



Determining the footprint of mines for plant diversity in different ecosystem types: integrating offsite impacts and the mine life cycle

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Context of the study

Offsite impacts: those impacts that are beyond the direct disturbance footprint or study area and may permeate far into apparently undisturbed areas (Raiter *et al*,2014).

Dust, salt, excess nutrients, or other toxins following air and water, also including light and noise pollution, resulting impacts away from the disturbance footprint or survey area.



Context of the study

An example: Offsite impacts of roads

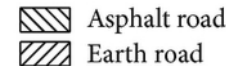
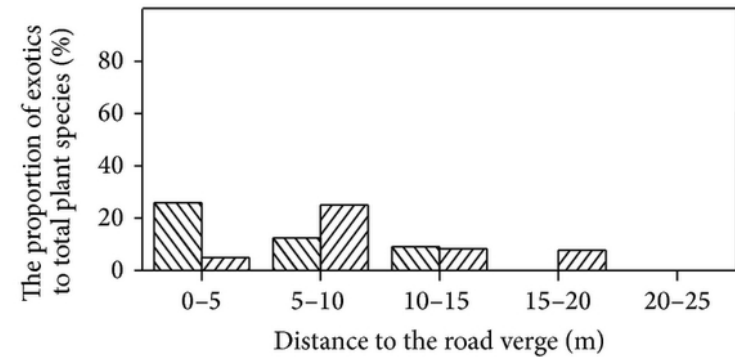
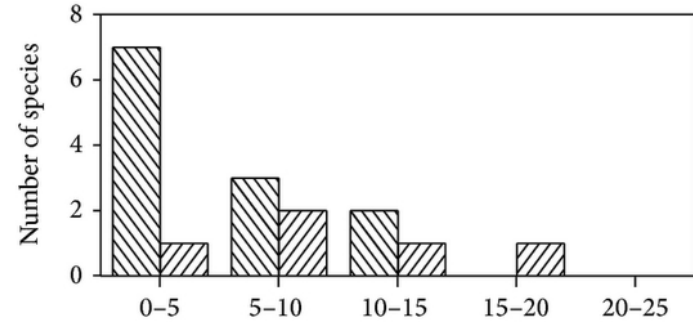
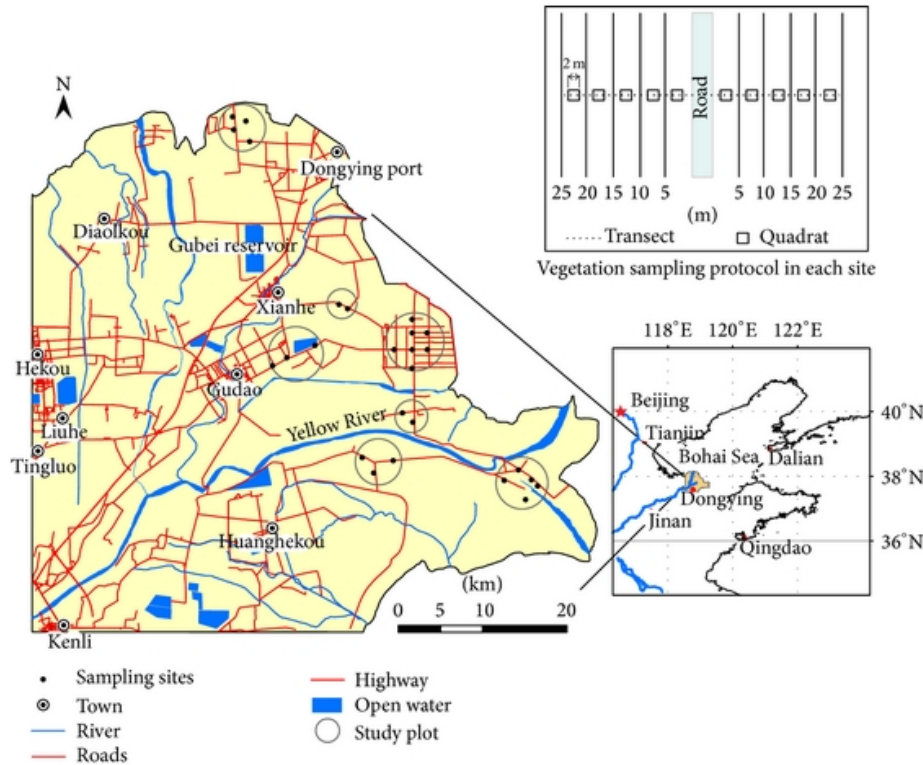


Fig. Number and proportion of alien plant species in plots of asphalt roadsides and earth roadsides.

