1	1	0.25	2	1	1
0-2m	Shrub	Green Alder	<i>Alnus</i>	<i>crispa</i>	Native											
0-2m	Shrub	Speckled Alder	<i>Alnus</i>	<i>incana</i>	Native											
0-2m	Shrub	Wolf Willow	<i>Eleagnus</i>	<i>commutata</i>	Native											
0-2m	Shrub	Prickly Rose	<i>Rosa</i>	<i>acicularis</i>	Native							0.5			2	
0-2m	Shrub	Highbush Cranberry	<i>Viburnum</i>	<i>edule</i>	Native											
0-2m	Shrub	Soapberry	<i>Shepherdia</i>	<i>canadensis</i>	Native							0.5				
0-2m	Shrub	Wild Red Raspberry	<i>Rubus</i>	<i>idaeus</i>	Native										0.5	
0-2m	Shrub	Labrador Tea	<i>Ledum</i>	<i>groenlandicum</i>	Native											0.25
0-2m	Shrub	Norwegian / Rough	<i>Potentilla</i>	<i>norvegica</i>	Native											
0-2m	Shrub	Pennsylvania Cinqu	<i>Potentilla</i>	<i>litoralis</i>	Native											
0-2m	Shrub	Common Juniper	<i>Juniperus</i>	<i>communis</i>	Native											
0-2m	Shrub	Juniper, undifferen	<i>Juniperus</i>	<i>sp.</i>	Native											
0-2m	Shrub	Shrub, undifferentiated			Native											
0-2m	Dwarf Shrub	Kinnikinnick / Com	<i>Arctostaphy</i>	<i>uva-ursi</i>	Native			1	0.5			2				0.5
0-2m	Dwarf Shrub	Red Bearberry	<i>Arctostaphy</i>	<i>rubra</i>	Native											
0-2m	Dwarf Shrub	Lingonberry / Low-	<i>Vaccinium</i>	<i>vitis-idaea</i>	Native											
0-2m	Dwarf Shrub	Bilberry	<i>Vaccinium</i>	<i>sp.</i>	Native											0.25
0-2m	Dwarf Shrub	Crowberry	<i>Empetrum</i>	<i>nigrum</i>	Native											
0-2m	Dwarf Shrub	Drummond's Moun	<i>Dryas</i>	<i>drummondii</i>	Native											
0-2m	Dwarf Shrub	Dwarf Heather, unc	<i>Cassiope</i>	<i>sp.</i>	Native											
0-2m	Forb	Common yarrow	<i>Achillea</i>	<i>millefolium</i>	Native				0.25	0.25	0.5			-1	0.5	

Appendix C
Plant Species Assessment

Layer	Plant Category	Common Name	Genus	Species Name	Native or Introduced	Possible Seed Mix Species?	Invasive Rank	KV-06-A	KV-07-A	KV-07-B	KV-08-A	KV-08-B	KV-09-Ref	KV-09-A	KV-09-B	KV-09-C
>10m	Tree	Trembling Aspen	<i>Populus</i>	<i>tremuloides</i>	Native											
>10m	Tree	Balsam Poplar	<i>Populus</i>	<i>balsamifera</i>	Native											
>10m	Tree	White Spruce	<i>Picea</i>	<i>glauca</i>	Native											
>10m	Tree	Black Spruce	<i>Picea</i>	<i>mariana</i>	Native											
>10m	Tree	Lodgepole Pine	<i>Pinus</i>	<i>contorta ssp. L</i>	Native											
2-10m	Tree	Trembling Aspen	<i>Populus</i>	<i>tremuloides</i>	Native											
2-10m	Tree	Balsam Poplar	<i>Populus</i>	<i>balsamifera</i>	Native							0.25				
2-10m	Tree	White Spruce	<i>Picea</i>	<i>glauca</i>	Native											
2-10m	Tree	Black Spruce	<i>Picea</i>	<i>mariana</i>	Native								3			
2-10m	Tree	Lodgepole Pine	<i>Pinus</i>	<i>contorta ssp. L</i>	Native											
