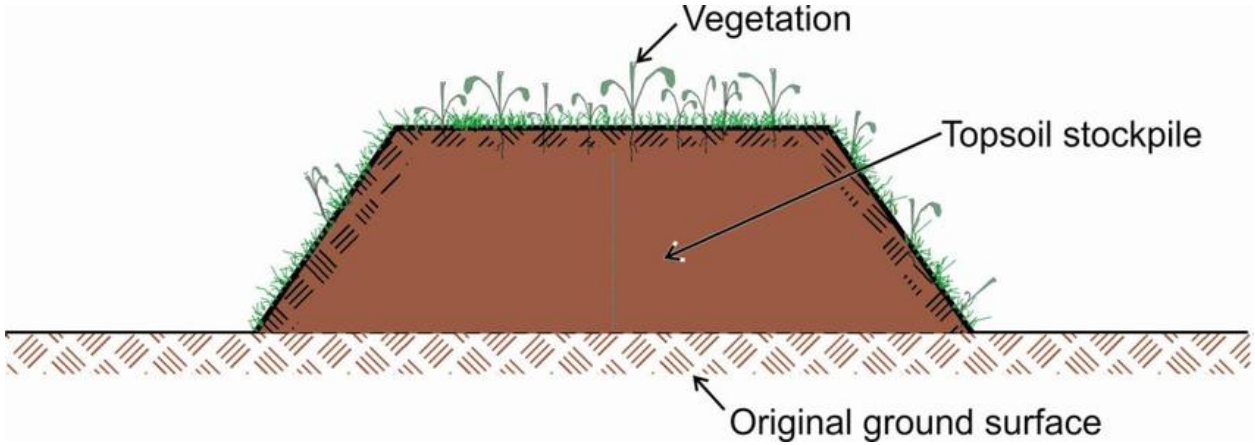
The Effects of Soil Stockpiling in the Oil Sands

Jennifer Buss, M.Sc. Candidate, University of Alberta

Supervised by: Dr. Brad PInno



https://www.researchgate.net/figure/Example-of-a-vegetated-topsoil-stockpile_fig167_318967507

Result of mining and industrial activities

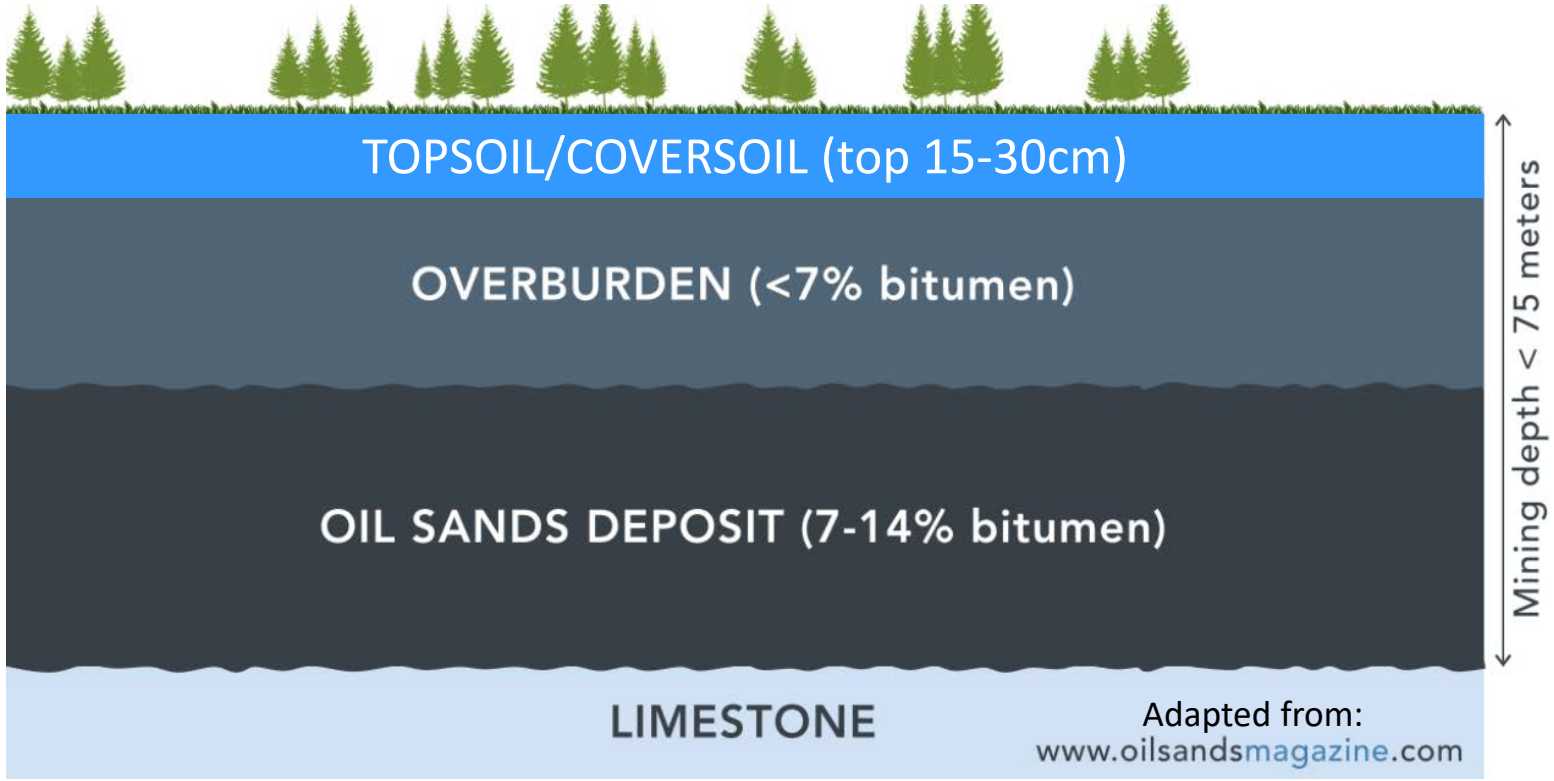
First step is to strip away any vegetation and soil above the deposit

