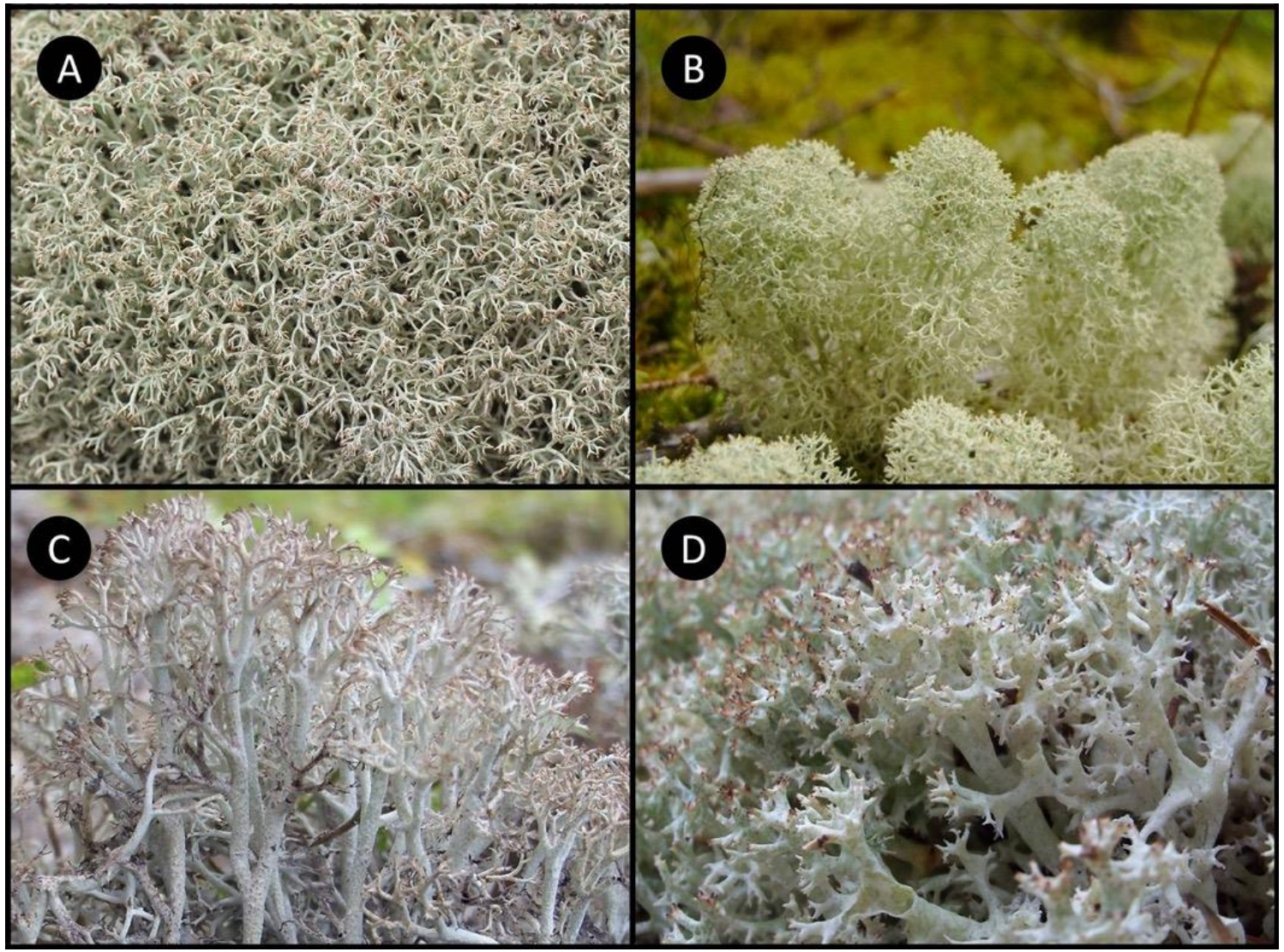
Terrestrial Lichen Caribou Forage Transplant Success

Year 5 and 6 results

What are terrestrial lichen?



A) *Cladonia mitis*

B) *C. stellaris*

C) *C. stygia,*

D) *C. uncialis*

Winter Forage for Woodland Caribou

- Historically the woodland caribou was found across Canada, from Newfoundland to Haida Gwaii.
- The Southern Mountain Caribou (SMC), a subpopulation in BC, is listed on Schedule 1 of the Federal SARA as *threatened*.
- The decline of SMC has mirrored the decline of woodland caribou populations in Canada.
- The reasons are complex. But linked to i) predation and ii) both anthropogenic and natural habitat alteration.

Federal Recovery Plan for Southern Mountain Caribou

- The Federal recovery strategy for SMC identifies habitat restoration as a management tool to be considered in recovery planning (Environment Canada, 2014).

- Restoration efforts often focus on the restoration of linear features, such as roadways or seismic lines.