Onsite Impacts Offsite Impacts

Understanding the offsite impacts of mine footprints on surrounding living organisms is crucial for conserving and restoring biodiversity (**objective 1**)



An example:

Oil sands development on woodland caribou in Alberta's boreal forest

(Dyer, et al, 2001)



- Oil Sands Areas in Alberta**
- Oil sands deposits
 - Oil sands surface mineable area
 - Alberta's boreal forest



About 1 km



In Canadian Boreal Areas

Animals



Vegetation



Microbiomes



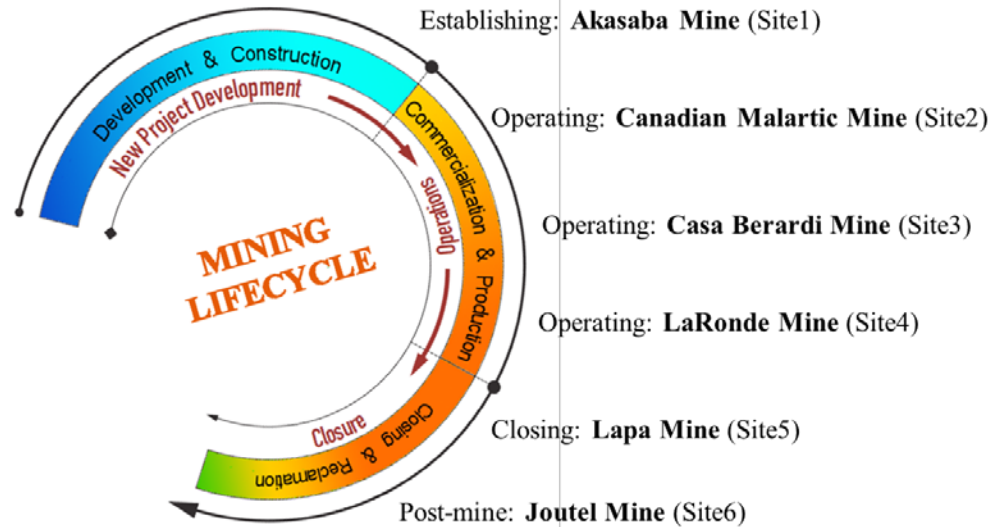
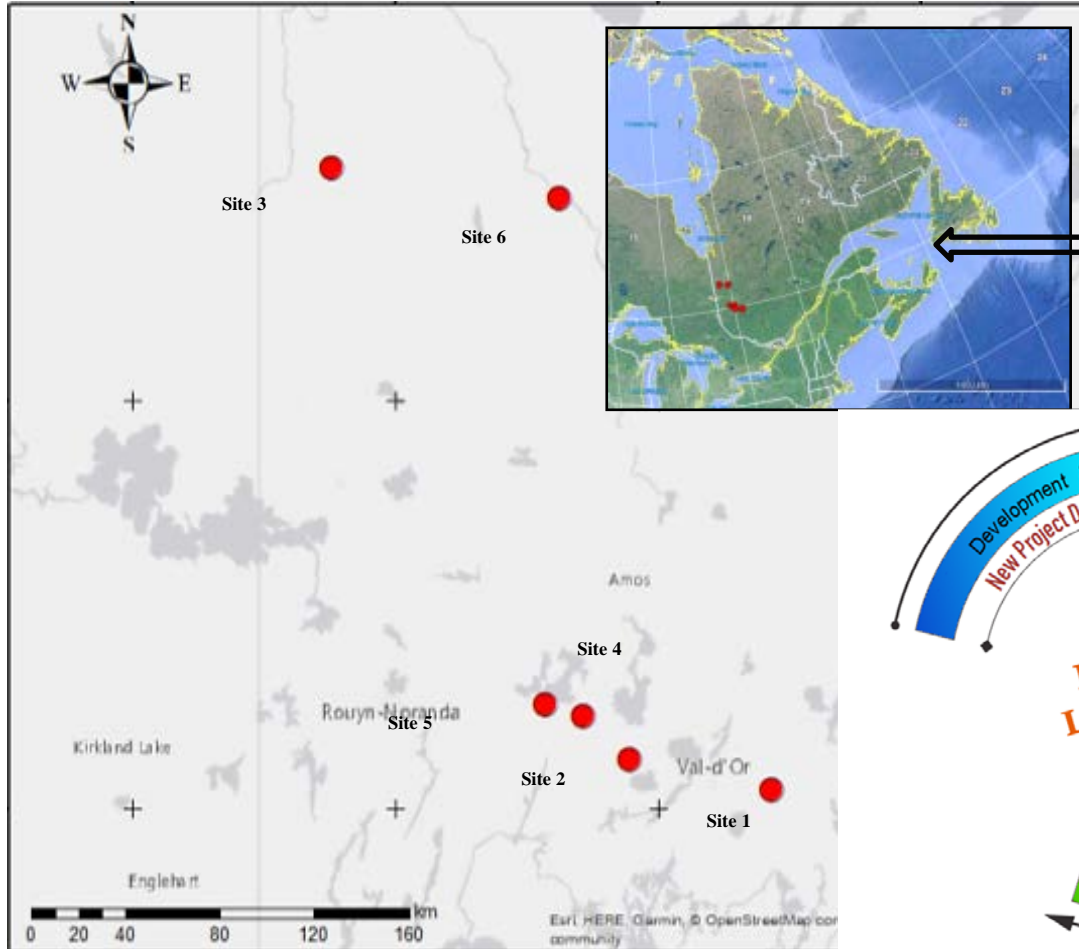
Objectives