Stored for later use in reclamation

Background

Soil salvage

- Topsoil stockpiled separately from overburden (not in older piles)
- In general upland and peatland soils not mixed



Oil sands reclamation

- 760km^2 disturbed lands
- 8 operating mines have >67 million m^3 of stockpiled soil
- 52% of CNRL lease will be reclaimed using stockpiles

Google maps 2018

Why stockpile research is important

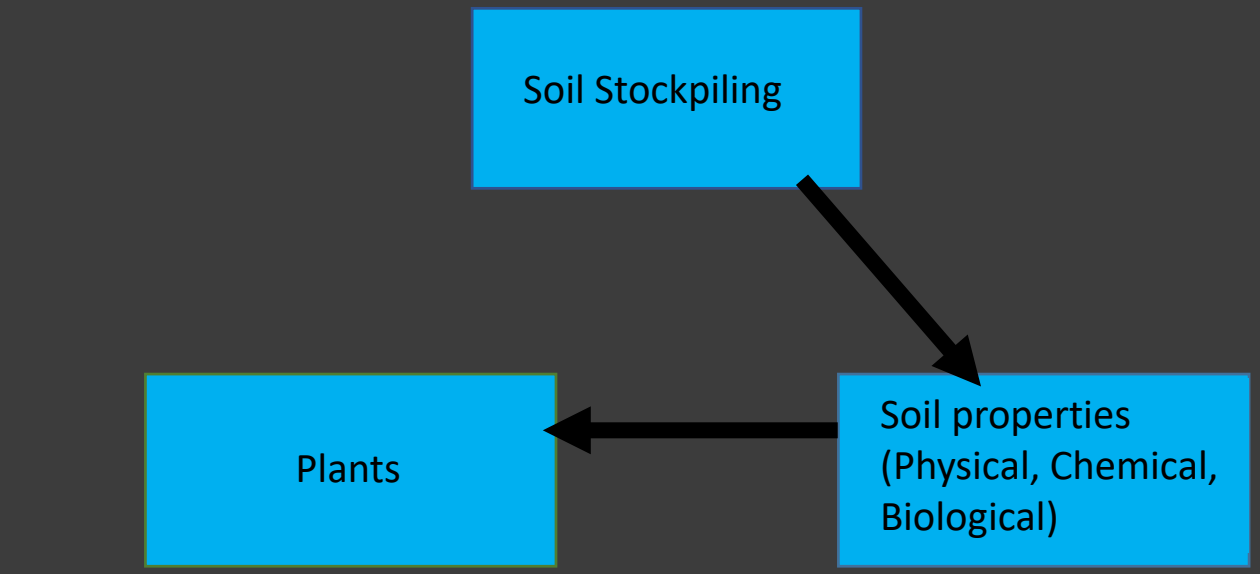
- Goal is to restore to a diverse native plant community
- Stockpiles low in plant propagules
- Use direct placement

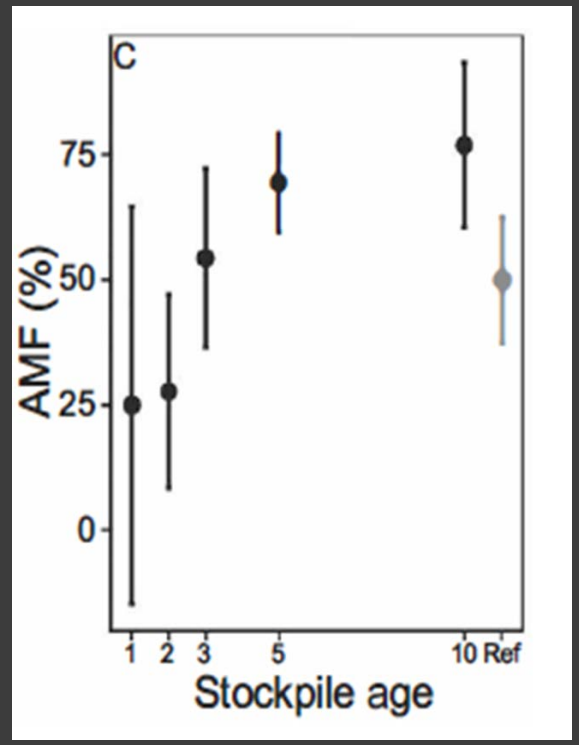
Image 17. Natural revegetation of native plants from propagules contained in upland surface soil salvaged from an a ecosite.