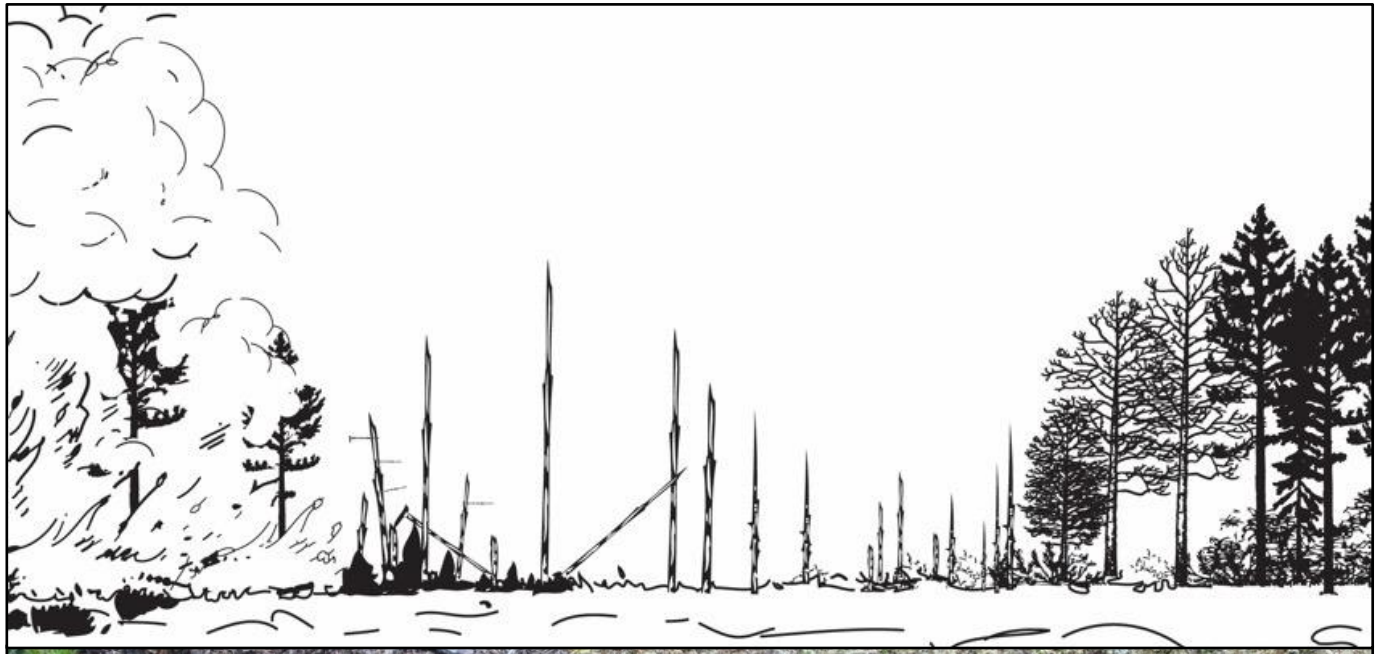
- However, could efforts also include the restoration of important forage species?

Cladonia subgenus *Cladina*

- Woodland caribou are diet specialists, often relying on *Cladonia* subgenus *Cladina* as a primary food source during winter months.
- Lichen are extremely slow growing, with a linear growth rate around 5 mm/year.
- *Cladina* reproduces asexually through fragmentation, and is dispersed through wind, rain, and wildlife.
- During dry periods, it readily desiccates (a great strategy) but this also makes it susceptible to fire.
- The research suggests that after fire, it takes 50-70 years for forage lichens to re-establish in suitable stands.

Classification of Natural Disturbance

- There are five Provincial Natural Disturbance Types (NDT).
- NDT 3 is the largest and are ecosystems with frequent stand-initiating events.
- In the Prince George Forest Region there the NDT's are further classified into 9 Natural Disturbance Units NDU.
- The experiment was undertaken in the Omineca Trench NDU.



- Following stand replacing fire, the assumption is that lichen are dispersal limited….
- Assumption is that they are not limited by the post fire conditions.
- To accelerate the return of these post-fire stands to productive caribou pine-lichen winter range, can we transplant these mat forming lichens?

Terrestrial Lichen Restoration

- Lichen winter forage habitat have not been the target of large-scale restoration efforts.

- However, there are examples of research trials:

1) Crittenden (2000) reported on experiments in 1971 in northern Finland led by P. Kallio in open pine stands.
2) Enns (1998) reports on aerial helicopter transplanting trial established in 1989 – 1990 within clearcut stands on the Chilcotin Plateau, BC.
3) Rourier and Bergsten (2009) in regenerating boreal forests northern Sweden.
4) Sarah Duncan (2011) experiments on reclaimed areas of oil sands surface mines in northern Alberta.

Terrestrial Lichen Restoration

- Multiple studies suggest that fragmentation of the lichen thallus as the most appropriate method for transplanting lichens.
- And that transplanted lichen thalli is biologically feasible and can increase in percent cover over time.
- However, the key uncertainty has been questions around the health and long-term survival of these transplanted lichens.
- Given the extremophilic nature and desiccation tolerance of lichen, how do we measure health and survival?

Research Objectives

- The goal of this study was to evaluate the success of *Cladonia* subgenus *Cladina* and *Cladonia uncialis* lichen transplants within a post-burn forested environment.

