Preliminary Report: **'Dusting the Environment' The Effect of Coal Dust on *Papaver dahlianum* (Svalbardvalmue)**

For Svalbard's Miljøvernfond

SVALBARD ENVIRONMENTAL PROTECTION FUND

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Introduction

In areas where mining is central to the local community, a comprehensive knowledge of environmental effects is compulsory. Coal mining is well known to have a significant impact on the environment (Elberling *et al.*, 2007, Rathor and Wright, 1993). This is anticipated, with regulations and laws in place to minimize the environmental effects. The main effects that are considered hazardous include geological effects, such as subsidence and slope deformation (Altun *et al*., 2010), and pollution of surrounding soils and water by heavy metals and other substances (Bullock *et al*., 1997, Askaer *et al*., 2008). These side effects of coal mining can have huge aesthetic impact within the landscape, and are a high priority to minimize and avoid (Askaer *et al*., 2008).

Longyearbyen has an extensive history of coal mining. Two mines are operated from this settlement, Svea Gruva (situated in Van Mijen Fjord) and Gruve 7 (in Adventdalen). It has been identified that mine tailings from coal mining in Adventdalen area can have detrimental effects on plant life, through high heavy metal concentrations (Askaer *et al.*, 2010). It was also noted that piles of coal waste can maintain increased temperature year-round, with further flow-on effects (Elberling *et al.*, 2007). However, the presence of small particles of coal (coal dust) may also have an impact on the environment. For instance, it has been shown that coal dust from mining activity in Svalbard changes snow melting patterns (Aamaas, 2009), and snow cover is one of the main factors shaping the arctic vegetation. Coal dust could also play a role in artificial heating of the vegetation, particularly when trapped inside flowers.

Papaver dahlianum ssp. polare, commonly known as ‘Svalbardvalmue’, is the iconic flower of Svalbard. A member of the Papaveraceae complex, it can be found with white or yellow petals (the two colour morphs of this species) and has a distinctive bowl shaped flower (Rønning, 1996). It grows on gravelly, disturbed areas, but is often found in a variety of environments, such as glacial moraines, mountain scree areas, and roadsides (Rønning, 1996). It was observed in 2010, that seed capsules of *P. dahlianum ssp. polare* contained small particles of black coal dust, which are likely to have been collected in the

hairs covering the capsule. This is suggested to cause an increase in temperature, which could have a variety of effects such as increased seed set, or the opposite - coal dust could reduce light influx and photosynthesis, for example as shown in mangrove trees (Naidoo and Chirkoot, 2004), where coal dust caused less vigorous growth, and reduced seed set. *Papaver dahlianum* is a flower that is strongly dependent on heliotropism (sun tracking) to optimize reproductive temperatures (Mølgaard, 1989). The presence of coal dust may interfere with this mechanism as well as with other cellular processes.

Objective of Study

The objective of this study was to assess the reproductive output of Svalbardvalmue in mining affected areas in Adventdalen using a combination of field and laboratory-based experiments. The results from these experiments will be used to discuss the impact of coal dust on the heating and production of seeds.

Methods

The study sites were chosen to represent a scale of mining influence – Gruve 7, with mining in operation and direct coal dust inputs, Gruve 6, with a history of mining but none in current operation, and Bayfjellnosa, where there is no coal mining influence (see Fig. 1). The type of vegetation at all sites was very similar, and all had the same gravelly substrate. The slope and aspect of each site was the same, as was altitude.

Flowering plants at each site were measured to assess size, and thermal images of flowers were taken at each site. Seed production experiments were set up at each of these sites, using four treatments (control, bagged, anthers removed and extra pollen added). Seed capsules were collected in August, during ripening but before seeds were dispersed. Seeds were counted to get total numbers of viable, failed and aborted seeds. HOBO loggers were set up at Gruve 7 and Gruve 6 to measure light, air temperature, soil temperature and moisture.

In order to experimentally test the effect of coal dust on flowering and seed production, 10 plants of *P. dahlianum* were collected in the field, and potted into gravel soils from the original site. These were placed in the climate rooms at UNIS at 9°C, with constant light. Statistical analyses were completed using R.