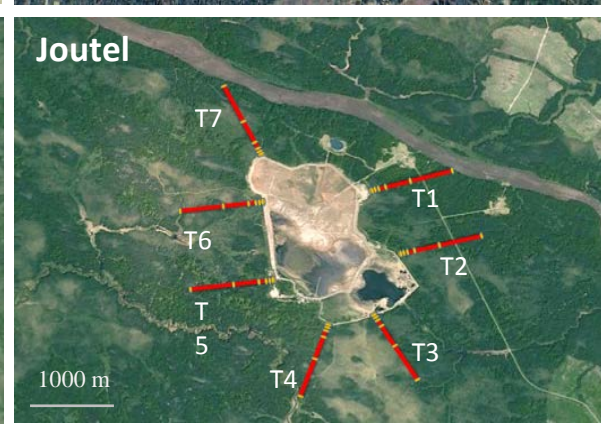
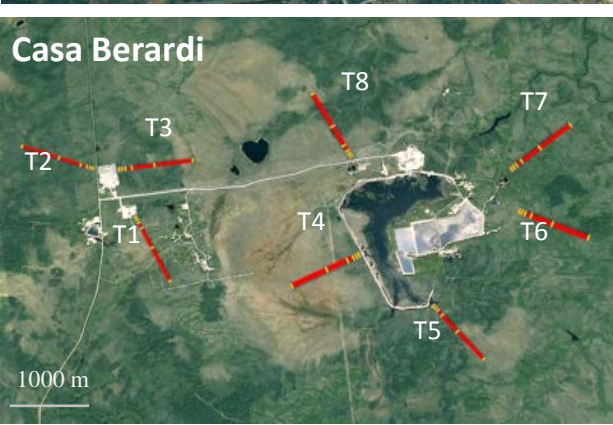
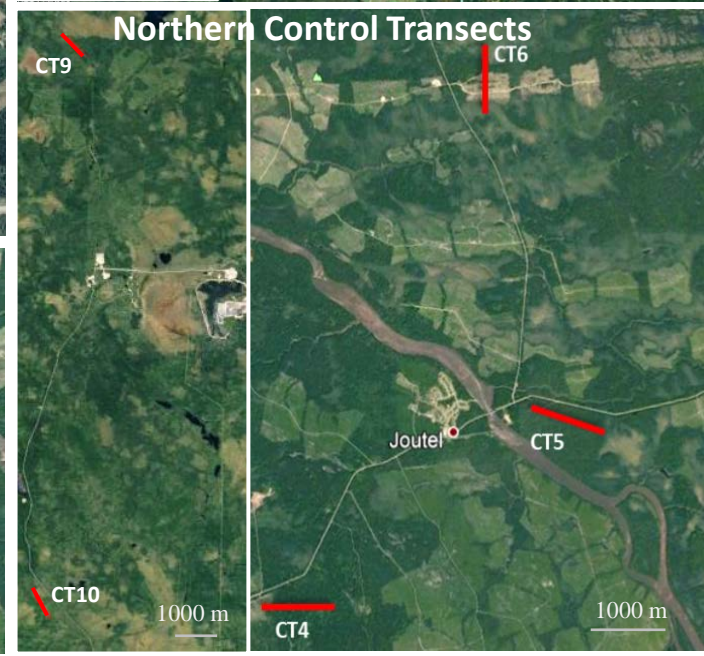
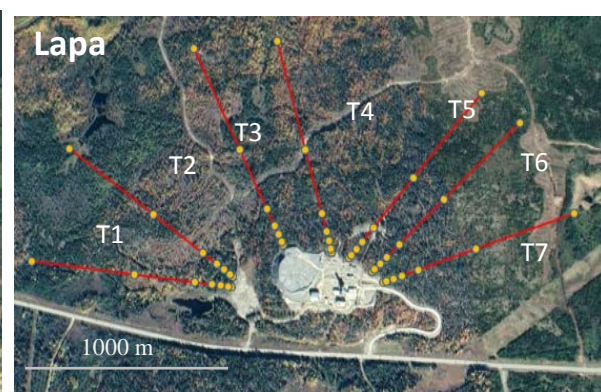
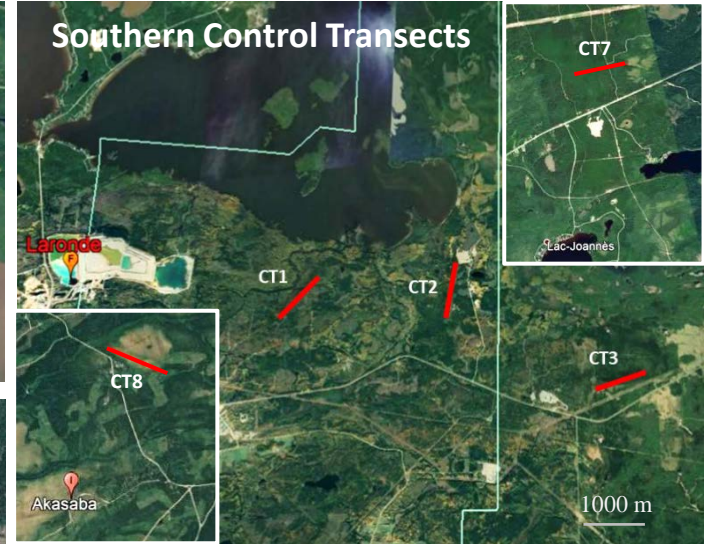
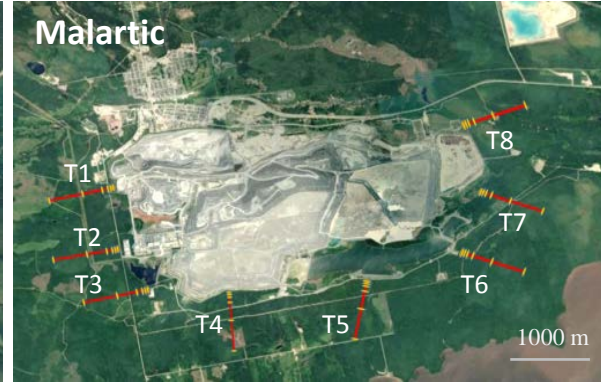
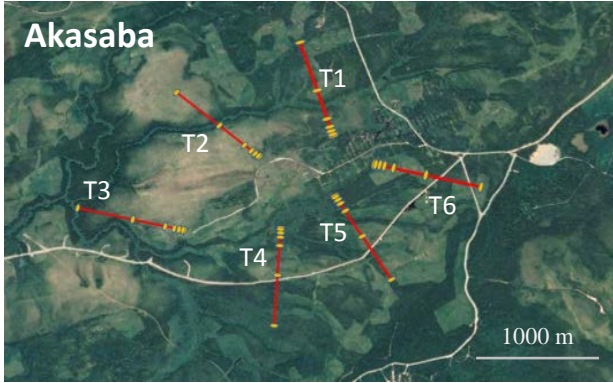
- 1) Determine the offsite impacts of mines on the diversity of plant and associated microbiomes in boreal areas.
- 2) Evaluate the main environmental factors that affect the magnitude of offsite impacts of mines in boreal areas.
- 3) Evaluate which vegetation groups could be used as reliable indicators to monitor the offsite impacts of mines in boreal areas.