I. Determine if the transplanted lichen survived.

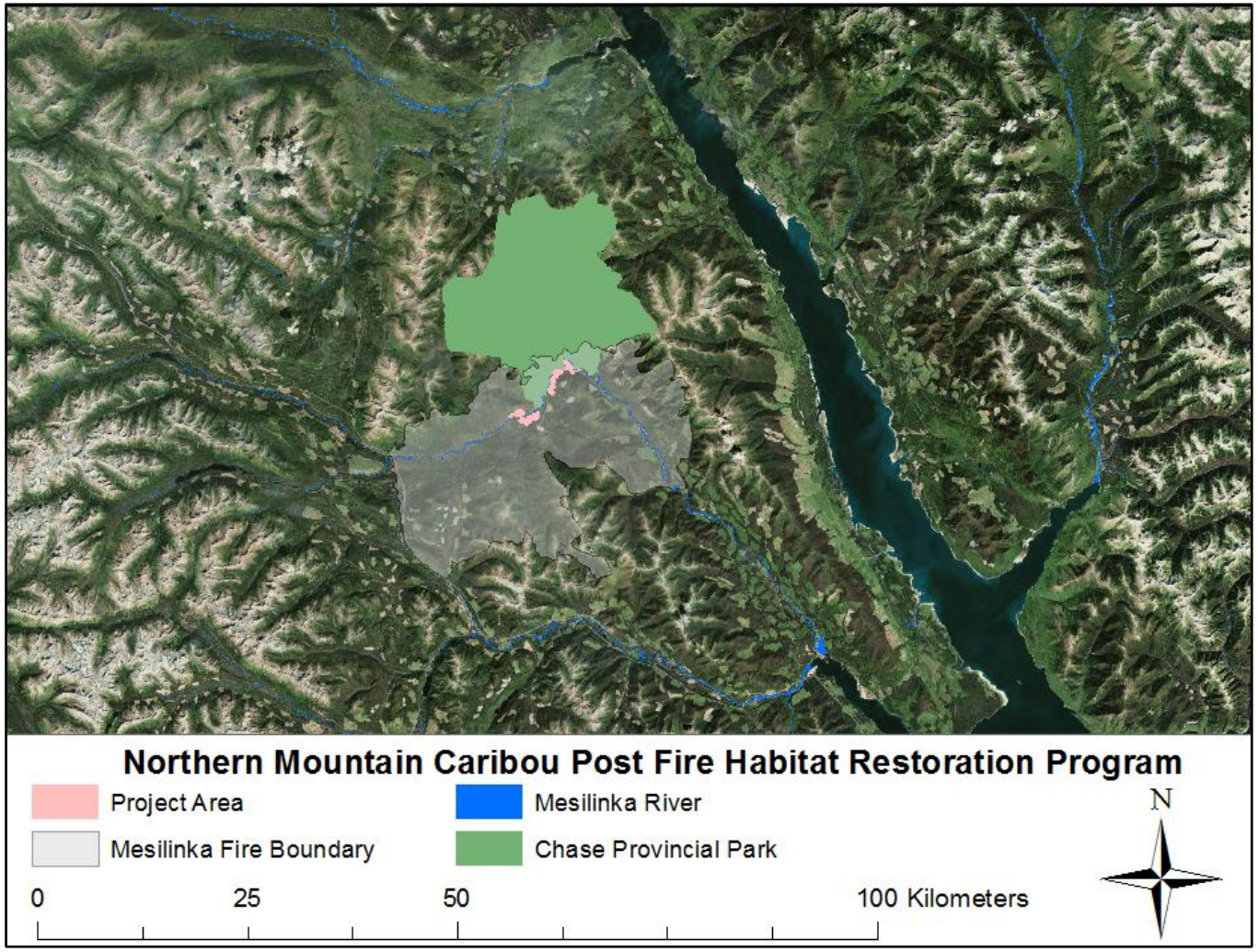
II. Compare survival between lichen species.

III. Determine if lichen transplants result in increased lichen percent cover.

IV. Examine the role of soil amendments with forest floor litter and varying treatments on lichen

Experimental Design

- Two field trials were established in 2015 and 2016.
- Each field trial is approximately 160 km northwest of Mackenzie, within the Mesilinka River drainage.
- The area is core low elevation winter and summer habitat for the Federally *threatened* Chase caribou and identified Caribou Ungulate Winter Range.
- The area consisted of pine lichen open canopy forest, with well drained and nutrient poor soils.
- The area was burned by wildfire in 2014.



Experimental Field Trial

- The first trial was established in July 2015.
- Randomized block design with 3 blocks A) Intense burn and hillcrest, B) Intense burn and flat, and C) Partial burn and flat.
- Six treatment combinations with 3 levels of lichen treatment i) no lichen, ii) lichen fragments, iii) entire mat, and 2 levels of amendment i) no amendment, and ii) addition of forest floor litter.
- Each experimental units was $1m^2$, with approximately 10 replicates of each treatment, for a total of 180 experimental units.

Operational Field Trial

- The Operational Trial was established in July 2016.
- Experimental units were 100m^2.
- 20 replicate sites with 4 treatments at each i) Control (no lichen), ii) Lichen mats only (100 L), iii) Lichen fragments only (100 L] and iv) Hybrid - lichen mats (50 L), and fragments (50 L).
- Lichen fragments were shredded into 2 – 7 cm pieces and broadcast evenly by hand.
- Lichen mats were intact pieces of lichen the size of a clenched fist or outstretched hand and placed with the basal area oriented downwards.
- In total, 80 experimental units were established in 2016, although only 11 were monitored in 2021 due to another wildfire.

Field Data Collection

- Within the **experimental field trial**, data was collected in July 2021, or 6 years after the trial had been established.