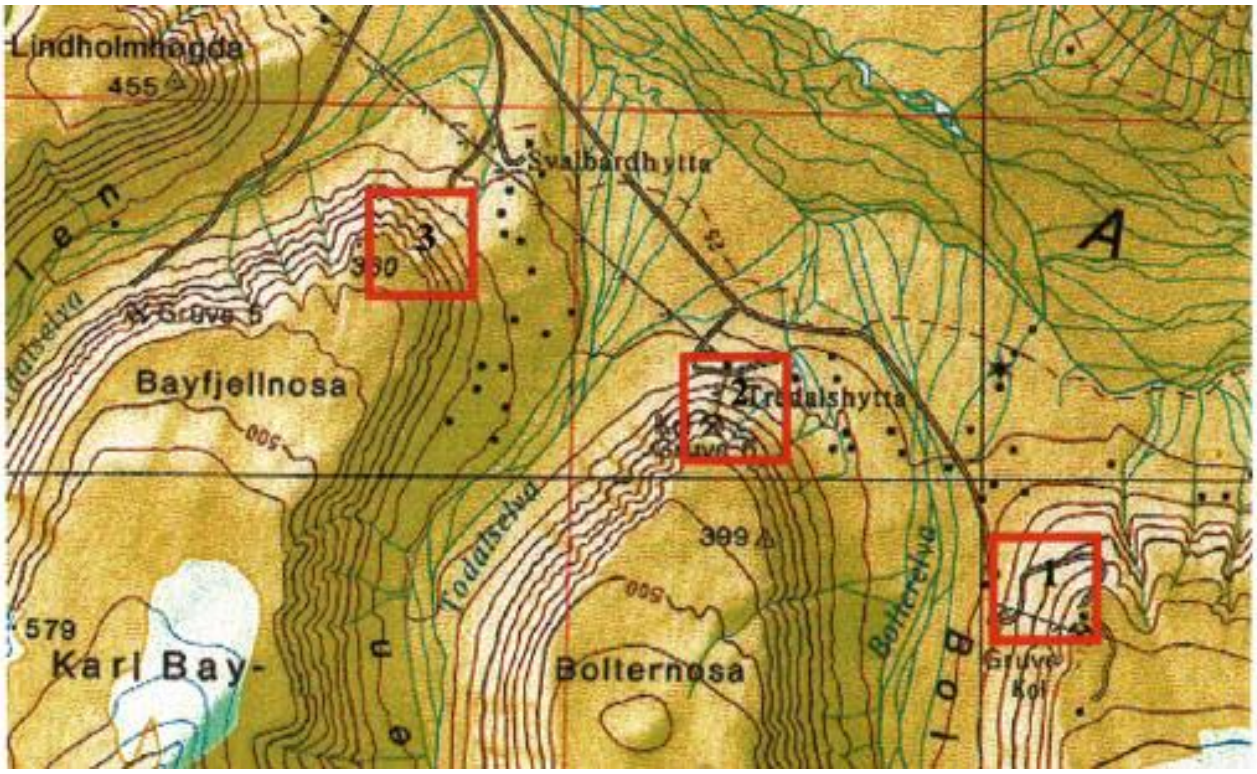

Figure 1. Showing sites where seed production experiments were set up to include a scale of mining impact; 1 – Gruve 7, current influence from mining; 2 – Gruve 6, has been influenced by mining in the past; 3 – Bayfjellnosa, no mining impact.

Figure 2. Each of the chosen sites (from left, Gruve 7, Gruve 6 and Bayfjellnosa). Taken in the first week of June 2011 – Gruve 7 site has least amount of snow.

Figure 3. Clockwise from Left: Marking plants for seed production measurements on Bayfjellnosa; P. dahlianum at Gruve 6, showing dust collected in flower; Marked flowers at Gruve 7; Seed capsule before counting seeds.

Results

Flower Size

The mean height of flowering stems of both white and yellow *Papaver dahlianum* was found to be significantly different between each of the three sites, with the tallest flowers being found at Bayfjellnosa, and the shortest being found at Gruve 7 (See Figure 4). Colour of the flower was also correlated with height of the flowering stem at Bayfjellnosa and Gruve 6; however this effect is not apparent at Gruve 7 (Figure 4).