Alberta Environment and Water 2012

Indirect effects on plants

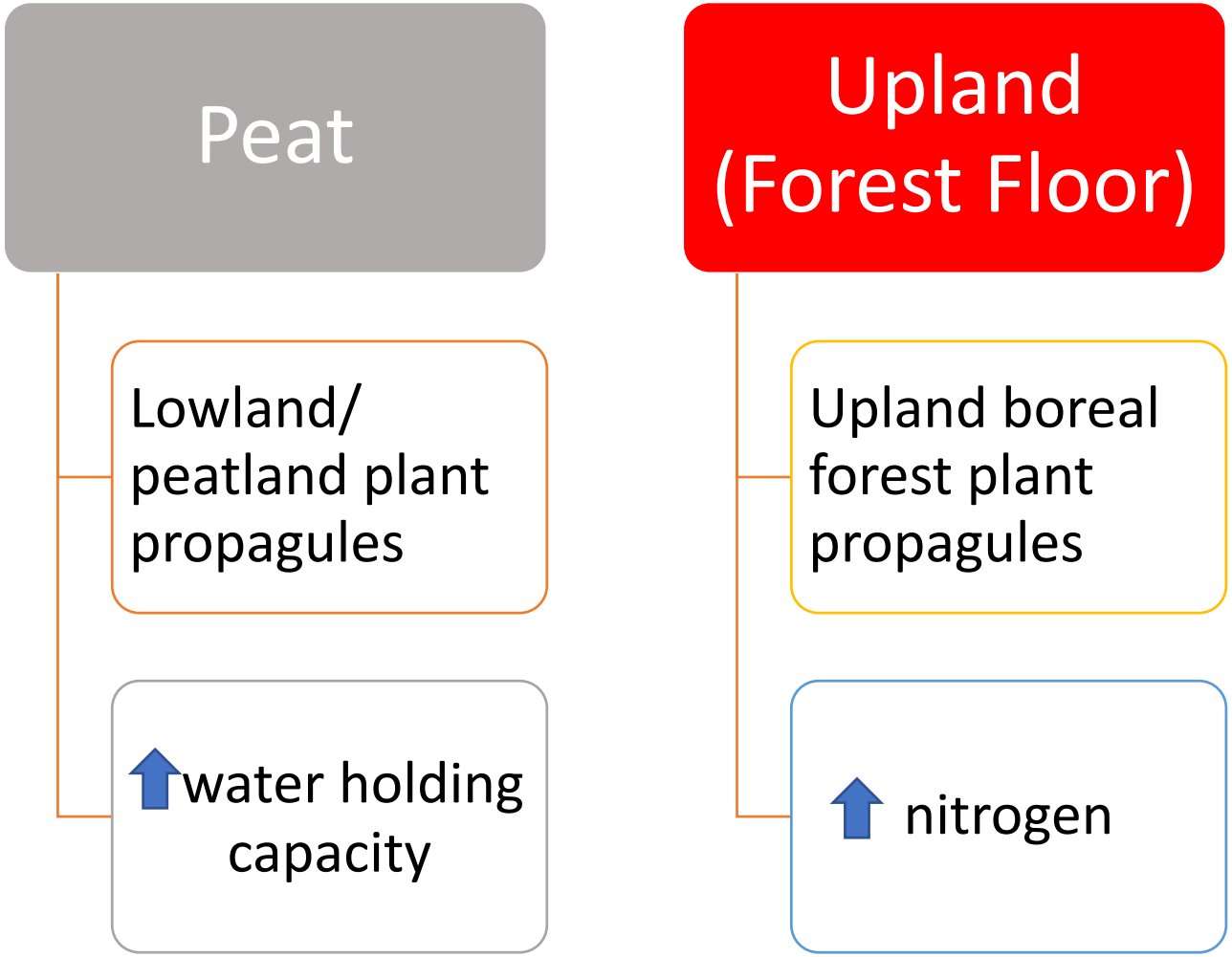
- ⬆ in bulk density
- ⬇ in aggregate stability
- ⬆ in compaction
- ⬆ in ammonium
- Initial ⬇ of mycorrhizal fungi
- ⬇ earthworms





Birnbaum 2017

2 types of stockpiled soil in oil sands region

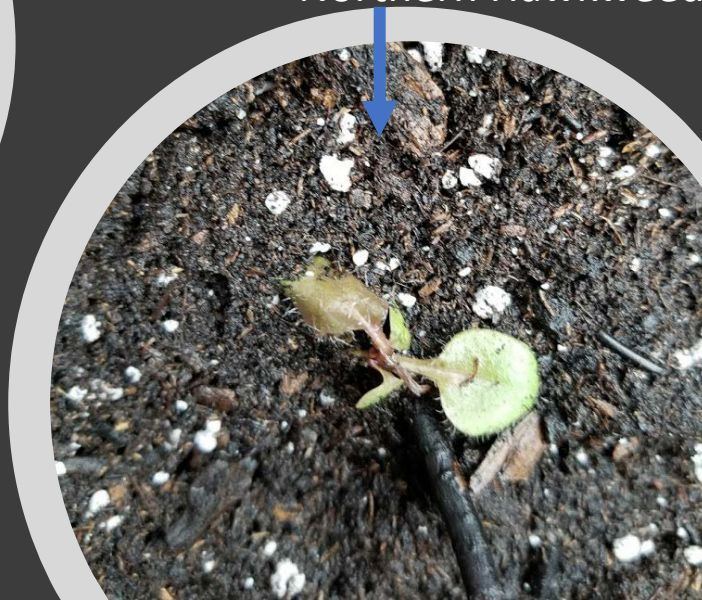


Direct effects of stockpiling on seeds

- Seed viability ↓ with **depth** and stockpile **age** due to:
  - Germination
  - Predation
  - Fungal pathogens

Stinging Nettle

Sow-thistle



Northern Hawkweed

What about undisturbed forests?