Methodology

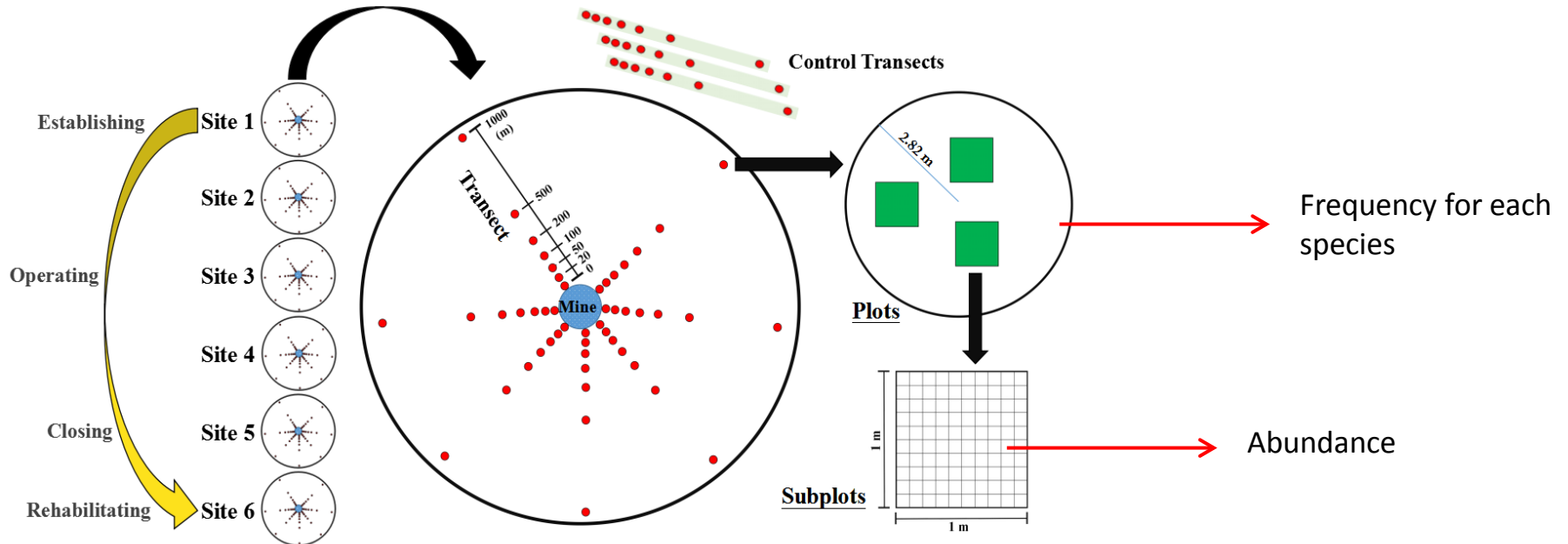
(Similar with Mélanie's project)





1. Six-eight transects perpendicular to each mine periphery
2. Through different types of ecosystems (coniferous, deciduous, mixed forest and wetlands)
3. Adjacent to different types of mine sectors (e.g. buildings, tailings impoundments)
4. Seven plots per transect (0, 20, 50, 100, 200, 500, 1000 m)
5. Three subplots per plot

(Same with Mélanie's project)





Vascular plants

Bryophytes

Seven plots per transect (0, 20, 50, 100, 200, 500, 1000 m)

