WEST KITIKMEOT / SLAVE STUDY SOCIETY

Re: Summer Behaviour of Bathurst Caribou at Mine Sites and Response of Caribou to Fencing and Plastic Deflector

And

Effect of Gravel Road and Tailing Pond Dust on Tundra Plant Communities Near Lupin Mine, NWT

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EFFECT OF GRAVEL ROAD- AND TAILING POND DUST ON TUNDRA PLANT COMMUNITIES NEAR LUPIN MINE, NWT.

1998 Final Report

submitted to

West Kitikmeot Slave Study Society

Submitted By

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Summary

The effect of road dust on tundra vegetation at Lupin mine site, in terms of total cover was minor although some vegetation units had a positive or negative response to higher dust loading. At the northern site of the tailings pond, no noticeable effect was observed. However, at its southern site, the high dust loading is associated with the lower vegetation cover and absence of certain plant assemblages – dwarf shrubs.

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INTRODUCTION

Mining exploration and development is occurring on the traditional ranges of the Bathurst caribou herd. The West Kitikmeot Slave Study Partners have identified caribou as a priority specifically such issues as how much time caribou spend at mine tailings ponds and how this can be mitigated. A related issue raised during the January 1996 Environmental Assessment Panel hearings was the effect of dust from tailings ponds and roads on caribou forage.

Construction of gravel roads for hauling the extracted materials and artificial ponds for tailings disposal are all necessary for mining activities. Both roads and tailings areas have been identified as the largest source of fugitive dust around the mines (Sinha and Banerjee, 1997) affecting the tundra vegetation.

Gravel roads are relatively easy to construct in the northern terrain since the ground is firm by the presence of permafrost and the cold climate helps in the road maintenance (Walker and Everett, 1987). Gravel and sands are usually readily available from the pre-sorted glacial deposits in various quaternary formations such as eskers and kames. The roads are usually elevated with respect to local topography and thus exposed to wind erosion.

Research of the dust effects on northern environments have mainly focused on dust generation from the haul roads and its deposition onto the surrounding vegetation (Walker and Everett, 1991). As a disturbing agent dust can be detrimental both in a physical as well as chemical way. Heavy dust deposits may also affect the habitats of small rodents, reduce albedo of snow along gravel roads, increase snow melt, freeing land for migrating animals earlier than in other parts of the local ecosystem. Dust can import nutrients, however, toxins and heavy metals can also be introduced in the affected areas (Everett and Walker,1987).

Meininger and Spatt (1988) reported from Alaska that several moss assemblages and their associated animals varied with respect to distance from haul roads. Furthermore, they attributed the differences primarily to the adverse effects of the blown-in road dust. Walker and Everett (1987) also pointed out to the vulnerability of certain plant forms (mosses and liverworts). In contrast, they also presented evidence that several common pioneering species benefit from mechanical disturbance and dust deposition due to increased nutrient availability.

Reduction of plant composition and cover have been shown to trigger further changes in the physical environment, such as large-scale erosion and thermokarst development (Walker and Everett, 1987). This can leave tundra ecosystems scarred and ecologically as well as aesthetically damaged long after a mine is closed and its roads or tailings ponds had ceased being used.

The present study reports on investigations into the effects of road- and tailing pond dust on the surrounding tundra vegetation of one of the northern mines north of Yellowknife (cf. “Study Site” section below). It further analyzes information presented in the author’s preliminary reports for the 1996 season (Svoboda, 1997; Svoboda et al., 1997) and deals with new data from the field investigation in 1997.

Objectives

The first objective was to identify the plant assemblages in the tundra mosaic surrounding the gold mine. The second objective was to measure the dust loading at the various distances from the source. Data on additional variables (soil moisture, bulk density and pH) were also gathered. With this information available, we attempted to find a correlation between the occurrence of certain plant assemblages and dust loading and/or the other measured variables.

Study Area

The Bathurst herd's summer range includes the vicinity of the Lupin Mine (a gold mine run by Echo Bay Mines Ltd.), approximately 1 km west of Contwoyoto Lake, NWT (65^{o} 46'N and 111^{o} 14'W). The mine is a complex of buildings, gravel airstrip, roads and tailings ponds (Figure1).