- ⬇ in viable seeds with depth also occurs in undisturbed forest sites
- Problem is ⬇ of viable seeds over time

Stockpile group project

- Are stockpiled soils useful for reclamation?
- What changes to the soil and plant community occur when soil is stockpiled?
- Can soil stockpiles be used to obtain a native plant community?
- Can we alter our stockpiling practices to make them better?

My project

- How stockpile soil conditions are impacting plants and plant propagules (seeds).
  - What **species** are present?
  - Does **depth** have an impact on the seedbank?
  - Does current **vegetation** have an impact on the seedbank?

Sweet clover

Perennial Sow-thistle

Slender Wheatgrass

Sampling soil stockpiles

4 depth treatments, 3 veg types

Sampling design

surface

0-10cm

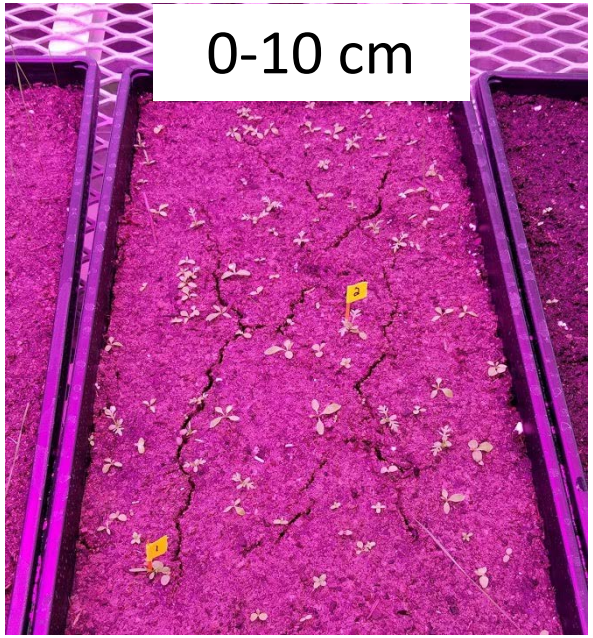