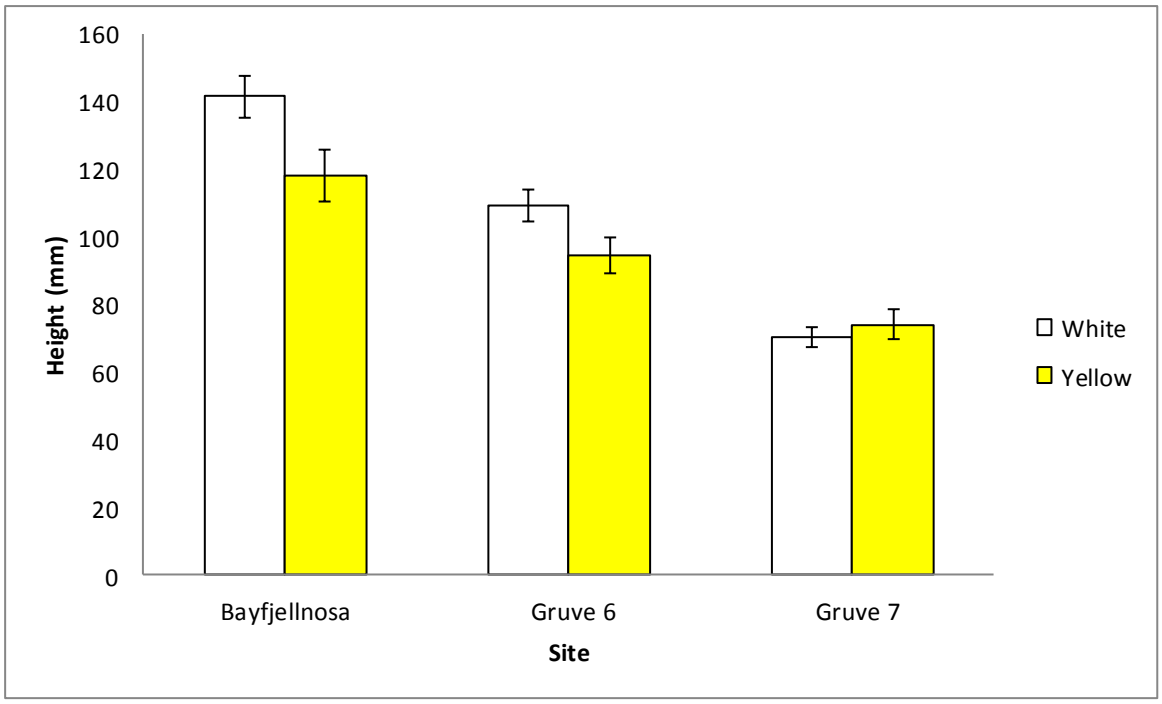

Figure 4. *Graph showing mean height of flowering stems of both colours of Papaver dahlianum (Svalbardvalmue) at the chosen sites. Gruve 7 has highest input of coal dust, Bayfjellnosa least input of coal dust.*

It was also found that the size of the seed-capsule inside the flowers, was smallest at Gruve 7, the high dust input site compared to Bayfjellnosa (See Figure 5). Capsules from Gruve 6 and Gruve 7 were significantly smaller than at Bayfjellnosa. Also, capsules from yellow poppies at Gruve 7 appear to be smaller than white, within the same site. The trend in height of the flowering stems at each site matched the length of the seed capsule, with the longest capsules being found at Bayfjellnosa, and the shortest at Gruve 7.