2-10m	Tree	Alaska Paper Birch	<i>Betula</i>	<i>neolaskana</i>	Native											
2-10m	Shrub	Shrubby Willow	<i>Salix</i>	<i>arbusculoides</i>	Native											
2-10m	Shrub	Willow, undifferent	<i>Salix</i>	<i>sp.</i>	Native											
2-10m	Shrub	Green Alder	<i>Alnus</i>	<i>crispa</i>	Native							0.25				
0-2m	Tree	Trembling Aspen	<i>Populus</i>	<i>tremuloides</i>	Native			0.5	1							
0-2m	Tree	Balsam Poplar	<i>Populus</i>	<i>balsamifera</i>	Native			3	3	3	-1	3			1	-1
0-2m	Tree	White Spruce	<i>Picea</i>	<i>glauca</i>	Native			1					1	1		-1
0-2m	Tree	Black Spruce	<i>Picea</i>	<i>mariana</i>	Native				1			1	2	1		-1
0-2m	Tree	Lodgepole Pine	<i>Pinus</i>	<i>contorta ssp. L</i>	Native											
0-2m	Tree	Alpine Fir	<i>Abies</i>	<i>lasiocarpa</i>	Native											
0-2m	Tree	Alaska Paper Birch	<i>Betula</i>	<i>neolaskana</i>	Native				1	1	-1					
0-2m	Tree	Dwarf / Shrub Birch	<i>Betula</i>	<i>glandulosa</i>	Native											
0-2m	Tree	Paper Birch	<i>Betula</i>	<i>papyrifera</i>	Native											
0-2m	Shrub	Shrubby Willow	<i>Salix</i>	<i>arbusculoides</i>	Native											
0-2m	Shrub	Willow, undifferent	<i>Salix</i>	<i>sp.</i>	Native			1	1	1	-1	1		1	1	-1
0-2m	Shrub	Green Alder	<i>Alnus</i>	<i>crispa</i>	Native											
0-2m	Shrub	Speckled Alder	<i>Alnus</i>	<i>incana</i>	Native											
0-2m	Shrub	Wolf Willow	<i>Eleagnus</i>	<i>commutata</i>	Native											
0-2m	Shrub	Prickly Rose	<i>Rosa</i>	<i>acicularis</i>	Native											
0-2m	Shrub	Highbush Cranberry	<i>Viburnum</i>	<i>edule</i>	Native											
0-2m	Shrub	Soapberry	<i>Shepherdia</i>	<i>canadensis</i>	Native							0.25		2	0.5	-1
0-2m	Shrub	Wild Red Raspberry	<i>Rubus</i>	<i>idaeus</i>	Native											
0-2m	Shrub	Labrador Tea	<i>Ledum</i>	<i>groenlandicum</i>	Native											
0-2m	Shrub	Norwegian / Rough	<i>Potentilla</i>	<i>norvegica</i>	Native					0.25					0.25	
0-2m	Shrub	Pennsylvania Cinqu	<i>Potentilla</i>	<i>litoralis</i>	Native											
0-2m	Shrub	Common Juniper	<i>Juniperus</i>	<i>communis</i>	Native											
0-2m	Shrub	Juniper, undifferen	<i>Juniperus</i>	<i>sp.</i>	Native											
0-2m	Shrub	Shrub, undifferentiated			Native											
0-2m	Dwarf Shrub	Kinnikinnick / Com	<i>Arctostaphy</i>	<i>uva-ursi</i>	Native			0.25	0.5					0.5		-1
0-2m	Dwarf Shrub	Red Bearberry	<i>Arctostaphy</i>	<i>rubra</i>	Native											
0-2m	Dwarf Shrub	Lingonberry / Low-	<i>Vaccinium</i>	<i>vitis-idaea</i>	Native								1			
0-2m	Dwarf Shrub	Bilberry	<i>Vaccinium</i>	<i>sp.</i>	Native											
0-2m	Dwarf Shrub	Crowberry	<i>Empetrum</i>	<i>nigrum</i>	Native							0.25	0.5			
0-2m	Dwarf Shrub	Drummond's Moun	<i>Dryas</i>	<i>drummondii</i>	Native									1	3	-1