A large tailings pond system was created by damming of the shallow tundra watershed. These artificial basins intercepted the slurry of fine-ground rock from the mine’s mill and processing complex (gold extraction units) and allowed sedimentation of the solid phase suspension. The partially cleared effluent was then directed into the second tailing pond where the chemical remediation and final sedimentation were done.

The tailings contained cyanide, arsenic and other metals (Pilegaard, 1994). In order to protect dry tailings from wind erosion and the contaminated fine dust spreading over the surrounding tundra, a layer of fine sand has been deposited over the dry tailing surface. This sealing off ("capping") of the underlying sediments is also supposed to raise the permafrost level to encase the tailings and further remove any possibility for leaking or movement of tailing compounds or products (Nutbrown pers. comm., 1997).

The various mine activity areas were connected with gravel roads, generally elevated above the tundra topography. Roads were regularly graded and repaired for truck traffic to haul gravel and for maintenance and inspection trips. The roads were the source of the mineral dust blown upon the surrounding tundra.

STUDY DESIGN

In 1996, we established two experimental areas in the low-shrub tundra, one along a gravel road connecting the Lupin mine complex with the tailings pond, and the other at the north and south side of a tailings pond. In 1997, an additional area was selected along a second road. To determine if dust deposition will create a gradient with a high loading near the road and tailing pond margins and a significantly reduced loading at a distance from the dust source (< 97% at 30m), additional dust and vegetation sampling zones, 100m distant from the road and tailing pond, were established as more reliable controls in 1997.

METHODS

The gravel road study areas: The segment of the road chosen for the 1996 study runs from northeast to southwest which was fairly perpendicular to the reported prevailing northwest wind. The road was heavily used by loaded and empty trucks. When the road was dry the trucks generated clouds of dust which the wind carried on to the adjacent tundra. We made sure that the selected study areas were distant from any other sources of disturbance. In 1997 a mirror image of the 1996 site was established along the second gravel road, approximately 190 m distant, yet parallel with the road used in the 1996.

Along each side of the road three 15 m segments (A,B and C) were staked out. These were separated from each other by approximately 200 m long breaks of unstudied tundra. Within each segment, three sampling zones were established at 0 m (i.e. directly adjacent to the road edge), 5 m and 30 m from the road margins (Figure 2). In 1997 a fourth, 100m distant zone was established along the road site and used as a control. These zones represented three parallel sampling transects perpendicular to both sides of the road.

The tailings pond study areas: The same experimental design applied at the gravel roads was also used at the tailing pond margins (Figure 3). Also here the pond margin used was perpendicular to the prevailing winds. The study areas bordered with the tailing cells which were the main source of dust. Also here a 100 m distant zone was added in 1997.

Sampling objectives and procedures In 1996 the investigation was conducted from July 6 to August 9; in 1997 from July 17 to August 4, at the peak of vegetation growth, when also the mine activity, including the road traffic, was high. To obtain information on the cause-effect variables related to dust dissipation in the Lupin mine area, the following physical parameters were measured: dust deposition, soil mass (bulk density), soil moisture and soil pH. The biological parameters included: vegetation composition and cover.

Dust deposition In order to measure dust deposition rates, three aluminum foil pans (400 cm^2) were placed in each zone (n= 9 per zone). The pans were fastened to the ground by wire tent pegs. In 1996 the pans with the deposited dust were collected on August 9, after 20 days of exposure to dust dryfall. This time period showed to be too long, for strong winds, rain or animal trampling was thought to cause a significant alteration of the amount of dust deposited. For this reason, in 1997 the pans were collected every 3 to 4 days on July 27, July 31, and August 4. Deposition rates were determined using equation 1.

$$D.R.=\left(\frac{Dg}{(Sa)(T)}\right) \qquad \text{Equation 1.}$$

where D.R= dust deposition rate (g m^{-2} day^{-1})

Dg = dust mass collected (g)

Sa = dust pan surface area (m^2)

T = duration of pans exposure (days)

Soil sampling Soil samples were collected regularly throughout the 1997 field operation. Particular attention was paid to soil characteristics such as soil pH, moisture and bulk density. Although the samples were initially collected at random points in each zone, the subsequent collections were done in the vicinity of the first sampling points. This procedure was adopted because of the great soil-vegetation heterogeneity. Six soil samples per zone at each site were collected more than 24 hours after a rainfall and at least 4 days after the previous sampling period. Because the high gravel and rock content of the soil made coring very difficult, the soil was dug out by a trowel to a depth of 20 cm and packed into a 450 ml can. The content was immediately emptied into plastic zip-lock bags, sealed and transported to the laboratory for moisture, bulk density and pH determination.