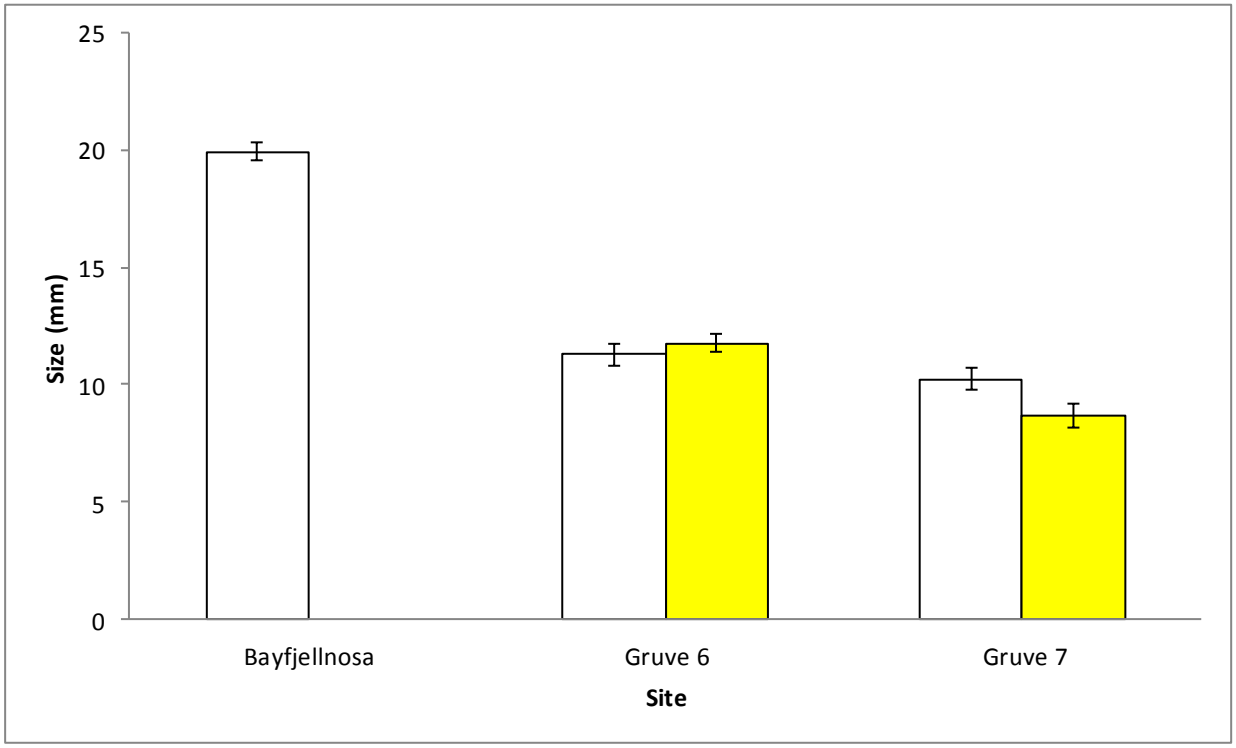

Figure 5. *Graph showing average length (mm) of capsules of both colours at each site. There were not enough yellow flowering plants to include in the experiment. Bayfjellnosa has the largest capsules, whereas Gruve 7 has the smallest overall.*

Seed Production

There was no significant difference of number of seeds produced between the pollination treatments. The proportion of viable seeds produced by *P. dahlianum* was found to be lower at the Gruve 7 site compared to Bayfjellnosa, which produced the highest proportion of viable seeds (Figure 6). No yellow flowers were included in the experiment at Bayfjellnosa, as there only were 13 yellow flowering plants found. There is no difference in the proportion of viable seeds produced between Gruve 6 and Gruve 7 overall. Yellow flowers at Gruve 6 produced slightly more seeds than white flowers. Deformed seed capsules were also observed at Gruve 6 and Bayfjellnosa.

Heliotropism and Temperature

Any difference in the heliotropic behavior of *P. dahlianum* between the sites based on coal dust was not identified, nor was a difference in thermal readings from between flower colour at each site.