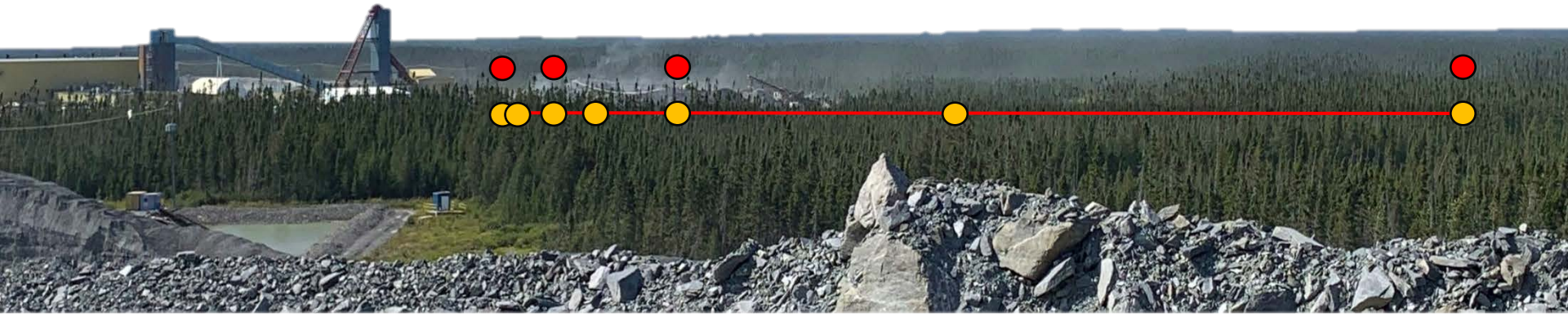
350 plots in total



The phyllosphere microbiome
of *Pleurozium schreberi*

Four plots per transect (0, 50, 200, 1000 m)

218 plots in total



Recent Advances

Fieldwork

2019.6 - 2019.9 (Biodiversity) The plant and phyllosphere samples (*Pleurozium schreberi*) were surveyed and collected.

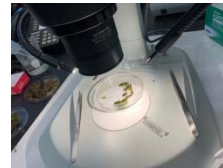
2020.6 - 2020.9 (Ecosystem types) The DBH (Diameter at breast height) of standing trees and the depth of organic soil layer were measured.

laboratory work

Microbiomes: ITS2 and 16S rRNA sequencing were used respectively to identify for fungi and bacteria. Analysis is ongoing.

Sample identification (plant species):

- 1) **Vascular plants:** In total 195 species in 47 families were found.
- 2) **Bryophytes:** In identification.



Preliminary results

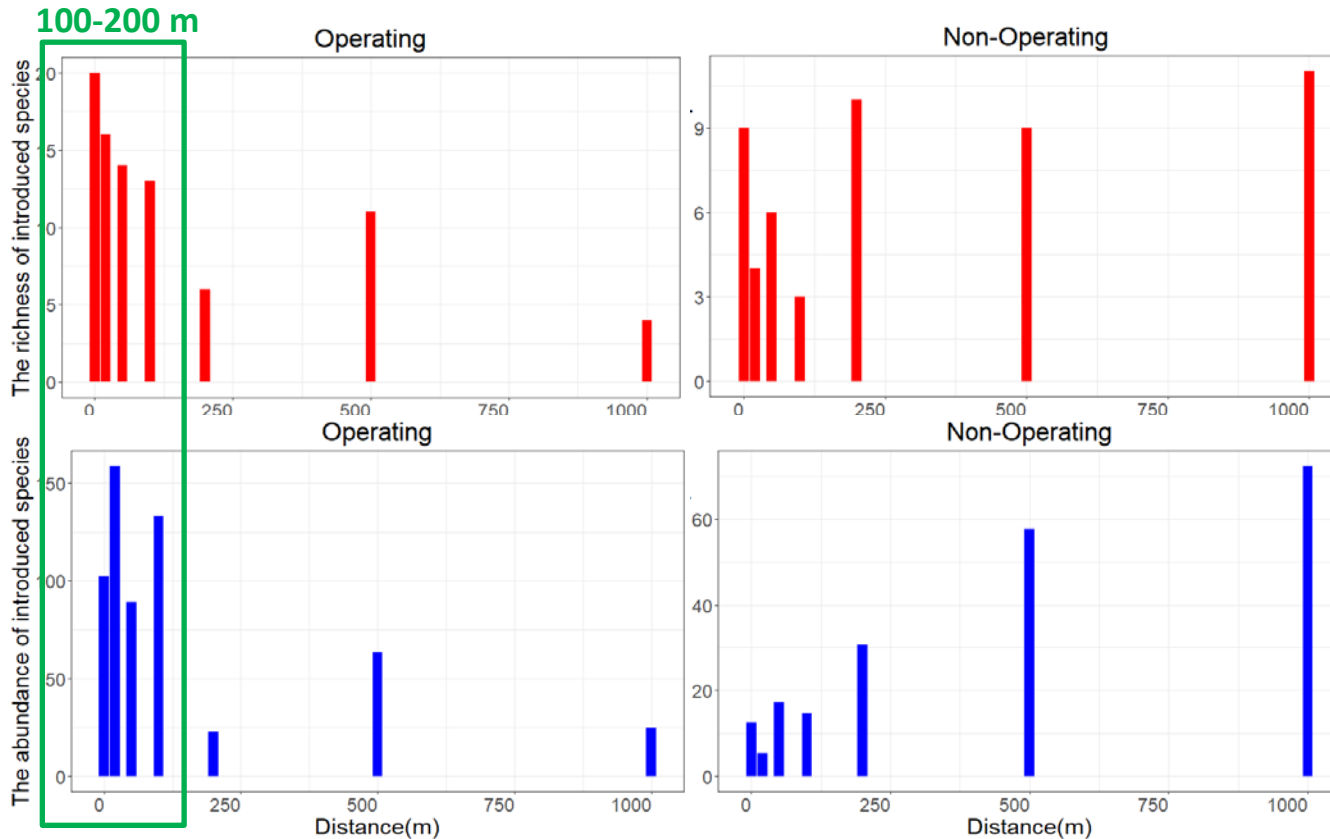


1. The offsite footprint of mines on introduced species

		Distance	Mine stage (Operating)	Distance: Mine stage(Operating)
Introduced species	Richness	0.2644081 (0.0376)	0.4860803 (0.0000*)	-0.5839719 (0.0007**)
	Abundance	0.5870269 (0.0087*)	0.9932041 (0.0000*)	-1.1394580 (0.0002**)