0-2m	Dwarf Shrub	Dwarf Heather, unc	<i>Cassiope</i>	<i>sp.</i>	Native											
0-2m	Forb	Common yarrow	<i>Achillea</i>	<i>millefolium</i>	Native			1		0.25		1		0.5	0.5	

Appendix C
Plant Species Assessment

Layer	Plant Category	Common Name	Genus	Species Name	Native or Introduced	Possible Seed Mix Species?	Invasive Rank	SV-01-Ref	SV-01-A	SV-01-B	SV-02-Ref	SV-02-A	KL-01-Ref	KL-01-A	KL-01-B	KL-02-Ref
>10m	Tree	Trembling Aspen	<i>Populus</i>	<i>tremuloides</i>	Native			0.5	0.5		0.25					
>10m	Tree	Balsam Poplar	<i>Populus</i>	<i>balsamifera</i>	Native					0.25						
>10m	Tree	White Spruce	<i>Picea</i>	<i>glauca</i>	Native			2			1		2			2
>10m	Tree	Black Spruce	<i>Picea</i>	<i>mariana</i>	Native			1			2					
>10m	Tree	Lodgepole Pine	<i>Pinus</i>	<i>contorta ssp. L</i>	Native											
2-10m	Tree	Trembling Aspen	<i>Populus</i>	<i>tremuloides</i>	Native				0.5		0.5	0.25				
2-10m	Tree	Balsam Poplar	<i>Populus</i>	<i>balsamifera</i>	Native				1	2		2		0.5	2	
2-10m	Tree	White Spruce	<i>Picea</i>	<i>glauca</i>	Native			2	2	1	1	0.5		2	1	2
2-10m	Tree	Black Spruce	<i>Picea</i>	<i>mariana</i>	Native						2					
2-10m	Tree	Lodgepole Pine	<i>Pinus</i>	<i>contorta ssp. L</i>	Native											
2-10m	Tree	Alaska Paper Birch	<i>Betula</i>	<i>neolaskana</i>	Native											
2-10m	Shrub	Shrubby Willow	<i>Salix</i>	<i>arbusuloides</i>	Native											1
2-10m	Shrub	Willow, undifferent	<i>Salix</i>	<i>sp.</i>	Native			1	0.5	0.5		1	2	0.25		
2-10m	Shrub	Green Alder	<i>Alnus</i>	<i>crispa</i>	Native											
0-2m	Tree	Trembling Aspen	<i>Populus</i>	<i>tremuloides</i>	Native				1	1	0.25					
0-2m	Tree	Balsam Poplar	<i>Populus</i>	<i>balsamifera</i>	Native				1						1	
0-2m	Tree	White Spruce	<i>Picea</i>	<i>glauca</i>	Native				2			0.25				
0-2m	Tree	Black Spruce	<i>Picea</i>	<i>mariana</i>	Native											
0-2m	Tree	Lodgepole Pine	<i>Pinus</i>	<i>contorta ssp. L</i>	Native											
0-2m	Tree	Alpine Fir	<i>Abies</i>	<i>lasiocarpa</i>	Native											
0-2m	Tree	Alaska Paper Birch	<i>Betula</i>	<i>neolaskana</i>	Native											
0-2m	Tree	Dwarf / Shrub Birch	<i>Betula</i>	<i>glandulosa</i>	Native											
0-2m	Tree	Paper Birch	<i>Betula</i>	<i>papyrifera</i>	Native											
0-2m	Shrub	Shrubby Willow	<i>Salix</i>	<i>arbusuloides</i>	Native											
0-2m	Shrub	Willow, undifferent	<i>Salix</i>	<i>sp.</i>	Native					1						
0-2m	Shrub	Green Alder	<i>Alnus</i>	<i>crispa</i>	Native											
0-2m	Shrub	Speckled Alder	<i>Alnus</i>	<i>incana</i>	Native											
0-2m	Shrub	Wolf Willow	<i>Eleagnus</i>	<i>commutata</i>	Native											
0-2m	Shrub	Prickly Rose	<i>Rosa</i>	<i>acicularis</i>	Native				0.5							1
0-2m	Shrub	Highbush Cranberry	<i>Viburnum</i>	<i>edule</i>	Native											0.5