Soil moisture Soil samples were kept in a cool place for gravimetric moisture determination. Their fresh weight was established within 24 hours after collecting (accuracy 0.1g) by the following procedure: The soil content was transferred from the plastic bag into a brown paper bag and immediately weighed. The bags were then placed into an oven and dried at 60^{o} C until constant weight. The bags were then re-weighed and the dry soil mass recorded. The soil moisture per volume was then determined by using Equation 2 from Miller and Donahue (1990).

$$Pv = (100)\left(\frac{Wg}{Sg}\right)\left(\frac{Bd}{Wd}\right) \qquad \text{Equation 2.}$$

where Pv= water percentage per volume (in case of water = g/cm^3)

Wg= weight of water (g)

Sg= weight of dry soil (g)

Bd= soil bulk density (g/cm^3)

Wd= density of water (assumed as 1.0g/cm^3)

Soil mass *The soil's bulk density was determined gravimetrically from the soil samples by using equation 3.*

$$Bd=\left(\frac{Wg}{Sv}\right) \qquad \text{Equation 3.}$$

where Bd= soil bulk density (g/cm^3)
Wg= weight of water (g)
Sv= soil sample volume (450 ml)

Soil pH This analysis was done in the University of Toronto laboratory. Each soil sample was crushed and well homogenized. A subsample (approx. 30 ml) was placed into a 75 ml plastic beaker and moistened with a deionized water until a paste consistency was reached. The beaker was capped, shaken and left to stand for 10 minutes to allow ions to equilibrate. An automatic pH meter (Fisher Scientific Accumet pH meter model 825 MP at 96% efficiency) was used after calibration with buffer solutions of pH 4 and 7. Moistened soil samples were subsequently measured for 30 seconds and the pH recorded to the nearest 0.1 pH unit.

RESULTS

GRAVEL ROADS

Vegetative Cover

Gravel Road Site 1 (R-1) A significantly higher ($p<0{,}05$[1]) plant cover was observed in the 0 m zones NA and SA (the road margins) and in the 5m zones NB and SB (Appendix Fig. 3). This increased cover was due to higher occurrence of a dwarf birch *Betula glandulosa*. In comparison, the 1997 cover was much lower. This happened because it was difficult to determine the exact margin between the road edge and the adjacent tundra (Appendix Fig. 4).

Gravel Road Site 2 (R-2) Plant cover profile displays high values in the 5m and 30m, i.e. B and C in zones (Appendix Fig. 5).

[1] The significance level in all the following statistics is at $p<0.05$.

Dust Recruitment Significantly higher rates of dust deposition were measured in the southern road margin zone (SA) compared to the more distant SB and SC zones. Figures 6, 7 and 8 summarize dust recruitment at sites R-1, 1996 and 1997, and R-2, 1997, respectively. Dust deposition in the northern road margin-(NA) and in the NB zone was also higher (78-95%) than that measured 30m away from the road (NC zone). Although the R-1, 1996 sampling yielded higher rates than in 1997, both years conformed with the expected dust deposition profile within the 30m transect.

Soil Moisture At the R-1 site, soil moisture content in the northern margin zone (NA) was significantly lower (Appendix Fig. 9) than in the NB, NC and ND zones. In contrast, at the R-2 site, soil samples taken from the 5m zone (NB) were significantly more moist than at the farther sampling distances (Appendix Fig. 10). Clearly, the drainage of the tundra topography predetermined the local soil moisture distribution and through it also the type of the vegetation present.

Soil Mass At the R-1 site, the soil mass in the northern road margin zone (NA) was significantly higher than in the more distant zones (Appendix Fig. 11). So was the soil mass in the southern road margin zone (SA) at the R-2 site (Appendix Fig. 12). It seems that erosion of the road sand and higher dust (= clay and silt) deposition near the road margin were responsible for the high mass reading here. With the exception of these two zones, no clear trends emerged which would indicate some relationships between the road distance and soil mass.

Soil pH Soil pH in all zones was strongly acidic and showed marked variability across the landscape. Soil pH in the northern margin zone (NA) was significantly higher than all other zones with a mean (SE) pH reading of 4.7 (0.1). In contrast, soil pH in the southern margin zone (SA) was significantly lower (4.2 (0.2)) than all other tested zones at the R-1 site (Appendix Fig. 13).