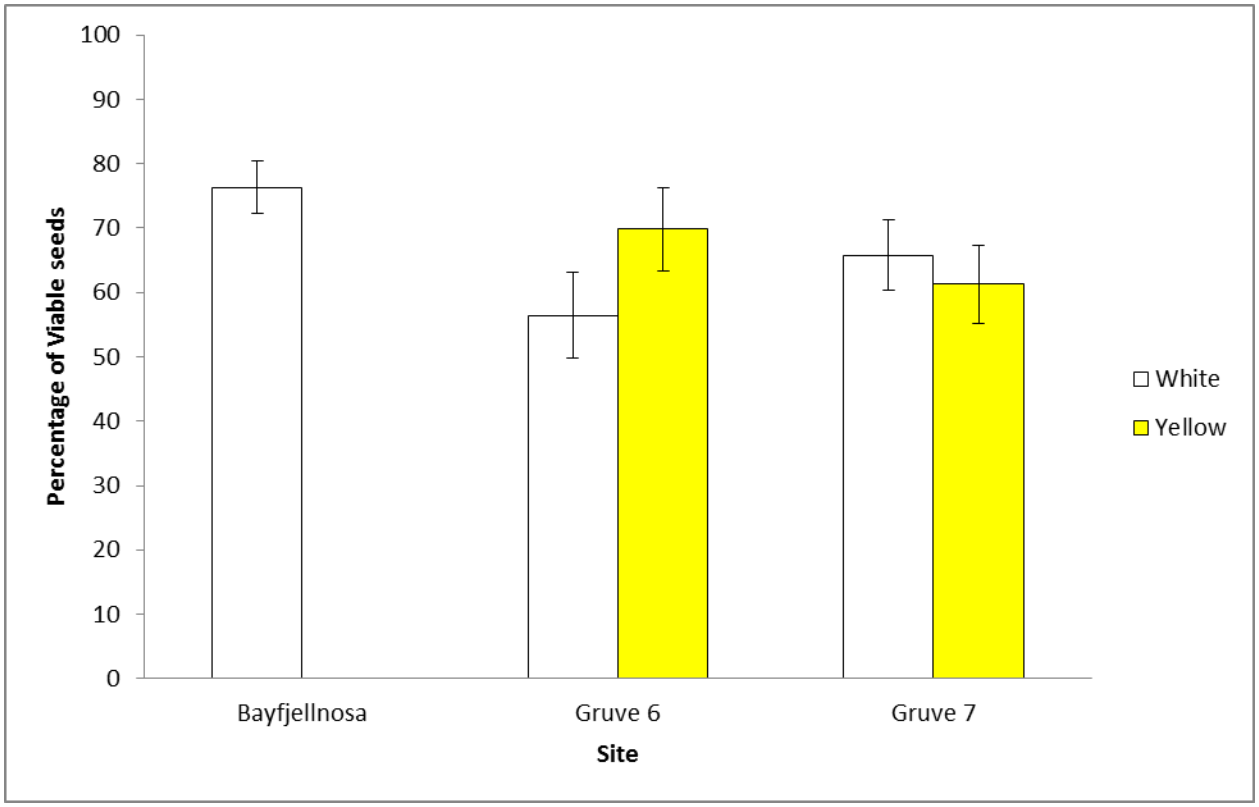

Figure 6. *Graph showing the percentage of viable seeds across all treatments at all sites. There was no significant difference between pollination treatment and number of seeds produced.*

Experimental Set Up in Climate Room

Unfortunately, all the plants died. Therefore no results were obtained from this experimental set up.

Discussion

Snow cover will impact on the growth of plant species in Arctic latitudes (Körner, 2003). It has been proven that coal will decrease the length of time that the snow lies on the ground in the early spring to summer months (as can be seen in June, 2011, Figure 2) (Aamaas, 2009). The lack of snow early in the season is likely to correspond with decreased growth in *P. dahlianum*, as it will affect water availability and exposure (Körner, 2003). Loss of snow cover, combined with coal dust particles from the mine and passing traffic, will have a definite effect on the ability of the plant to photosynthesize, thus controlling height and size of flowers (Levesque *et al.,* 1997).

The results from this investigation have shown that *P. dahlianum* flowers at Gruve 7 (directly below the mine, with high coal dust input) are significantly shorter in height and producing less viable seeds than the P. dahlianum at Bayfjellnosa (with no coal dust input). This suggests that coal dust in the environment is having a direct effect on growth and an indirect effect on reproduction of *P. dahlianum*. It is possible that the size difference is a result of differing ages in the plants (Levesque *et al.,* 1997) – Bayfjellnosa is a undisturbed site by vehicles, or roading and therefore the plants at this site may be older than those at Gruve 7 which are in a highly disturbed roadside area, as well as an area with coal dust input.

The difference in height between the two colours was not significant at the Gruve 7 site, which contrasts to the other sites. This result suggests that either the cost of producing yellow pigments, or the benefit of white petals (indicated through differences of height) is hidden at this site for some reason. The high input of coal dust at this site will inhibit photosynthesis (Naidoo and Chirkoot, 2004), which could cause the white flowers to be less tall.

Surprisingly, the proportion of viable seeds was found to be the lowest at Gruve 6, lower by a small margin than that found at Gruve 7. It is possible that this could be due to

other reasons than the presence of coal dust input, although both Gruve 6 and 7 had less seeds produced than Bayfjellnosa. Deformed capsules and peach-tinted flowers were observed at Gruve 6. This could indicate some other environmental influence, such as the presence of heavy metals in the soil from historical mining (Elberling *et al.,* 2007).

There may be differences in the soil composition between each of these sites (which were not measured) which could also contribute to these findings. Factors other than coal dust may also be controlling growth and production of seeds, and these cannot be ruled out in the field set up. Experiments set up in the lab, using plants taken from each site, to control for other confounding factors were unsuccessful, as the plants died. This was most likely due to the stress of being replanted.

In Conclusion:

The results from this investigation clearly show that P. dahlianum is not as successful in terms of growth or reproduction at Gruve 7, as it is in a natural environment without coal dust and disturbance. Snow melt will occur faster in the presence of coal dust, which will impact the fitness of this species, and potentially others as well. Therefore, it is recommended that the impact of coal dust, even though it is unnoticed aesthetically, should be minimized.

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