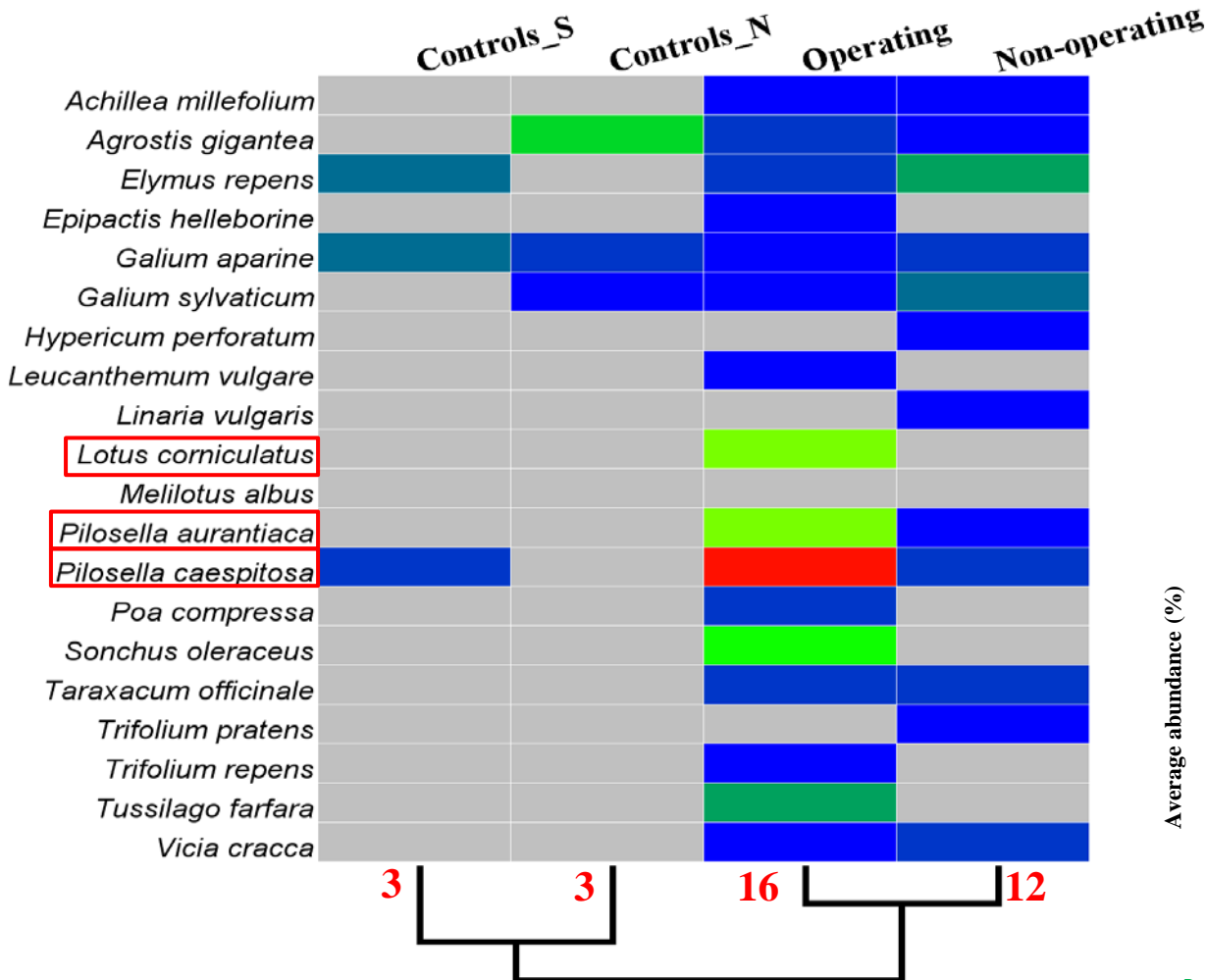
(*) Significant effect (p<0.05)

(-) Variable not included in the model



➤ Introduced species were more abundant and diverse near operating mines.

1. The offsite footprint of mines on introduced species



- In total, 20 Quebec introduced species were found
- The Abundance of *Pilosella caespitosa*, *Pilosella aurantiaca* and *Lotus corniculatus* were most near operating mines.