10-20cm

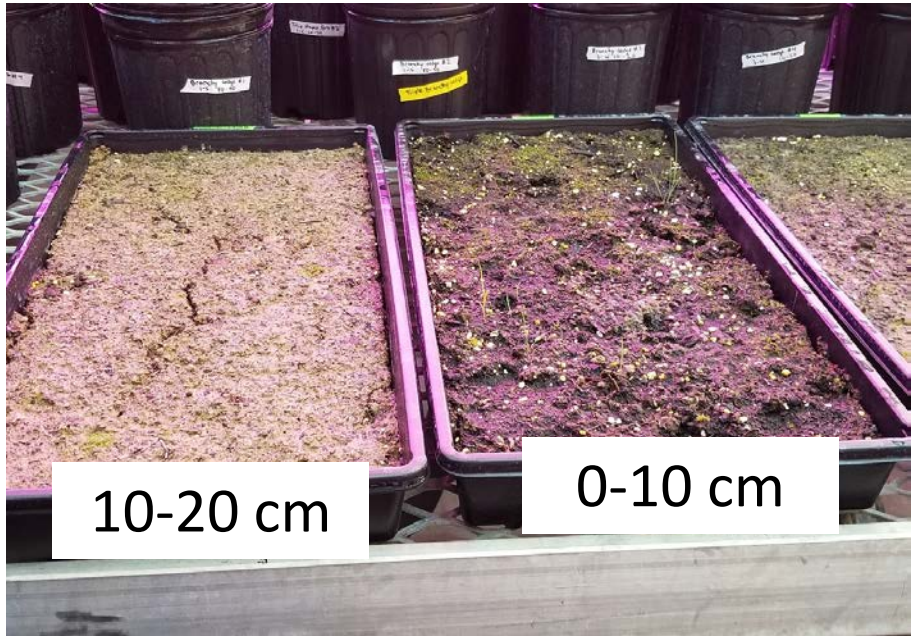
20-30cm

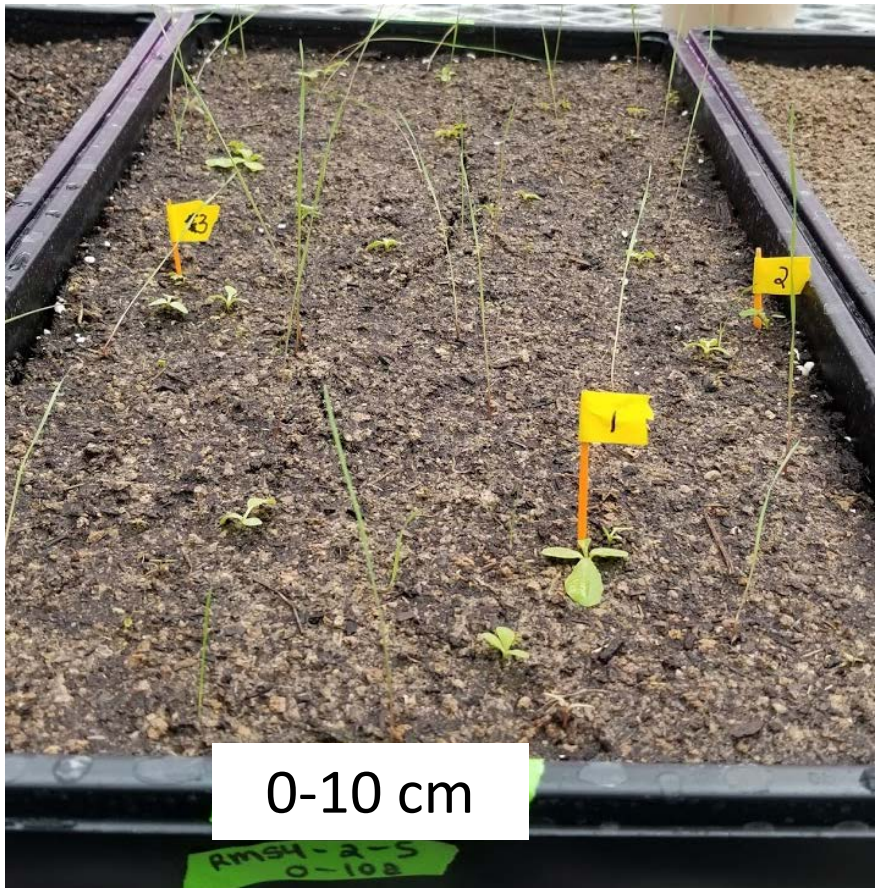
80-90cm

Greenhouse seedbank germination study

Repotted plants



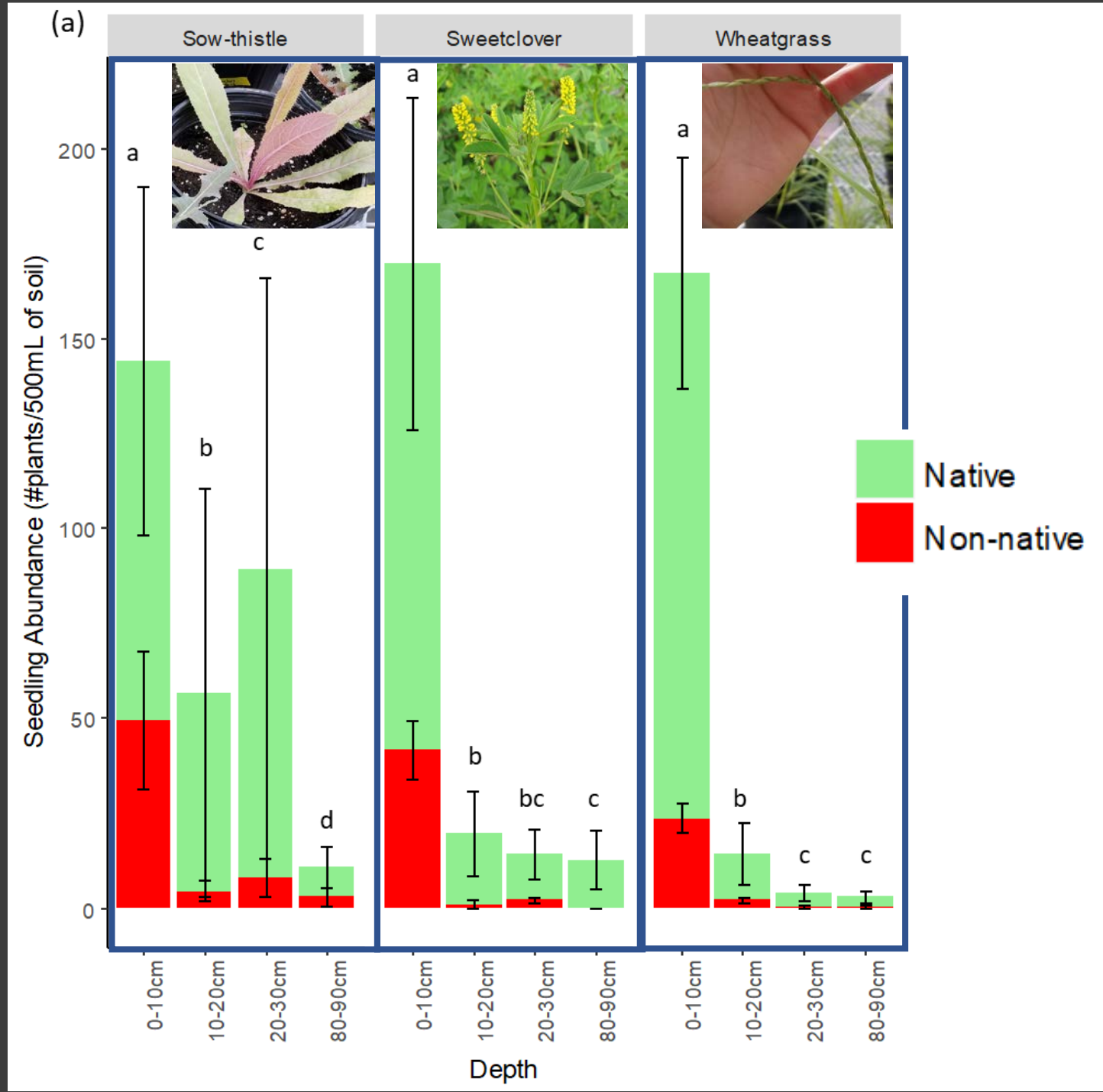




Effect of depth

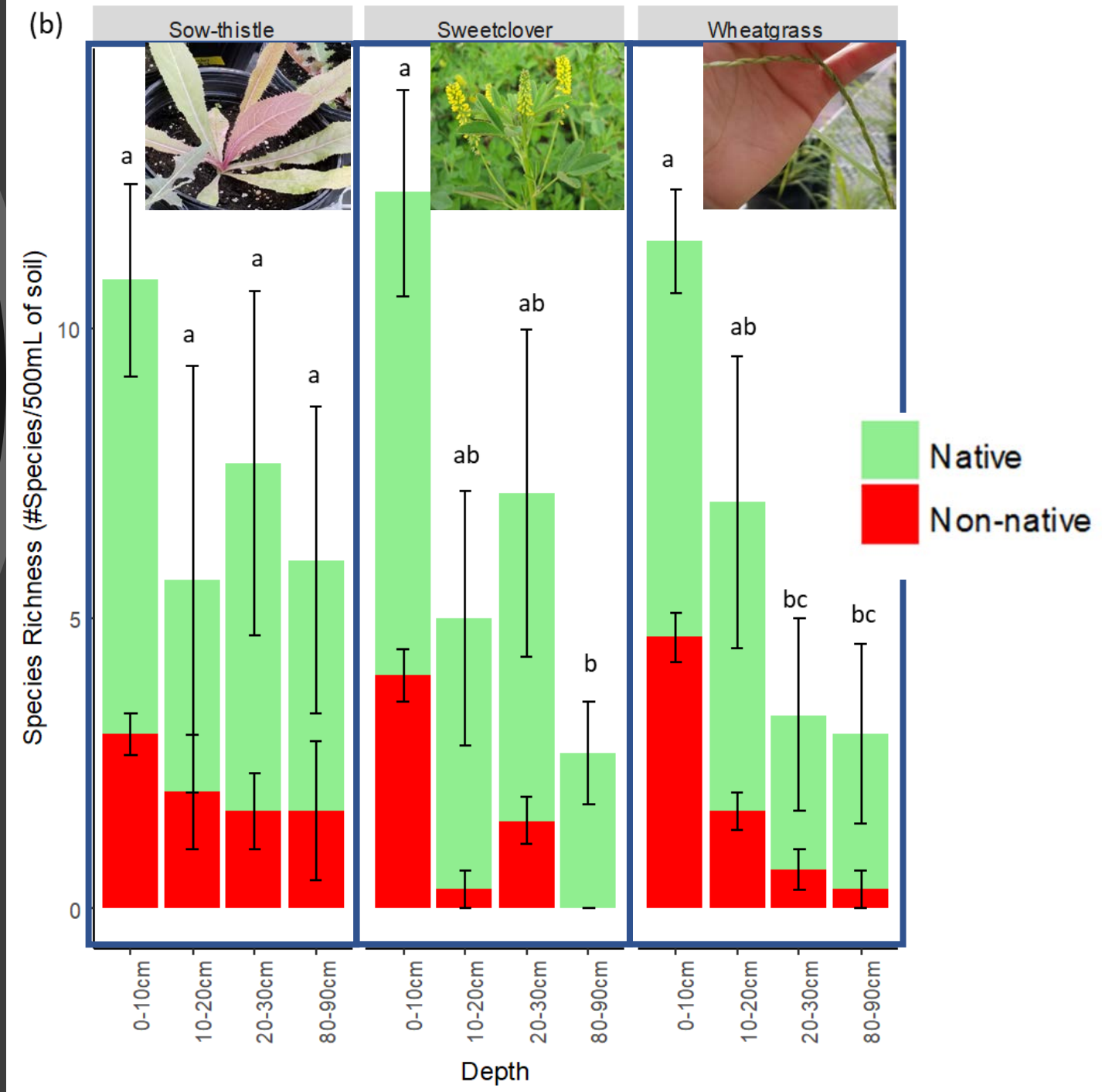
Seedling abundance

- ↑ seedling abundance at the surface
- ↑ seedling abundance for sow-thistle
- ↑ native individuals at all depths



