Dust Report

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Introduction

Dust deposition along the Dempster Highway may be contributing to changes in species composition and diversity in the roadside plant communities. This project will measure the distribution of dust coming off the Dempster Highway; this paper summarizes our current progress and the future of this study. This is a joint project between the Porcupine Caribou Management Board (PDMB), Canadian Wildlife Service (CWS), and Environment Yukon. The study will be done on the Dempster Highway between the Yukon and Northwest Territories.

This study, at the current low traffic levels, will provide a baseline for when the study is repeated in a few years when traffic levels increase. When comparing the two studies we will be able to see the cumulative effects of road dust on vegetation community species composition and plant productivity and biomass near the Dempster Highway.

The Dempster Highway is about 670 km long, from Dawson City, Yukon to Inuvik, NWT. The construction of the Dempster Highway began in 1959 when gas reserves were discovered in the Eagle Plains area but then stopped in 1961 due to lack of funding. The government then re-established interest in the project to maintain Canadian sovereignty in the north and the Dempster Highway was eventually completed in 1979. Currently it is mainly used by tourists and as support for the communities along the highway and in north western NWT; it is also used by oil and gas industry as access to small exploration camps in the Eagle Plains area. Current traffic levels are low relative to other major highways; it is composed mainly of residents, tourists (in the summer), supply trucks for the communities, and some trucks supporting road construction and mining exploration.

The Porcupine Caribou Herd uses a large area around the Dempster Highway as their winter range. The herd consists of about 120,000 animals and ranges through north eastern Alaska and northern Yukon. They are an important herd for several first nations, such as the Vuntut Gwitch'in, Tr'ondek Hwech'in, Tetlit Gwich'in, and Nacho Nyak Dun. They are also important harvest species for both first nations and non-first nations. During the winter months the caribou feed mainly on lichen; however in the summer, their diet diversifies and they may feed on sedges, grasses, and twigs and leaves of shrubs.

Effects of Dust on Vegetation, Mosses, and Lichens

Depending on the geology of the surrounding area and the composition of the material used for the road bed and top, the generated dust can significantly change soil pH levels. Arctic soils are generally acidic due to poor drainage; water is usually trapped on the surface by permafrost and decomposition of organic matter can only occur in the thin the active layer (ground that is frozen in the winter but melts in the summer).

Tundra plant species have specialized morphological traits that allow them a greater chance of survival in the harsh arctic climates; this includes mat or prostrate growth forms which keep the plant close to the ground away from wind and under the snow pack during the winter. As dust deposition increases these plants are weighed down and growth is limited. Since much of their photosynthetic surfaces are also horizontal, as the dust settles in will also clog the stomata which are used for the exchange of gases during photosynthesis.

As dust accumulates on top of the snow in the winter, it changes the albedo increases, which in turn increases snow melt. As snow melt increase and more water becomes available earlier in the spring, the permafrost below the regular active layer, also begins to melt. As permafrost degrades, the active layer increases, changing the water table and water drainage. The permafrost creates an impermeable layer to prevent surface water from draining away. As the active layer increases, so does drainage, leaving the surface much dryer and susceptible to wild fires. Also, without the solid ice and with the sudden introduction of water, slope stability decreases and landslides become common.

In the Walker and Everett study (1987), they found sphagnum moss was absent up to 20m away from the roadside, in areas where it is very common. Sphagnum mosses are known to have a low tolerance for changes in soil pH; the alkaline soil near the roadway is not suitable for sphagnum mosses which prefer more acidic soils. Other mosses which were more tolerant of the alkaline soil did move into the area (species composition change).

Excess water from the melting permafrost (as described earlier) blocks lichen thalli; this reduces gas diffusion and photosynthesis. Dust may absorb water from the lichen through the non-cuticle "leaf" surfaces and increase evaporation away from the lichens. Changes in soil pH will also have damaging effects. The algae part is fairly tolerant of different levels, but the fungal part of lichens has a much smaller tolerance range and is therefore restricted to substrates with particular pH levels. Lichens are also very susceptible to bioaccumulation of atmospheric pollution in the dust particles; they will store the pollution and then pass it on up the food chain when the lichen is eaten by animals, including caribou.

In 1997, a study by Nancy A. Auerbach, Marilyn D. Walker, and Donald A. Walker, titled *Effects of Roadside Disturbance on Substrate and Vegetation Properties in Arctic Tundra,* discusses the chemical effects of road dust on roadside vegetation. They compared sites in two acidity ranges: soil pH ≥5.0 (non-acidic) and pH < 5.0 (acidic). The different pH levels also resulted in different plant composition at the study sites. The geology of the area was such that the dust produced from the road made the surrounding areas more alkaline; therefore the substrates in the ~pH 4.0 zone were more effected by the addition of dust then the ~pH 6.0 zones. Auerbach et al. expected to see a decrease in lichens, mosses, etc. and an increase in deciduous shrubs, etc. at the roadside due to changes in pH. The study area was based on the Dalton highway (used to maintain the Trans-Alaskan pipeline) and may have a similar usage to the Dempster highway when the MVP is created.