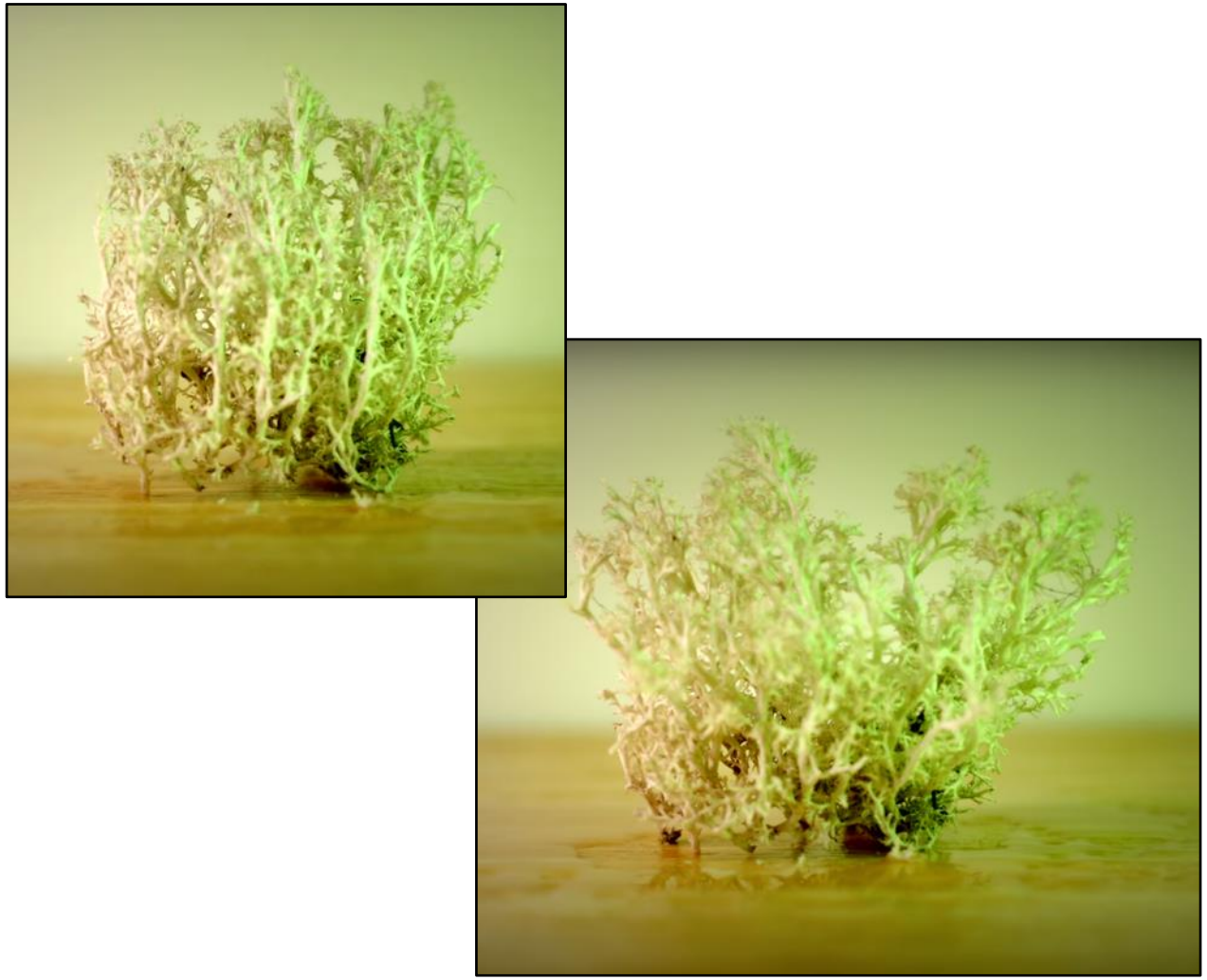
- Within the **operational field trial**, field data was collected in October 2021, so 5 years and 3 months after the trial was established.

- Collected data:
  - Ocular percent cover of *Cladonia* subgenus *Cladina*
  - Samples of *C. rangiferina, C. arbuscula* ssp. *mitis* and *C. uncialis* collected for fluorometry analysis
  - Lichen dispersal (cm distance) beyond the experimental unit

Why use fluorometry to assess lichen health?

- Difficult to accurately assess lichen health and survival with ocular assessments due to:
  - Desiccation tolerance, extremophilic life history,
  - Fruticose growth pattern, and
  - Slow growth rate.

- We used **chlorophyll fluorescence** to understand thallus viability in lichens from both trials.
  - Potential photosynthetic activity is measured to assess environmental stress and is used to understand viability in plants and lichens.



Laboratory Procedures

- Lichen thalli from both trials were preconditioned in the lab.
  - Thalli were dried, then were hydrated at room temperature for 24 hours.

- The potential photosynthetic activity (Fv/Fm) was recorded with a portable fluorimeter.
  - following methods of Gauslaa et al. 2012.