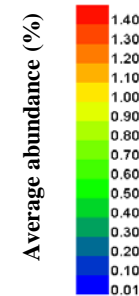
Lotus corniculatus



Pilosella caespitosa



Pilosella aurantiaca



2. The offsite footprint of mines on five herb species



Coptis trifolia



Maianthemum canadense



Cornus canadensis



Linnaea borealis



Lysimachia borealis



Rémi Boisvert

2. The offsite footprint of mines on five herb species



Coptis trifolia



Maianthemum canadense



Cornus canadensis



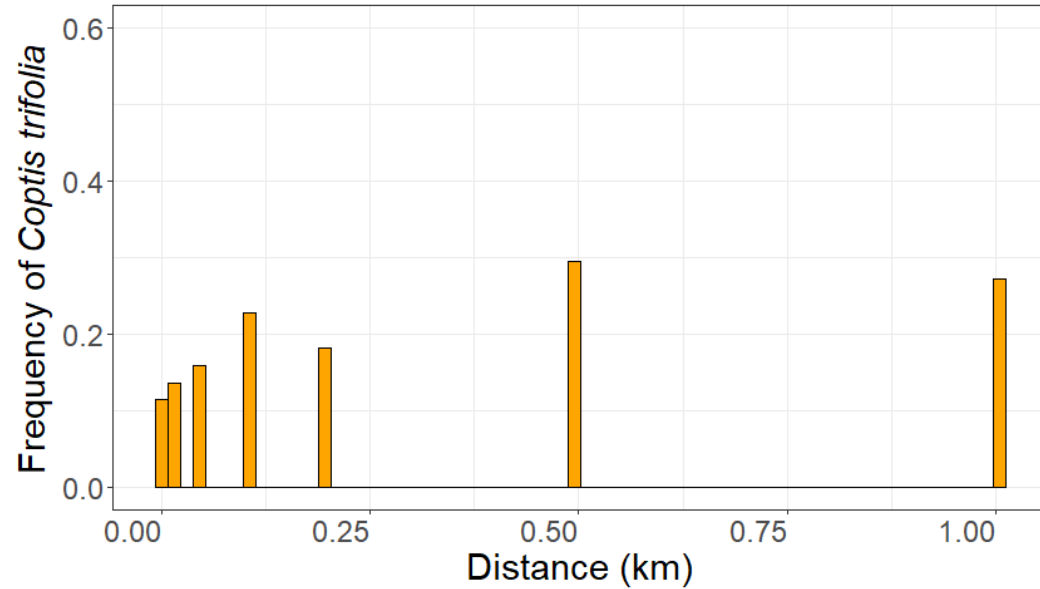
Linnaea borealis



Lysimachia borealis



Rémi Boisvert



2. The offsite footprint of mines on five herb species



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Coptis trifolia



Maianthemum canadense



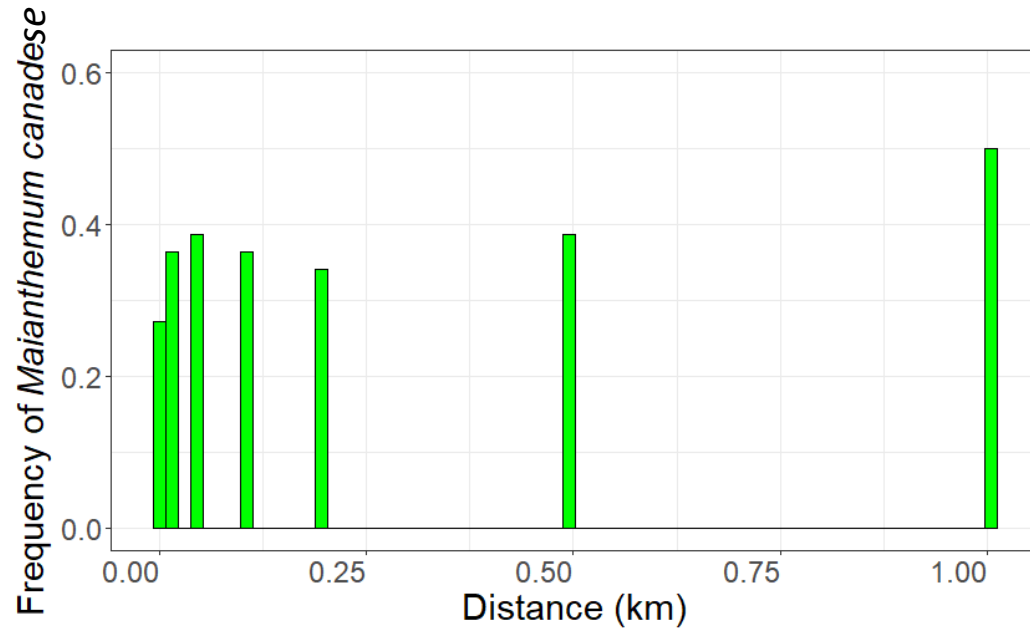
Cornus canadensis



Linnaea borealis



Lysimachia borealis



➤ *Coptis trifolia* and *Maianthemum canadense* were negatively affected by mines