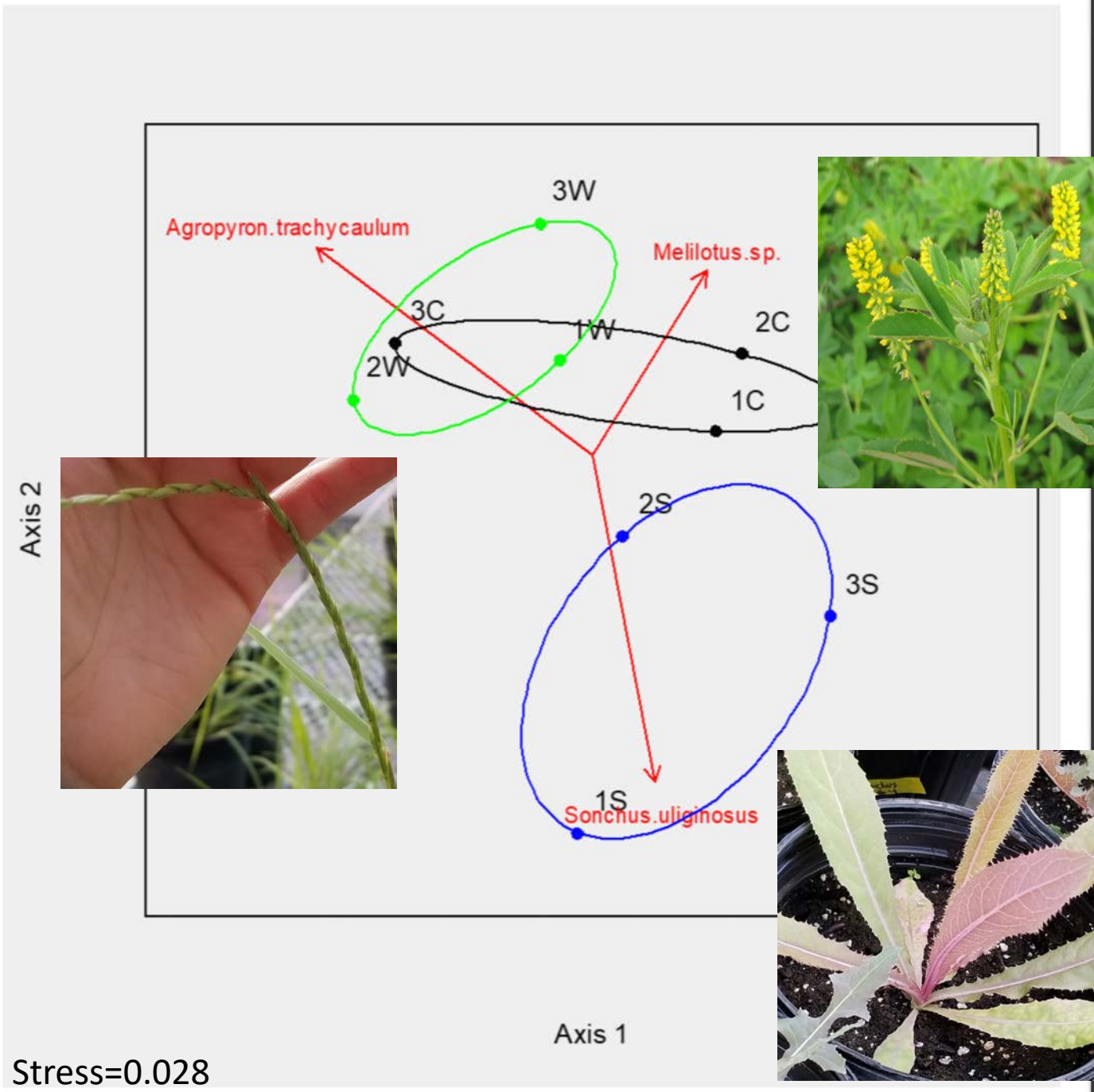
Species richness

- ↑ species at the surface
- No difference between vegetation types
- ↑ native species at all depths



Effect of surface vegetation community

- NMS Ordination
- Dominant surface species = largest impact on seed bank community



Vegetation Type →

Seed bank	Wheatgrass				Sweet clover				Sow-thistle			
Species ↓	0-10	10-20	20-30	80-90	0-10	10-20	20-30	80-90	0-10	10-20	20-30	80-90
Agropyron trachycaulum	**6.99**	**0.28**	**0.00**	**0.06**	4.73	0.00	0.03	0.00	1.49	0.28	0.69	0.03
Melilotus sp.	0.98	0.00	0.00	0.00	**2.37**	**0.00**	**0.00**	**0.00**	0.03	0.00	0.00	0.00
Sonchus uliginosus	0.25	0.06	0.03	0.00	0.77	0.08	0.06	0.00	**2.99**	**0.17**	**0.19**	**0.06**

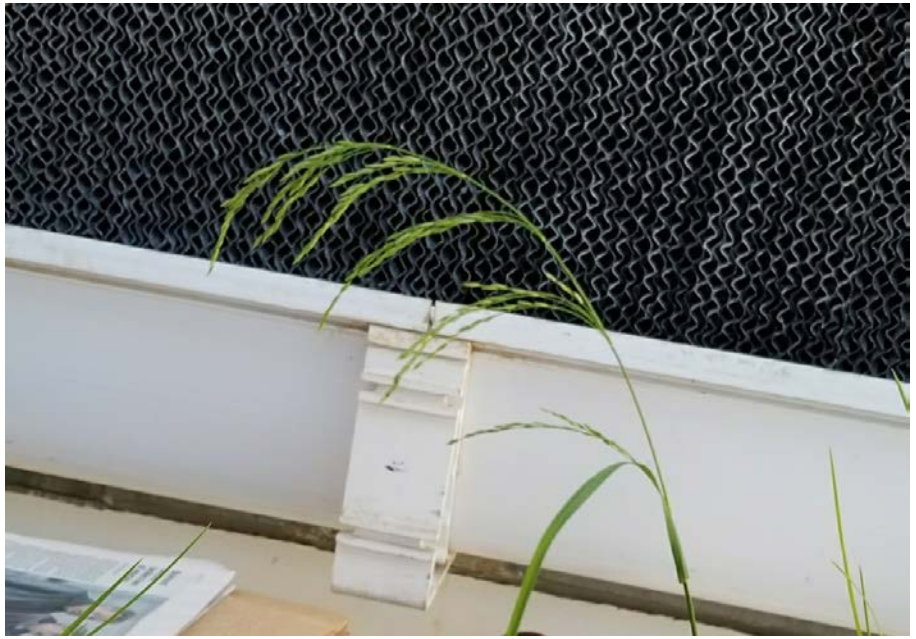
- % total seedling abundance

Decrease with depth

Potentilla norvegica

Urtica dioca

Glyceria striata



Epilobium ciliatum

Species that were common at lower depths

Conclusions

1

Seeing a lot of native species across all depths.