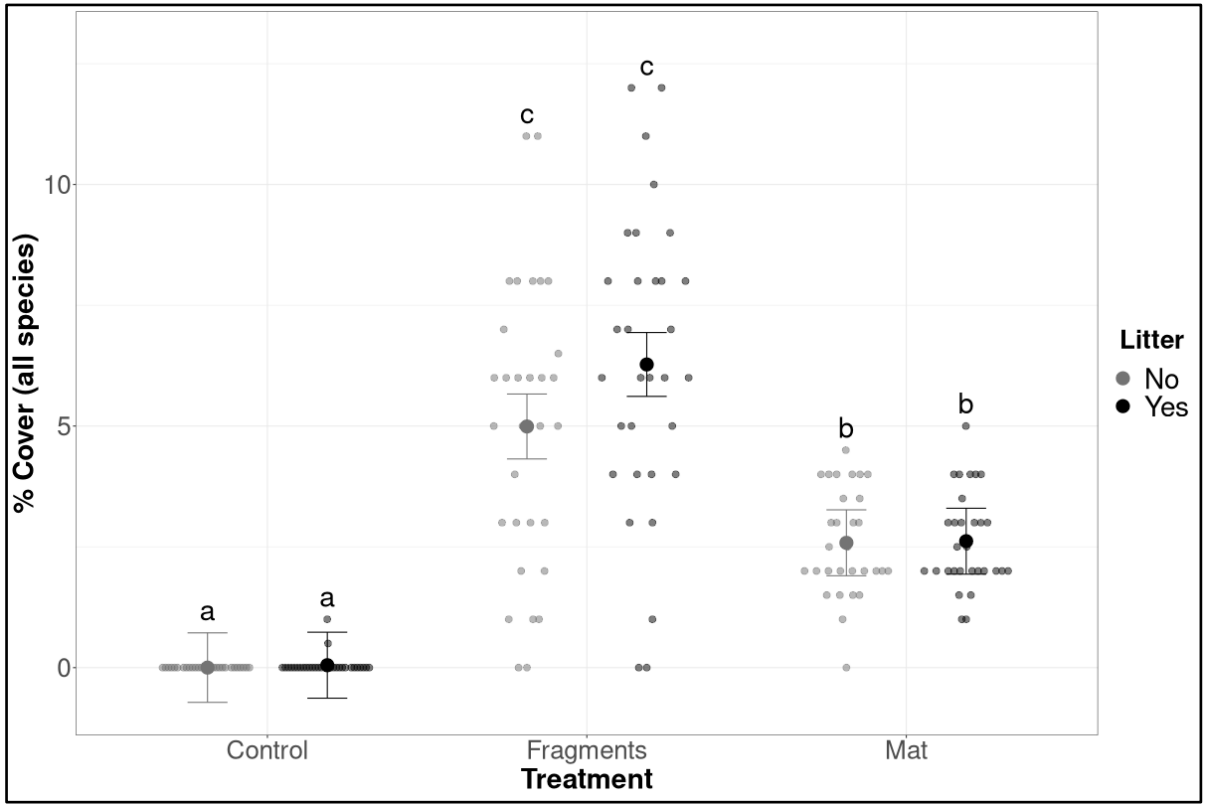
- Thalli with > 0.7 Fv/Fm values were assessed as not demonstrating signs of stress (Fernandez-Salegui et al. 2006; Nayaka et al. 2009; Kralikova et al. 2016).

Statistical Analysis

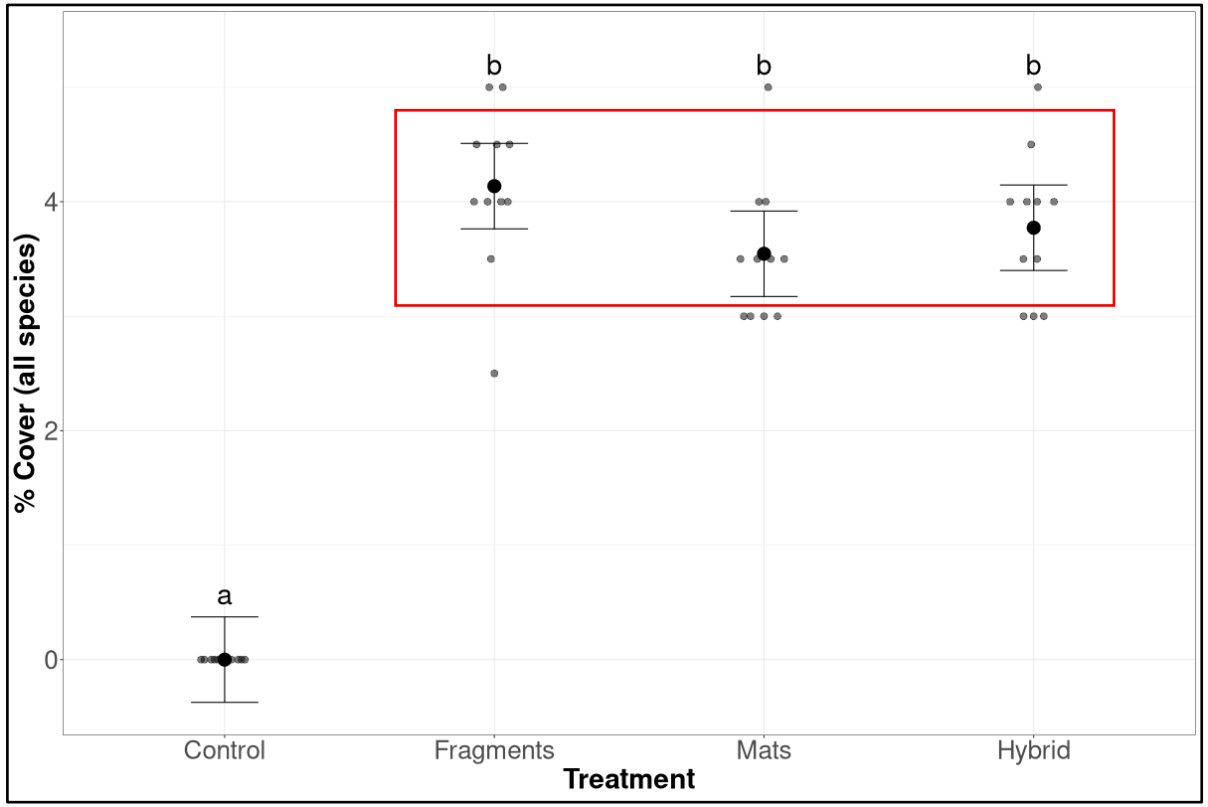
- ANOVA models fit to evaluate differences in **percent cover** between **treatments**.
- Pairwise comparisons made using Tukey's HSD method.

Results After 5 and 6 years

- There was a significant effect of treatment on lichen percent cover ($p < 0.0001$).
- No significant effect of litter ($p > 0.05$) or the litter-treatment interaction ($p = 0.05$).