At the R-2 site, the mean pH value of 4.2 (0.2), obtained from the northern zone was significantly lower compared to all other zones here, with a pH ranging 4.4 - 4.6 (Appendix Fig. 14).

Floristic Analysis In this report the TWINSPAN analysis was performed separately by site and by year of data collection. No attempt was made to produce a compiled analysis which would pool all the vegetation data into one output.

Road site 1, 1996; the TWINSPAN analysis of the 270 vegetation quadrats produced 5 noda at the third level of classification (Appendix Fig. 15). The initial vegetation assemblage separated along the *Betula glandulosa*, *Ledum decumbens* and *Vaccinium vitis ideae* which accounted for > 97% of the quadrats and *Trisetum spicatum, Eriophorum angustifolium.* These represented only a minute portion of the quadrats (< 3%) and were placed in the 5th nodum. At the second level, the *Ledum* group was split along the *Cassiope tetragona - Salix sp., Empetrum nigrum, Carex aquatilis* line. At the third level four noda emerged with the indicator species marked in Appendix Fig. 15.

At the third level of division *B.glandulosa* group branched into four noda. Nodum 1 was characterized by *Empetrum nigrum, Cassiope tetragona,* and *Salix sp..* This group was distributed throughout the transect, however, its highest representation was in the SB and SC zones. Nodum 2, characterized by *L. decumbens, V. uliginosum, V.vitis-ideae,* and *Carex lugens* occurred throughout the transect, but showed preference for the northern 5m (NB) and 30m (NC) zones. Nodum 3, characterized by *Salix sp.*and *E. nigrum* was present mostly near the road margin zones NA,SA,SB. Nodum 4, characterized by *C. aquatilis*, was exclusive to road margins NA,SA. Nodum 5, which originated from the initial division at level 1 and was characterized by *Trisetum spicatum* and *Eriophorum angustifolium* was present mainly in the southern margin zone SA (Appendix Fig. 16).

Road site 1, 1997; the floristic analysis included data from the 100m distant zone. As a result eight noda were produced at the third level of division (Appendix Fig. 16). As in 1996, at the first division, there was a split along the *Ledum decumbens* group of species - *Carex aquatilis* line.

At the third level, the *Ledum* group produced four noda. Nodum 1, characterized by *E. nigrum* and nodum 2, characterized by *Salix sp.* and *V. vitis-ideae* were present throughout the transect with no clear zonal preference. Nodum 3, characterized by *L. decumbens, C.tetragona, Luzula confusa* and bryophytes showed preferences for zones distant from the road margins. Nodum 4, characterized by *C.aquatilis, V.vitis-ideae* and *V.uliginosum* was absent near the road margins, and showed preference for the more distant zones at the south road side (SC,SD).

The *C.aquatilis* group also branched into four noda at the third level. Nodum 5, characterized by *L.decumbens* and bryophytes, and nodum 6 characterized by *E.nigrum* and *Salix sp. were both* exclusive to the road margin zones NA,SA,SB. Nodum 7, characterized by *L.confusa* and *B.glandulosa*, and nodum 8, characterized by *C.aquatilis* occupied the road margin and central zones and were absent in the distant 30m and 100m zones (Appendix Fig. 16).

<u>Road site 2, 1997</u>; TWINSPAN classification of 315 quadrats resulted in only four noda at the third level of division. At the first division, *Carex physocarpa* group was separated and created nodum 4, which was exclusive to the SC zone. The other branch produced three noda at the third level. Nodum 1, characterized by *Arctagrostis latifolia* was exclusive to the northern margin zone NA. The largest nodum 2, characterized by *V.vitis-ideae, V.uliginosum, C.tetragona, B.glandulosa,* and *L.decumbens,* was highly represented in all zones. Similarly nodum 3, characterized by *C.aquatilis* was present through the transect with the exception of the road margin zone, NA (Fig 17).

TAILING POND SITE

Vegetative Cover South of the tailings pond vegetative cover increases from the pond margin zone (SA), towards the 5m, 30m and 100m zones (Figs. 18 and 19). Here the 100m zone had a significantly higher cover then the 0m and 5m (SA,SB) zones.