2

Decrease in seed bank seedling abundance and species richness with depth.

3

Large impact of aboveground vegetation on the surface seedbank.

Management implications

Vegetation management is important.

Stockpiling utilization options.

My future research

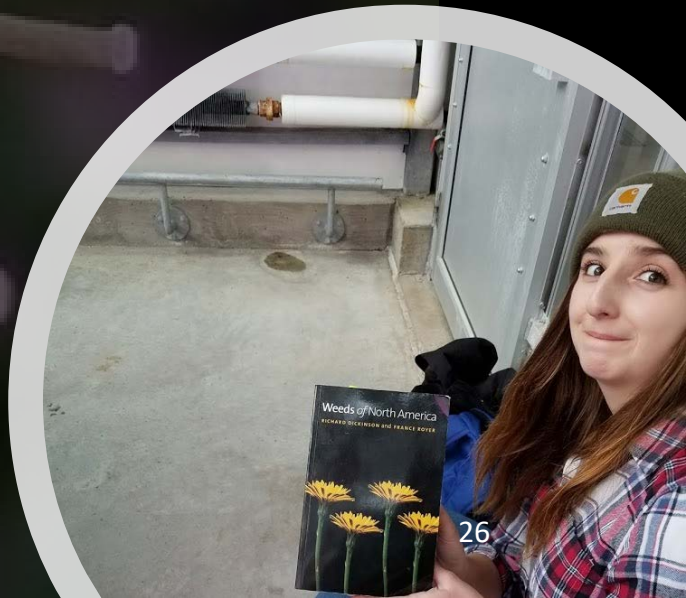
- How long can soil be safely stockpiled before we start seeing negative impacts?
- At what depth are we seeing declines in seedling abundance and species richness?
- How do soil conditions impact the seedbank?

References

- Abdul-Kareem, A. W., & McRae, S. G. (1984). The effects on topsoil of long-term storage in stockpiles. Plant and Soil, 76(1-3), 357-363.
- Alberta Environment and Water. 2012. Best Management Practices for Conservation of Reclamation Materials in the Mineable Oil Sands Region of Alberta. Prepared by MacKenzie, D. for the Terrestrial Subgroup, Best Management Practices Task Group of the Reclamation Working Group of the Cumulative Environmental Management Association, Fort McMurray, AB. March 9, 2011.
- Birnbaum, C., Bradshaw, L. E., Ruthrof, K. X., & Fontaine, J. B. (2017). Topsoil stockpiling in restoration: Impact of storage time on plant growth and symbiotic soil biota. *Ecological Restoration*, *35*(3), 237-245.
- Dickie, J. B., Gajjar, K. H., Birch, P., & Harris, J. A. (1988). The survival of viable seeds in stored topsoil from opencast coal workings and its implications for site restoration. Biological conservation, 43(4), 257-265.
- Edwards, G. R., & Crawley, M. J. (1999). Effects of disturbance and rabbit grazing on seedling recruitment of six mesic grassland species. Seed Science Research, 9(2), 145-156.
- Google Maps. (2018). Study area. Retrieved from: https://www.google.ca/maps/@57.9751669,-108.5696605,3117216m/data=!3m1!1e3
- Google Maps. (2018). My Sites. Retrieved from: https://www.google.ca/maps/place/CNRL+Wolf+Lake/@54.4086015,-120.4525771,2249018a,35y,356.95h,0.78t/data=!3m1!1e3!4m5!3m4!1s0x53a64368a1a46207:0xc85128040c35071!8m2!3d54.6957119!4d-110.7308578
- Harris, J. A., & Birch, P. (1987, January). The effects on topsoil of storage during opencast mining operations. In Journal of the Science of Food and Agriculture (Vol. 40, No. 3, pp. 220-221). BAFFINS LANE CHICHESTER, W SUSSEX, ENGLAND PO19 1UD: JOHN WILEY & SONS LTD.
- Harris, J.A., Birch, P. and Short, K.C. (1989), Changes in the microbial community and physico-chemical characteristics of topsoils stockpiled during opencast mining. Soil Use and Management, 5: 161–168. doi:10.1111/j.1475-2743.1989.tb00778.x
- Oil Sands Magazine. 2018. Land Use. Retrieved from: http://www.oilsandsmagazine.com/technical/environment/land-usage
- OSRIN, 2014. OSRIN's Did You Know Series: The Collected Works. Oil Sands Research and Information Network, University of Alberta, School of Energy and the Environment, Edmonton, Alberta. OSRIN Report No. SR-11. 163 pp.
- https://en.wikipedia.org/wiki/Melilotus_indicus

Questions?

- Greenhouse help: Ruth Errington, Chris Wohl, and Shelby Feniak.
- Funding from CNRL. Greenhouse space from Natural Resources Canada.



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