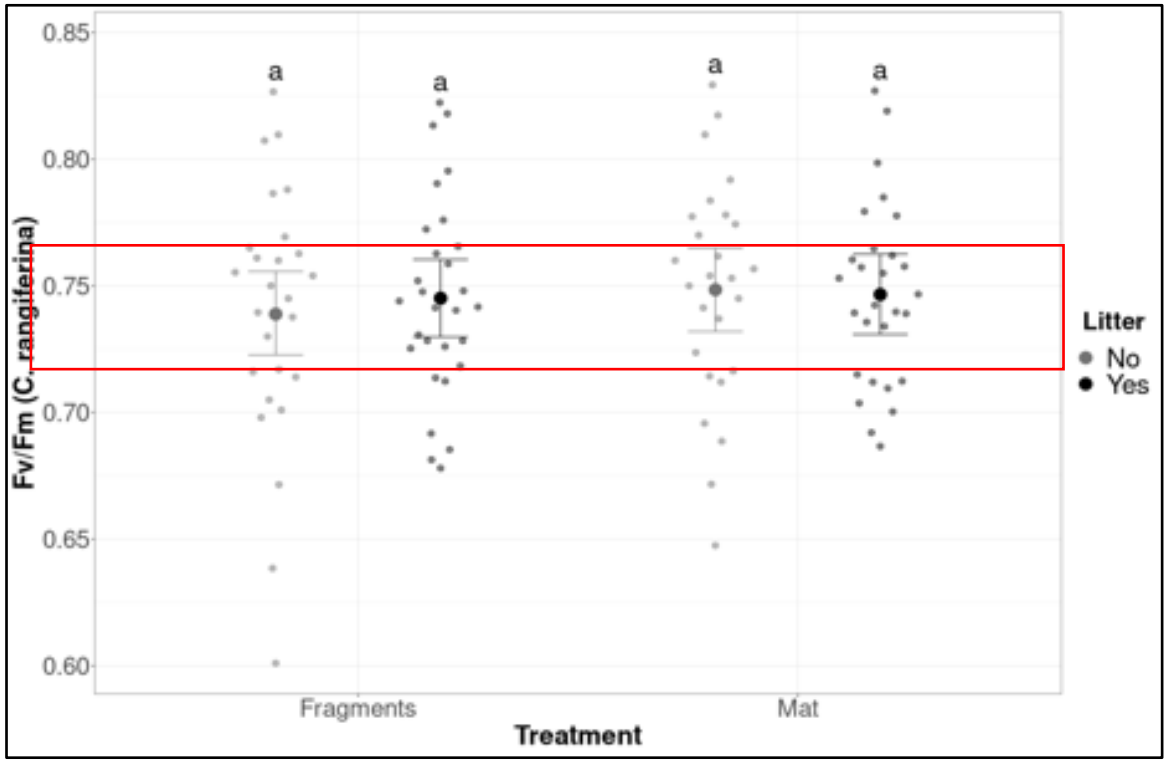
Mean lichen percent cover in Experimental Field Trial

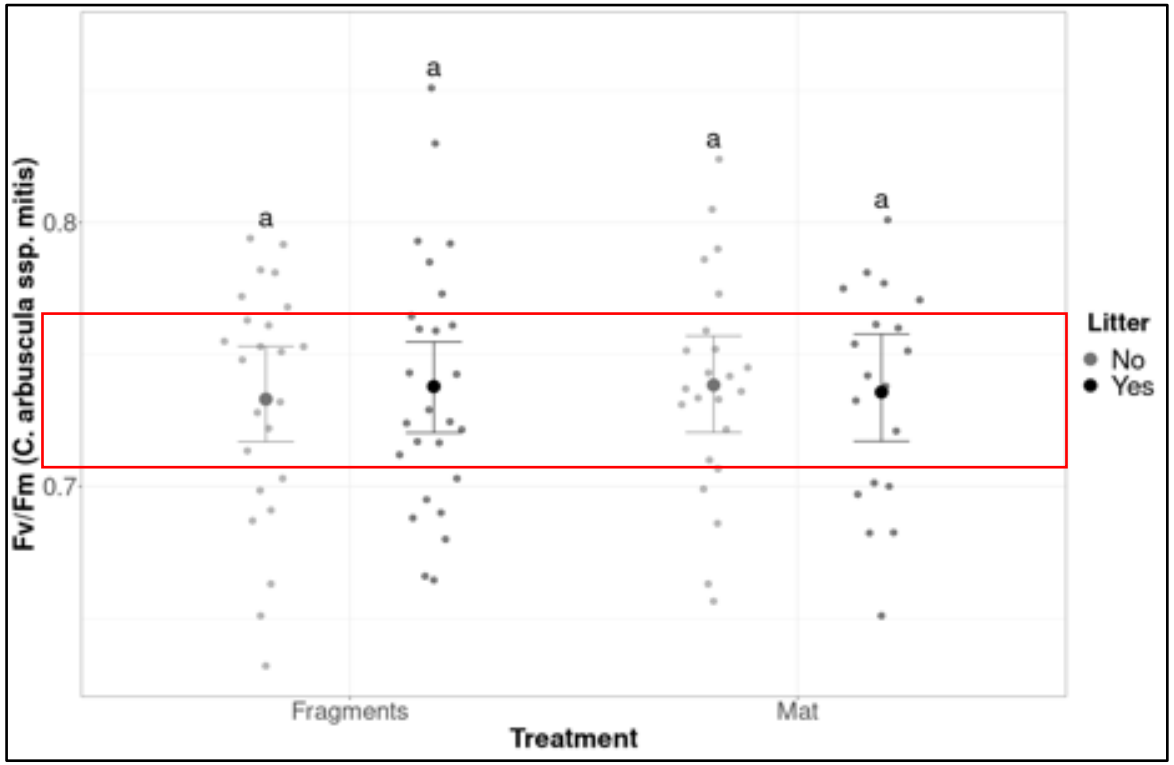


Mean lichen percent cover in Operational Field Trial

Experimental Trial Results

- Results indicate that approximately 77% of *C. arbuscula* ssp. *mitis* thalli and 87% of *C. rangiferina* thalli exceeded the 0.7 Fv/Fm threshold (unstressed = potential photosynthetic activity > 0.7).
- No significant effect of treatment ($p > 0.05$), litter ($p > 0.05$), or a treatment-litter interaction ($p > 0.05$) on lichen stress.