0-2m	Shrub	Soapberry	<i>Shepherdia</i>	<i>canadensis</i>	Native			1	1	0.25	0.5			2	0.5	
0-2m	Shrub	Wild Red Raspberry	<i>Rubus</i>	<i>idaeus</i>	Native				0.5	0.25						
0-2m	Shrub	Labrador Tea	<i>Ledum</i>	<i>groenlandicum</i>	Native											0.25
0-2m	Shrub	Norwegian / Rough	<i>Potentilla</i>	<i>norvegica</i>	Native											
0-2m	Shrub	Pennsylvania Cinqu	<i>Potentilla</i>	<i>litoralis</i>	Native											
0-2m	Shrub	Common Juniper	<i>Juniperus</i>	<i>communis</i>	Native											
0-2m	Shrub	Juniper, undifferen	<i>Juniperus</i>	<i>sp.</i>	Native											
0-2m	Shrub	Shrub, undifferentiated			Native											
0-2m	Dwarf Shrub	Kinnikinnick / Com	<i>Arctostaphy</i>	<i>uva-ursi</i>	Native				0.5							0.5
0-2m	Dwarf Shrub	Red Bearberry	<i>Arctostaphy</i>	<i>rubra</i>	Native											0.25
0-2m	Dwarf Shrub	Lingonberry / Low-	<i>Vaccinium</i>	<i>vitis-idaea</i>	Native			1			2					0.5
0-2m	Dwarf Shrub	Bilberry	<i>Vaccinium</i>	<i>sp.</i>	Native											
0-2m	Dwarf Shrub	Crowberry	<i>Empetrum</i>	<i>nigrum</i>	Native											0.5
0-2m	Dwarf Shrub	Drummond's Moun	<i>Dryas</i>	<i>drummondii</i>	Native							3		0.5	2	
0-2m	Dwarf Shrub	Dwarf Heather, unc	<i>Cassiope</i>	<i>sp.</i>	Native											
0-2m	Forb	Common yarrow	<i>Achillea</i>	<i>millefolium</i>	Native				0.25	0.25						

Appendix C
Plant Species Assessment

Layer	Plant Category	Common Name	Genus	Species Name	Native or Introduced	Possible Seed Mix Species?	Invasive Rank	SV-01-Ref	SV-01-A	SV-01-B	SV-02-Ref	SV-02-A	KL-01-Ref	KL-01-A	KL-01-B	KL-02-Ref
0-2m	Forb	Cut-leaved Anemone	<i>Anemone</i>	<i>multifida</i>	Native											
0-2m	Forb	Blue Flax	<i>Linum</i>	<i>lewisii</i>	Native											
0-2m	Forb	Bunchberry	<i>Cornus</i>	<i>canadensis</i>	Native											
0-2m	Forb	Pearly Everlasting	<i>Anaphalis</i>	<i>margaritacae</i>	Native											
0-2m	Forb	Pussytoes, undifferentiated	<i>Antennaria</i>	<i>sp.</i>	Native											
0-2m	Forb	Forb, taxonomy undetermined								0.25						
0-2m	Grass	Foxtail barley	<i>Hordeum</i>	<i>jubatum</i>	Native											
0-2m	Grass	Hair grass, undifferentiated	<i>Deschampsia</i>	<i>sp.</i>	Unknown											
0-2m	Grass	Tufted hair grass	<i>Deschampsia</i>	<i>caespitosa</i>	Native	Yes										
0-2m	Grass	Altai Fescue	<i>Festuca</i>	<i>altaica</i>	Native											
0-2m	Grass	Sheep fescue	<i>Festuca</i>	<i>ovina</i>	Native											
0-2m	Grass	Red Fescue	<i>Festuca</i>	<i>rubra</i>	Unknown	Yes										
0-2m	Grass	Purple reedgrass	<i>Calamagrostis</i>	<i>purpurascens</i>	Native						0.25					
0-2m	Grass	Blue-joint Grass	<i>Calamagrostis</i>	<i>canadensis</i>	Native				0.25	0.5						0.5