2. The offsite footprint of mines on five herb species



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Coptis trifolia



Maianthemum canadense



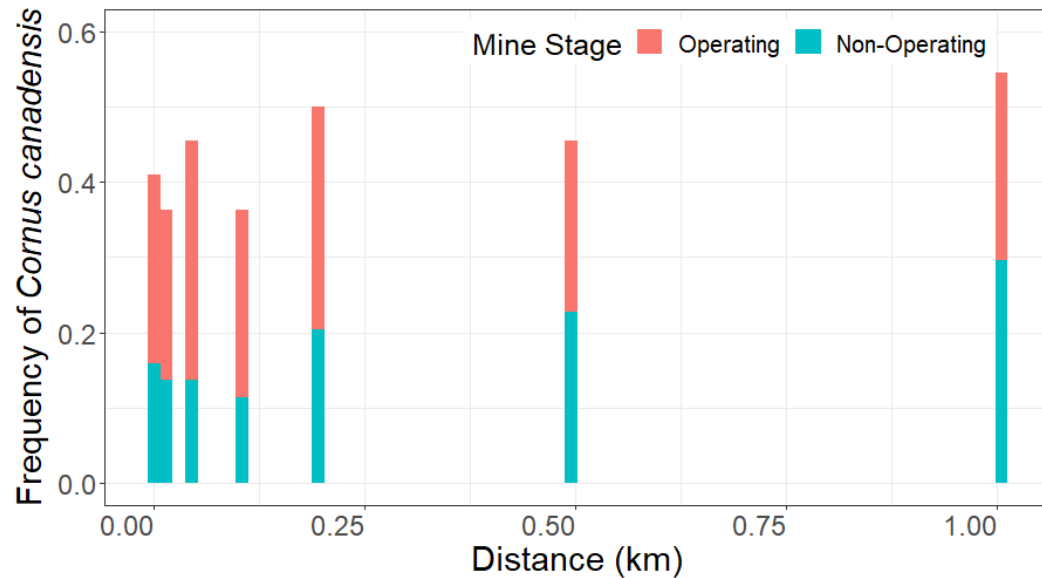
Cornus canadensis



Linnaea borealis



Lysimachia borealis



- *Coptis trifolia* and *Maianthemum canadense* were negatively affected by mines
- Conversely, *Cornus canadensis* was favoured by mining activity, which indicates its resilience to the stress caused by mines

2. The offsite footprint of mines on five herb species



Rémi Boisvert



Coptis trifolia



Maianthemum canadense



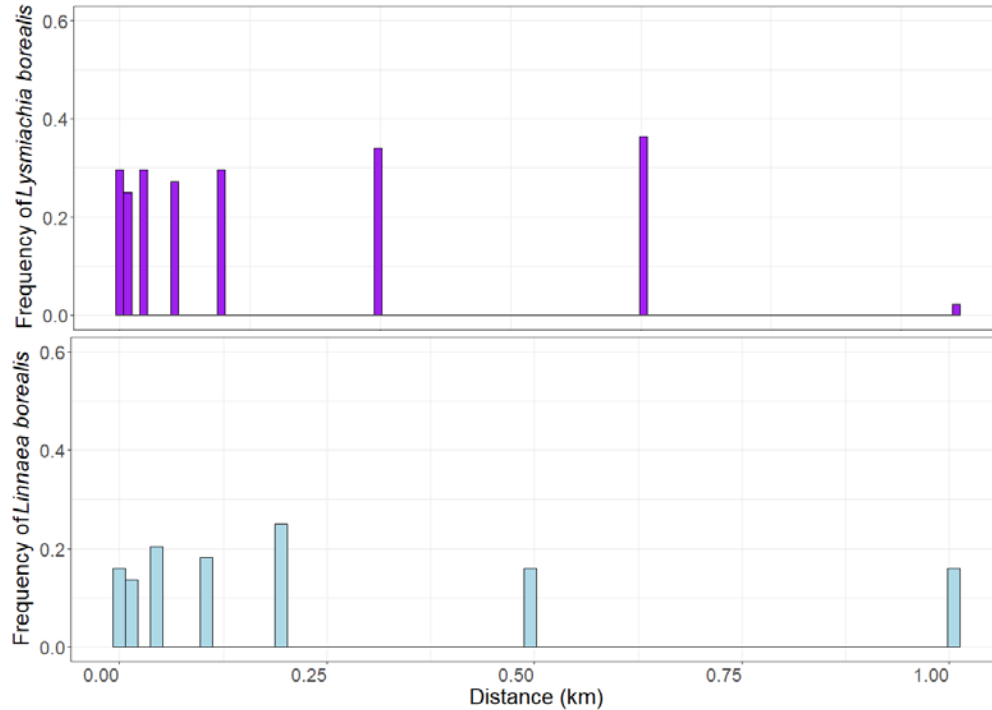
Cornus canadensis



Linnaea borealis



Lysimachia borealis



- *Coptis trifolia* and *Maianthemum canadense* were negatively affected by mines
- Conversely, *Cornus canadensis* was favoured by mining activity, which indicates its resilience to the stress caused by mines
- No effects on *Linnaea borealis* and *Lysimachia borealis* were observed

Publication

Boivert, Rémi; Yin, Xiangbo; Fenton, Nicole*. **Offsite effects of mining on the frequency and abundance of five herbaceous species in western Québec (Canada)**. *Botany* (Submitted, In progress).

Summary

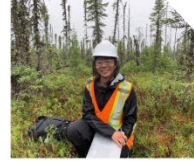
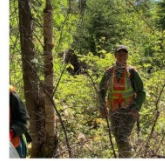
- Our study documents the presence of offsite impacts of mines on plants however detailed analyses need to be completed.
- Introduced species and *Cornus canadensis* are interesting, with significant effects by the interaction between the distance from mines and mine stage. They maybe used as indicators for offsite impacts of mines in boreal areas.

Next Steps

- Bryophyte sample identification, further analysis for the offsite impacts of mines on vegetation and phyllosphere microbiomes.

- Other variables: ecosystem types, types of adjacent sectors (e.g. buildings, tailings impoundments), wind direction, distance to roads, depth of organic soil layer.....

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