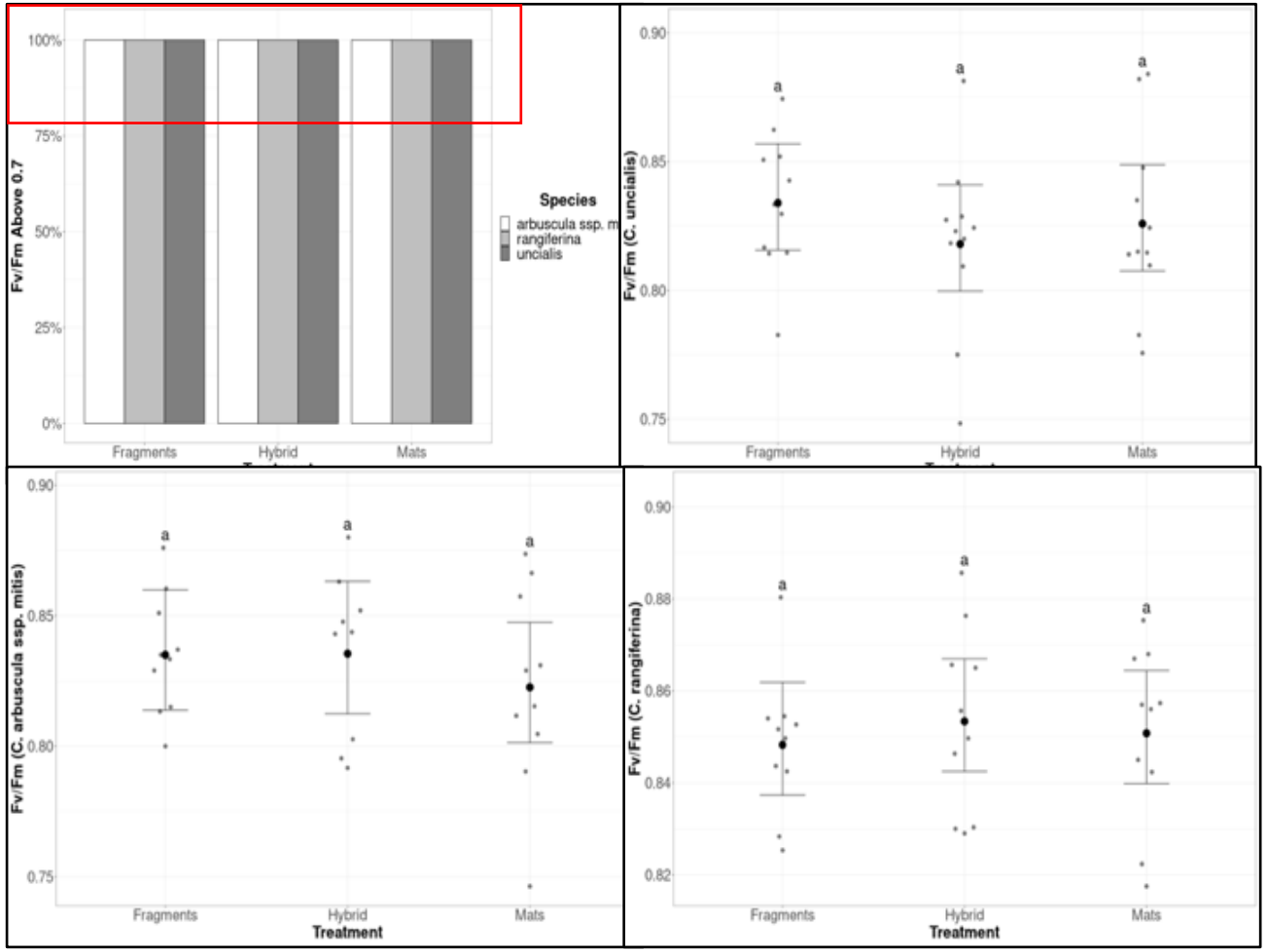




Fv/Fm values with the Experimental Field Trial for *Cladonia arbuscula ssp. mitis* and *Cladonia rangiferina*.

Operational Trial Results

- No variance in stress between treatments.
- The Fv/Fm values exceeded the stress threshold (unstressed = potential photosynthetic activity > 0.7) for all species, in all plots, for 100% of the lichen thalli collected.
- All of the lichen sampled in the Operational Trial had survived!



Fv/Fm values within the Operational Field Trial for *Cladonia arbuscula* ssp. *mitis*, *Cladonia rangiferina*, and *Cladonia uncialis*.

Results

- The results demonstrate that transplanted lichen fragments and mats of *Cladonia* subgenus *Cladina* had survived 5 and 6 years after being transplanted within a post-wildfire environment.

- The lichens not only survived, but they had potential photosynthetic activity values that suggest no or low stress in the specimens at the time of monitoring in 2021 regardless of species.

- Transplantation of lichen was found to increase lichen percent cover compared to 0% in the control plots.

- This suggests that *Cladonia* subgenus *Cladina* is dispersal limited, but not limited by the substrate or the environmental conditions of the post-wildfire environment.