0-2m	Grass	Wheatgrass - common	<i>Agropyron</i>	<i>pauciflorum</i>	Native											
0-2m	Grass	Bluebunch Wheat	<i>Agropyron</i>	<i>spicatum</i>	Native				0.25	0.5						
0-2m	Grass	Slender Wheatgrass	<i>Agropyron</i>	<i>trachycaulum</i>	Native	Yes			0.25	0.5						
0-2m	Grass	Wheatgrass	<i>Agropyron</i>	<i>sp.</i>	Unknown	Yes										
0-2m	Grass	Glaucous Bluegrass	<i>Poa</i>	<i>glauca</i>	Native											
0-2m	Grass	Kentucky bluegrass	<i>Poa</i>	<i>pratensis</i>	Introduced		7									
0-2m	Grass	Pine Bluegrass	<i>Poa</i>	<i>secunda</i>	Native											
0-2m	Grass	Smooth Brome	<i>Bromus</i>	<i>inermis</i>	Introduced	Yes	1									
0-2m	Grass	Brome, undifferentiated	<i>Bromus</i>	<i>sp.</i>	Unknown											
0-2m	Grass	Tickle Grass / Hair E	<i>Agrostis</i>	<i>scabra</i>	Native											
0-2m	Grass	Spike trisetum	<i>Trisetum</i>	<i>spicatum</i>	Native											
0-2m	Grass	Introduced Grass, undifferentiated			Introduced	Yes										
0-2m	Grass	Native Grass, undifferentiated			Native			0.5		0.25						
0-2m	Fungi	Mushroom-like fungus, undifferentiated			Native											
Ground		Rock/Cobbles/Pebbles							5%			55%			5%	
Ground		Exposed Fines							15%			20%			20%	10%
Ground		Plant Litter						5%	40%	60%	20%	5%			60%	10%
Ground		Thick Moss/Lichen						95%	30%	30%	80%	15%		5%		80%
Ground		Crustal Moss/Lichen / Cryptogram Layer								5%		5%			15%	
Ground		Tripe-like Lichen / Liverwort							10%							

**Appendix C
Plant Species Assessment**

Layer	Plant Category	Common Name	Genus	Species Name	Native or Introduced	Possible Seed Mix Species?	Invasive Rank	KL-02-A	KL-02-B	KL-03-Ref	KL-03-A	KL-03-B	KL-04-Ref	KL-04-A	KL-04-B	HR-01-Ref
>10m	Tree	Trembling Aspen	<i>Populus</i>	<i>tremuloides</i>	Native											
>10m	Tree	Balsam Poplar	<i>Populus</i>	<i>balsamifera</i>	Native											
>10m	Tree	White Spruce	<i>Picea</i>	<i>glauca</i>	Native											
>10m	Tree	Black Spruce	<i>Picea</i>	<i>mariana</i>	Native					2			2			
>10m	Tree	Lodgepole Pine	<i>Pinus</i>	<i>contorta ssp. L</i>	Native											
2-10m	Tree	Trembling Aspen	<i>Populus</i>	<i>tremuloides</i>	Native											
2-10m	Tree	Balsam Poplar	<i>Populus</i>	<i>balsamifera</i>	Native		0.5	2			2	1				
2-10m	Tree	White Spruce	<i>Picea</i>	<i>glauca</i>	Native											
2-10m	Tree	Black Spruce	<i>Picea</i>	<i>mariana</i>	Native					1				2		
2-10m	Tree	Lodgepole Pine	<i>Pinus</i>	<i>contorta ssp. L</i>	Native											
2-10m	Tree	Alaska Paper Birch	<i>Betula</i>	<i>neolaskana</i>	Native							0.25				
2-10m	Shrub	Shrubby Willow	<i>Salix</i>	<i>arbusuloides</i>	Native		1									
2-10m	Shrub	Willow, undifferent	<i>Salix</i>	<i>sp.</i>	Native		2				1		0.5			