Plant cover in the northern zone transect showed less clear-cut results. The only significant difference was measured between the pond margin and the 30m (NC) zone. The mean cover varied among the zones and the 100m zone (ND) was not different in total plant cover from the other northern zones.

Dust Recruitment In both sampling years the mean dust deposition rates exhibited similar fast-decreasing profiles with the increasing distance from the dust source. Figures 20 and 21 summarize the zonal means for the tailing site for 1996 and 1997.

Differences in the rates of deposition were significant between the zones (except between SA and SB in 1996). Both northern and southern 30m zones (NC and SC) showed 80% to 99% reduction in comparison with their respective pond margin zones (NA and SA). It should be emphasized that even in the 100m zone there was a measurable dust deposition.

Soil moisture At the tailing pond site, samples for soil moisture and other soil analyses were collected in 1997. Figure 22 summarizes the mean moisture content measured in the eight zones. Samples taken closer to the pond margins had significantly higher moisture contents then samples taken further away. This steeply declining soil moisture profile was observed along both, the northern and the southern zone transects.

Soil mass Similarly to the road site soil mass profile, significantly higher soil mass values (bulk density) were found in both pond margin zones. These were also decreasing with the distance from the pond, although the south side values were declining less dramatically than those at the north side (Appendix Fig. 23). There was some 40 percent difference between the highest and the lowest soil mass (0.6 - 1.1 g/cm^3).

Soil pH The tailing pond site soils showed to be very acidic (pH 3.0 - 3.7), with the lowest values measured in the pond margin (SA) zone (Appendix Fig. 24). However, the increase in pH away from the tailings edge did not reveal significant differences between zones.

Floristic Analysis Floristic analysis of the tailing pond site 1996 vegetation produced 5 noda at the third level of division (Appendix Fig. 25). At the first division *Betula glandulosa*- dominated community, which was present in >98 % of the quadrats, separated from the *Eriophorum angustifolium*-dominated group of species. This group, present in only a few quadrats at the southern pond margin zone (SA), ended up as nodum 5. At the second level the *Betula* - dominated group split along the *Betula , Carex lugens - V. uliginosum*, *V. vitis-idaea, C.tetragona, E.nigrum* and *L.decumbens* line. At the third level the *Betula* group produced four distinct noda (Appendix Fig.25).

Nodum 1 characterized by indicator species *Trisetum spicatum,V.uliginosum* and *C.lugens* was present in the pond margin zones NA, SA and SB. Nodum 2 characterized by *L.decumbens* and high-cover. *B. glandulosa* was present in all zones but its highest representation was in NA and NB zones. Nodum 3 characterized by *V. uliginosum, E.nigrum, C.tetragona, V.vitis-idaea* and *L. decumbens* was present in all zones but predominated in zones more remote from the pond margins (NC,SC). The single indicator species of Nodum 4 was *E. nigrum*. Also this group was present in almost all zones but was mostly represented in the SA, SB, SC zones. Nodum 5, derived from the initial division and characterized by *E.angustifolium* was present exclusively in the southern pond margin zone SA (Appendix Fig. 25).

Floristic analysis of the 1997 vegetation included data from the 100m distant zone. This modified the outcome of the TWINSPAN analysis. At the third level, seven noda were produced (Appendix Fig. 26). At the first division there was a split along the *L.decumbens, B.glandulosa - C.aquatilis* line.

The first group branched into four noda: Nodum 1, characterized by *Salix sp*. and *E.nigrum* was mainly present in the NB and SC zones. Interestingly, this assemblage was absent in pond margin (SA) and 5m (SB) zones. Nodum 2, characterized by *C.tetragona*, *B.glandulosa* and *L.decumbens* occupied mostly the extremely distant zones. Nodum 3, characterized by *V.vitis-ideae, Luzula confusa* and *L.decumbens* was evenly represented throughout the zone transect except for the pond margins zones (NA,SA). Nodum 4, characterized by *C.aquatilis* was mostly present near the pond margin zones NC, NB, SA, SB (Appendix Fig. 26).

The second group, characterized by *C.aquatilis* branched into noda 5,6 and 7. Noda 5 and 6 with the indicator species *C.aquatilis* were exclusive to the pond-margin NA, SA zones. Nodum 7, characterized by *Salix sp.* was exclusive to northern pond zones NA, NB and NC (Appendix Fig. 26).

