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

D. Lister, P.Eng.

Altura Environmental Consulting
PO Box 2004
Marsh Lake, Y.T. Y0B 1Y2

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 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 tremoloides* 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 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 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 indentified 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.

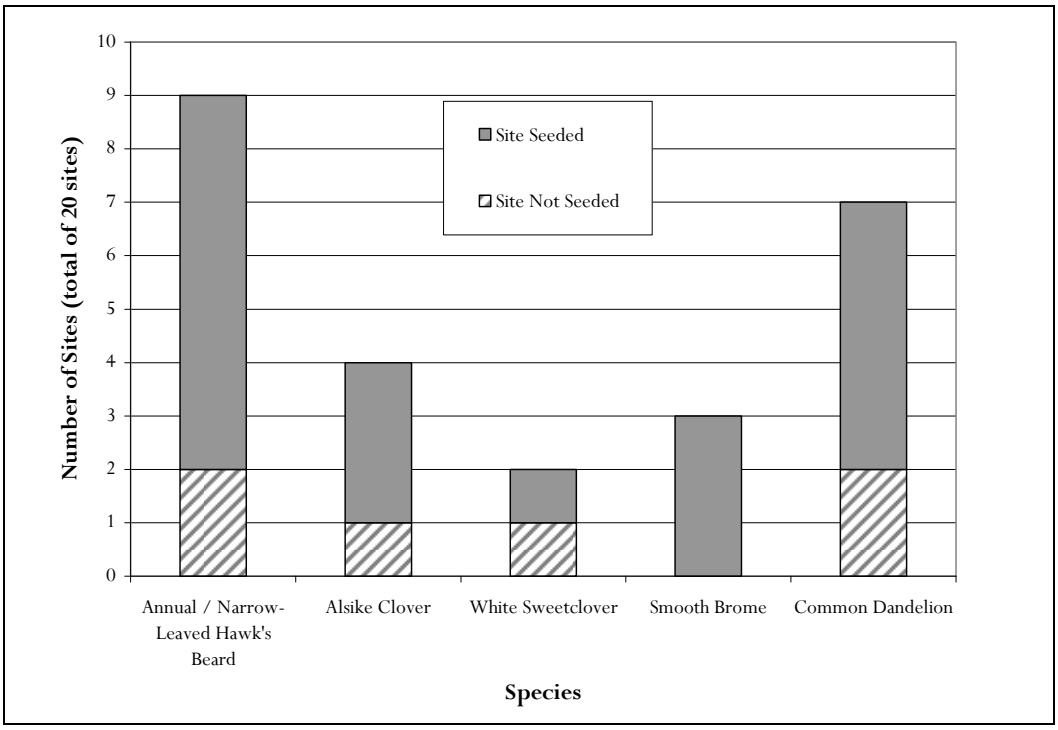

Figure 6. Occurrence of invasive species at seeded and non-seeded sites.

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.

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