2-10m	Shrub	Green Alder	<i>Alnus</i>	<i>crispa</i>	Native											
0-2m	Tree	Trembling Aspen	<i>Populus</i>	<i>tremuloides</i>	Native		0.25				1				1	
0-2m	Tree	Balsam Poplar	<i>Populus</i>	<i>balsamifera</i>	Native		0.25	1			1				1	
0-2m	Tree	White Spruce	<i>Picea</i>	<i>glauca</i>	Native		0.5				0.5					
0-2m	Tree	Black Spruce	<i>Picea</i>	<i>mariana</i>	Native					3						
0-2m	Tree	Lodgepole Pine	<i>Pinus</i>	<i>contorta ssp. L</i>	Native											
0-2m	Tree	Alpine Fir	<i>Abies</i>	<i>lasiocarpa</i>	Native											
0-2m	Tree	Alaska Paper Birch	<i>Betula</i>	<i>neolaskana</i>	Native											
0-2m	Tree	Dwarf / Shrub Birch	<i>Betula</i>	<i>glandulosa</i>	Native											2
0-2m	Tree	Paper Birch	<i>Betula</i>	<i>papyrifera</i>	Native		0.25									
0-2m	Shrub	Shrubby Willow	<i>Salix</i>	<i>arbusuloides</i>	Native			1								
0-2m	Shrub	Willow, undifferent	<i>Salix</i>	<i>sp.</i>	Native		2	2			2					1
0-2m	Shrub	Green Alder	<i>Alnus</i>	<i>crispa</i>	Native							0.25				
0-2m	Shrub	Speckled Alder	<i>Alnus</i>	<i>incana</i>	Native											
0-2m	Shrub	Wolf Willow	<i>Eleagnus</i>	<i>commutata</i>	Native										1	
0-2m	Shrub	Prickly Rose	<i>Rosa</i>	<i>acicularis</i>	Native		0.25									
0-2m	Shrub	Highbush Cranberry	<i>Viburnum</i>	<i>edule</i>	Native											
0-2m	Shrub	Soapberry	<i>Shepherdia</i>	<i>canadensis</i>	Native								0.25		0.25	
0-2m	Shrub	Wild Red Raspberry	<i>Rubus</i>	<i>idaeus</i>	Native											
0-2m	Shrub	Labrador Tea	<i>Ledum</i>	<i>groenlandicum</i>	Native					0.25						0.5
0-2m	Shrub	Norwegian / Rough	<i>Potentilla</i>	<i>norvegica</i>	Native											
0-2m	Shrub	Pennsylvania Cinqu	<i>Potentilla</i>	<i>litoralis</i>	Native									0.25		
0-2m	Shrub	Common Juniper	<i>Juniperus</i>	<i>communis</i>	Native											
0-2m	Shrub	Juniper, undifferen	<i>Juniperus</i>	<i>sp.</i>	Native											0.25
0-2m	Shrub	Shrub, undifferentiated			Native											
0-2m	Dwarf Shrub	Kinnikinnick / Com	<i>Arctostaphy</i>	<i>uva-ursi</i>	Native						0.5					0.25
0-2m	Dwarf Shrub	Red Bearberry	<i>Arctostaphy</i>	<i>rubra</i>	Native											0.25
0-2m	Dwarf Shrub	Lingonberry / Low-	<i>Vaccinium</i>	<i>vitis-idaea</i>	Native					0.5						
0-2m	Dwarf Shrub	Bilberry	<i>Vaccinium</i>	<i>sp.</i>	Native											0.25
0-2m	Dwarf Shrub	Crowberry	<i>Empetrum</i>	<i>nigrum</i>	Native							0.25				1
0-2m	Dwarf Shrub	Drummond's Moun	<i>Dryas</i>	<i>drummondii</i>	Native										0.25	
0-2m	Dwarf Shrub	Dwarf Heather, unc	<i>Cassiope</i>	<i>sp.</i>	Native											
0-2m	Forb	Common yarrow	<i>Achillea</i>	<i>millefolium</i>	Native		0.25	0.5			0.25					

Appendix C
Plant Species Assessment