In addition to the TWINSPAN, a constrained analysis (COINSPAN) was also performed with environmental variables being included. However, the eigenvalues achieved by the COINSPAN analysis were substantially lower than those produced by the TWINSPAN (cf. TWINSPAN, Figs. 15 to 17, 25, 26, and COINSPAN, Appendix 4 to 8). Nevertheless, some changes in the structure of the dendrograms did occur at the second and third levels of ordination and may be worthwhile of a further pursuit. However, in this report only the outcome of the TWINSPAN analysis was applied as a method of the vegetation ordination.

DISCUSSION

The problem of road and tailings pond dust of an active gold mine, deposited on the surrounding tundra is not a simple problem to resolve. Tundra vegetation is a mosaic of plant communities fine-tuned to the topographic, edaphic and microclimatic conditions. This patchwork of tundra assemblages would become a ‘noise’ in attempts to discern the effect of a single variable, such as dust, in the local ecosystem. For this reason, a high-replicate sampling of vegetation (1530 quadrats) and of environmental variables in zones was proposed and over two field seasons realized. These zones, established arbitrarily at increasing distances from the dust source had no meaning on their own. In other words, they did not reflect any pre-existing natural pattern in the study area.

The first objective was to identify the plant assemblages in the tundra mosaic surrounding the gold mine. The second objective was to measure the dust loading at the various distances from the source. Data on additional variables (soil moisture, bulk density and pH) were also gathered. With this information available, we attempted to find a correlation between the occurrence of certain plant assemblages and dust loading and/or the other measured variables.

Basic comparisons of the vegetation distribution (Figs. 3 to 5) and dust loading (Figs. 6 to 8) did not reveal any convincing relationships in either road sites. The elevated plant cover, mainly due to the occurrence of erect shrubs along the road margin (zones NA and SA; Appendix Fig. 3) was probably due to the effect of the high road embankment.

At the tailings pond site, plant cover showed marked decrease towards the southern pond margin in 1996 and 1997 (Figs. 18 and 19). This corresponded to the high dust loading in the same zone (Figs. 20 and 21) due to the prevailing northwest winds. As the plant cover along the northern pond margin was higher and the dust loading lower, we infer that high dust loading had an effect on the south pond margin vegetation. However, the pH levels (3.0; Appendix Fig. 24) in the SA zone were acid and were the lowest of all sites measured and possibly the highest in arsenic levels. The effect on tundra vegetation here was obvious to the eye as in some areas the herbaceous layer was buried by blown dust.

At the road sites, floristic analysis (TWINSPAN) of the surrounding tundra vegetation revealed a number of distinct plant assemblages (noda). Their distribution varied and in some cases appeared to be noticeably non-random (cf. Results and Figs. 15 to 17). However, not all 'non-random' assemblages could be associated with high dust loading. Those which seem to be positively associated were the following: nodum 4 and 5 (1996; Appendix Fig. 15), nodum 5, 6 and 8 (1997, Appendix Fig. 16). Perhaps more importantly, noda which seem to be negatively associated with high dust loading were the following: nodum 2 (1996, Appendix Fig. 15), nodum 4 and 7 (1997, Appendix Fig. 16), and nodum 3 and 4 (1997, Appendix Fig. 17). At road site 2, 95 % of the quadrats were located in noda 2 and 3, indicating high site homogeneity of tundra.

At the tailings pond site, TWINSPAN analysis revealed these 'non-randomly' distributed noda occurred in high dust loading zones: nodum 1 and 5 (1996, Appendix Fig. 25), and nodum 4 and 5 (1997, Appendix Fig. 26). The negative association was found for nodum 3 (1996, Fig 25), and noda 1, 2, 3 and 7 (1997, Appendix Fig. 26).

The above observations are based on reading into the dendrograms and associated noda distributions within the zones. The DCA ordination, as used by Meininger and Spatt (1988), Forbes (1995), Jones (1997) and Levesque (1997) would probably be more successful in discerning the effect of dust and other measured variables on particular plant communities. Furthermore, pooling all zonal data for both years into a common data matrix may also increase the robustness of the ordination analysis.

The Lupin mine has been temporarily closed in fall of 1997, and may remain so for some time. The road site tundra was relieved from most of the fugitive dust loading, and the affected tundra communities should be slowly responding to this change. At the tailings pond, however, the dust deposition still continues and until the surface of the tailings pond is stablized either by engineering or establishement of vegetation cover, the close-by tundra communities will be further affected.

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