In their results, they found the soil pH was higher near the roads, Nitrogen and Phosphorous concentrations were lower, and the active layer was deeper. The total plant biomass was lower by the road at both sites, but there was a greater change in the acidic site; sphagnum moss was particularly negatively affected by the increase in pH. Species composition changed and species richness decreased. Lichen abundance also decreased next to road in both sites.

An earlier study, *Road Dust and its Environmental Impact on Alaska Taiga and Tundra*, by Walker, D.A. & K.R. Everett, in 1987 looked at the effects of dust on roadside vegetation along the Dalton Highway and Prudhoe Bay Spine Road in Alaska. The paper summarizes both the chemical and physical effects of dust on arctic plants and lichens. The Walker et. al. paper was followed up 20 years later in 2006. A study by Myers-Smith, I. H., B. K. Arnesen, R. M Thompson, & F. S. Chapin III, *Cumulative Impacts on Alaskan Arctic Tundra of a Quarter Century Road Dust.* The researchers returned to the site where Walker et al. had done their study on the Dalton Highway 20 years earlier. They found significant changes to the roadside ecology, species distribution and composition and attributed these changes in part to the increase in dust from the Dalton Highway.

Summer 2008

The summer of 2008 was one of the rainiest on record, so we were not able to fully test all the methods and protocols of the study. We were, however, able to prepare the equipment and run some preliminary tests with the various dust collection methods.

We decided on three methods to determine the amount dust collection on the Dempster Highway: 1) water traps, 2) fibertex dust traps, and 3) PAR sensor data loggers. PAR sensors provide a complete record of the effect of dust on availability of sunlight to photosynthetic plants. The PARs were to be paired up, with one being cleaned daily which will serve as a control, and one left to accumulate dust, and be washed by whatever rain falls naturally. Data loggers were to record the PAR data each hour. The simulated lichen plots (fibertex pads) were to be laid out on the ground for a week, collected and washed with distilled water, and the dust particles collected on filter paper was to be weighed. The trays with water were intended as simple dust traps. Again, the dust was to be filtered out of the water and weighed. The 3 sets of sampling equipment were to be set out together along transects (student determined transect interval and sampling distance) perpendicular to the highway. The 3 methods were to be compared to each other to determine the most efficient way to quantify the amount of dust deposited.

The set up for the both the water traps and fibertex dust traps was tested for weather durability and appears that they will last through the summer field tests. The PAR sensor data loggers were also tested on two occasions with artificially created dust. These dust collecting methods could potentially provide accurate measurements, but the process of analysis and water filtration could be time consuming. An alternative are the PAR sensor data loggers, which measure available light intensity. The relative difference between the control and treatment PAR sensor data loggers was most noticeable right after the control PS was cleaned, in all experimental sets. This suggests that with constant attention in the field, these PAR sensor data loggers may work very well in

determining dust levels. Additional trials, over a longer time period, on the Dempster Highway, using real dust measurements, will be the best way to determine for sure if the PAR sensor data loggers are the best way to measure dust levels.

Summer 2009

At the beginning of the summer, it is important to continue the trials we were not able to do last summer and determine the best way of measure dust distribution. From there we will be able to fine tune the study methods and protocols.

It will also be necessary to know a few more things regarding the geology of the region as well as contact with the Department of Highways to know what is currently being used as dust control and when. Further detail on dust composition and size (likely based on geology of surrounding region) and distribution rates need to be understood.

We will need to talk to meteorologists and geologists familiar with the Dempster Highway regions. They will be able to provide us with information on prevailing winds, wind strength, precipitation levels, rock types and other factors that may affect dust distribution. The Dempster Highway needs to be separated into major geological/meteorological units for the study, since it is likely that dust type and possible distribution will vary along the highway. Sets of transects will be run in each of these units.

There are additional methods that could be implemented to help us better understand dust deposition along the Dempster Highway. These include: soil sampling to determine pH, active layer depth and soil moisture content; vegetation sample plots along the transects to identify species composition and diversity; snow cores to measure dust deposition over the winter months; and photos of each of the sampling sites to use as comparisons when the study is repeated in a few years. These methods would likely not give direct results to the amount of dust be deposited or the direct effects of the dust; however, if the study is repeated, they would serve as a baseline to monitor change.

Conclusion

It has been shown that dust from highways and roads can greatly affect roadside vegetation communities. They have observed changes in pH, water availability, species composition and diversity. All plant species, mosses and lichens appear to be affected. With a possible increase in traffic levels along the Dempster Highway, it is important that we have a baseline data set in order to monitor or mitigate any possible changes. This delicate ecosystem is important for the Porcupine Caribou Herd and people of the North.