Layer	Plant Category	Common Name	Genus	Species Name	Native or Introduced	Possible Seed Mix Species?	Invasive Rank	KL-02-A	KL-02-B	KL-03-Ref	KL-03-A	KL-03-B	KL-04-Ref	KL-04-A	KL-04-B	HR-01-Ref
0-2m	Forb	Cut-leaved Anemone	<i>Anemone</i>	<i>multifida</i>	Native											
0-2m	Forb	Blue Flax	<i>Linum</i>	<i>lewisii</i>	Native										0.25	
0-2m	Forb	Bunchberry	<i>Cornus</i>	<i>canadensis</i>	Native										0.25	
0-2m	Forb	Pearly Everlasting	<i>Anaphalis</i>	<i>margaritacea</i>	Native											0.5
0-2m	Forb	Pussytoes, undifferentiated	<i>Antennaria</i>	<i>sp.</i>	Native											
0-2m	Forb	Forb, taxonomy undetermined									0.25					
0-2m	Grass	Foxtail barley	<i>Hordeum</i>	<i>jubatum</i>	Native									0.25		
0-2m	Grass	Hair grass, undifferentiated	<i>Deschampsia</i>	<i>sp.</i>	Unknown											
0-2m	Grass	Tufted hair grass	<i>Deschampsia</i>	<i>caespitosa</i>	Native	Yes										
0-2m	Grass	Altai Fescue	<i>Festuca</i>	<i>altaica</i>	Native											
0-2m	Grass	Sheep fescue	<i>Festuca</i>	<i>ovina</i>	Native											0.25
0-2m	Grass	Red Fescue	<i>Festuca</i>	<i>rubra</i>	Unknown	Yes										
0-2m	Grass	Purple reedgrass	<i>Calamagrostis</i>	<i>purpurascens</i>	Native											
0-2m	Grass	Blue-joint Grass	<i>Calamagrostis</i>	<i>canadensis</i>	Native											
0-2m	Grass	Wheatgrass - common	<i>Agropyron</i>	<i>pauciflorum</i>	Native											
0-2m	Grass	Bluebunch Wheat	<i>Agropyron</i>	<i>spicatum</i>	Native											
0-2m	Grass	Slender Wheatgrass	<i>Agropyron</i>	<i>trachycaulum</i>	Native	Yes					0.5					
0-2m	Grass	Wheatgrass	<i>Agropyron</i>	<i>sp.</i>	Unknown	Yes		0.25								
0-2m	Grass	Glaucous Bluegrass	<i>Poa</i>	<i>glauca</i>	Native											
0-2m	Grass	Kentucky bluegrass	<i>Poa</i>	<i>pratensis</i>	Introduced		7									
0-2m	Grass	Pine Bluegrass	<i>Poa</i>	<i>secunda</i>	Native											
0-2m	Grass	Smooth Brome	<i>Bromus</i>	<i>inermis</i>	Introduced	Yes	1									
0-2m	Grass	Brome, undifferentiated	<i>Bromus</i>	<i>sp.</i>	Unknown						0.25					
0-2m	Grass	Tickle Grass / Hair Grass	<i>Agrostis</i>	<i>scabra</i>	Native											
0-2m	Grass	Spike trisetum	<i>Trisetum</i>	<i>spicatum</i>	Native											
0-2m	Grass	Introduced Grass, undifferentiated			Introduced	Yes			1		0.5	0.5		2	2	
0-2m	Grass	Native Grass, undifferentiated			Native					0.25						0.25
0-2m	Fungi	Mushroom-like fungus, undifferentiated			Native			0.25								
Ground		Rock/Cobbles/Pebbles						5%	10%					15%		10%
Ground		Exposed Fines												5%		
Ground		Plant Litter						80%	65%				20%	10%		
Ground		Thick Moss/Lichen						15%	5%				80%	5%		70%
Ground		Crustal Moss/Lichen / Cryptogram Layer														
Ground		Tripe-like Lichen / Liverwort							20%							