Implications and Operational Considerations

- Several operational considerations that must be made before incorporating lichen transplants into a caribou winter habitat restoration project:
  - Where to collect lichen?
  - What volume of lichen harvest can be considered sustainable?
  - What is the impact of forest succession on transplanted lichen survival? (e.g., as light levels decrease, or high litterfall occurs)
  - We demonstrated lichen survival but what is the growth rate? Are they growing at a rate sufficient to provide caribou forage habitat?
  - Seasonal changes in chlorophyll fluorescence?

- While restoration is always an option, it is a long-term endeavour, especially if attempting to restore pine lichen winter habitat.

- The most cost-effective means of recovering caribou populations is to protect their habitat from further degradation, before its lost.

Thank You

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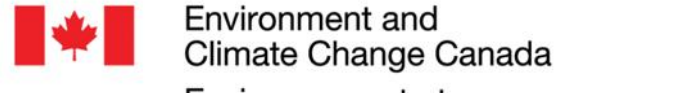
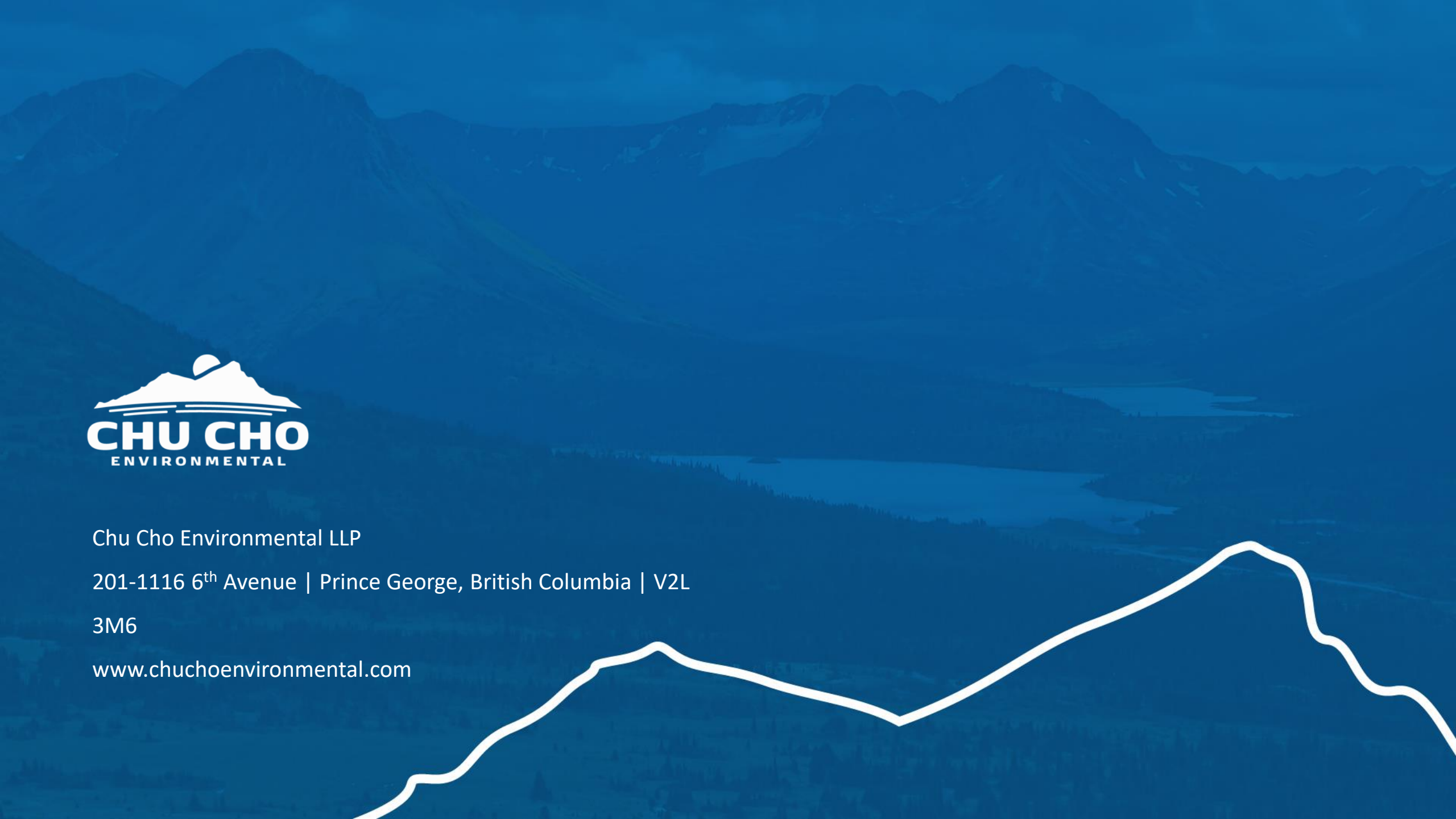


Learn More

- Chu Cho Environmental YouTube Channel….. “Watching Lichen Grow….Scientifically” https://www.youtube.com/@ChuChoEnvironmental

- Rapai SB, McColl D, Collis B, Henry T, Coxson D. (2023) Terrestrial lichen caribou forage transplant success: year 5 and 6 results.
- Rapai S,McMullin T, Newmaster S, Hanner R (2018) Restoring *Cladonia* subgenus *Cladina* in a post mine environment. The Forestry Chronicle 94:283–291.
- Rapai SB, McColl D, McMullin RT (2017) Examining the role of terrestrial lichen transplants in restoring woodland caribou winter habitat. The Forestry Chronicle 93:204–212.



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