



Islands – plant community dynamics on a new oil sands reclamation design

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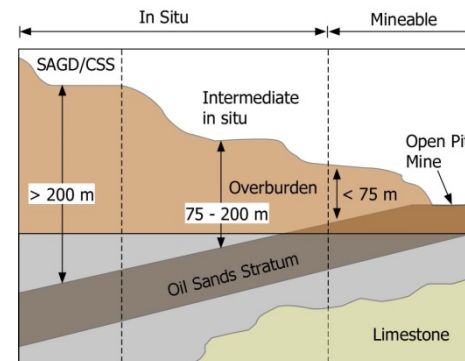


Oil Sands in Alberta

- Mining occurs where the oil deposit is thick and close to the surface, i.e. near the Athabasca River north of Fort McMurray, in-situ extraction used everywhere else
- Most of the rest of Alberta is underlain by conventional oil and gas deposits
- Oil sands mining has directly disturbed over 80,000 ha of boreal forest so far; 8,200 ha are under active reclamation
- Re-establishing a functioning boreal forest ecosystem is a key priority
- The cumulative impacts of oil & gas development, forestry, agriculture, recreation, other human uses and natural disturbances are substantial in Alberta



Note: 1 km² = 1 square kilometre = 0.39 square miles



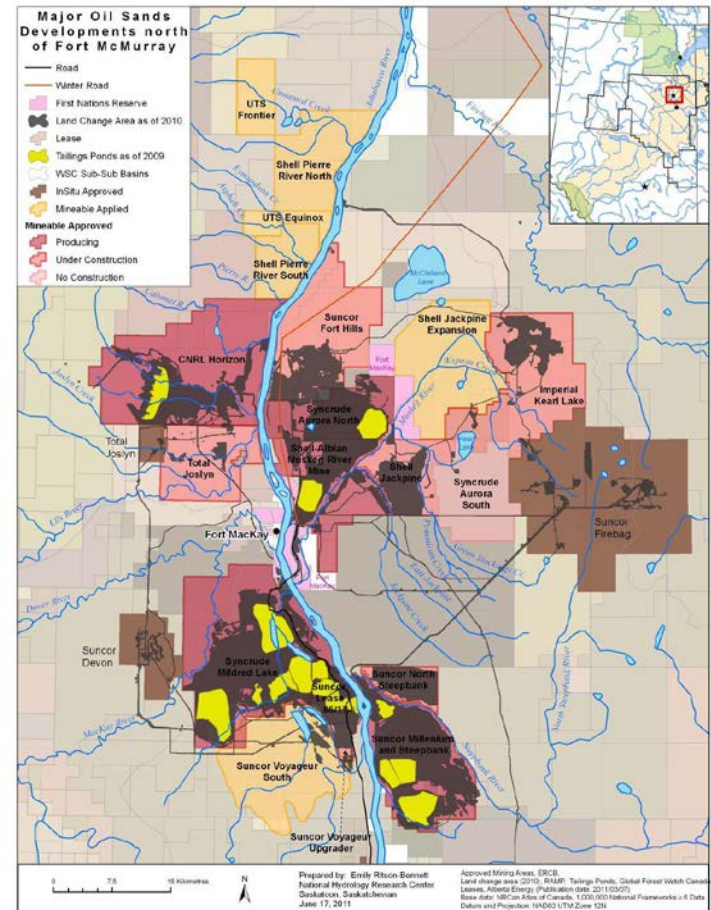
Mines are where overburden is shallow and oil sand is close to the surface.

Fort McMurray Developments

- Major oil sands open pit mines and in-situ projects
- Approximately 1/5 of mineable oil sands area has been developed
- Most reclamation work will take place 2035+
- Current ecological research focusing on operational reclamation techniques and processes within natural and reclaimed ecosystems

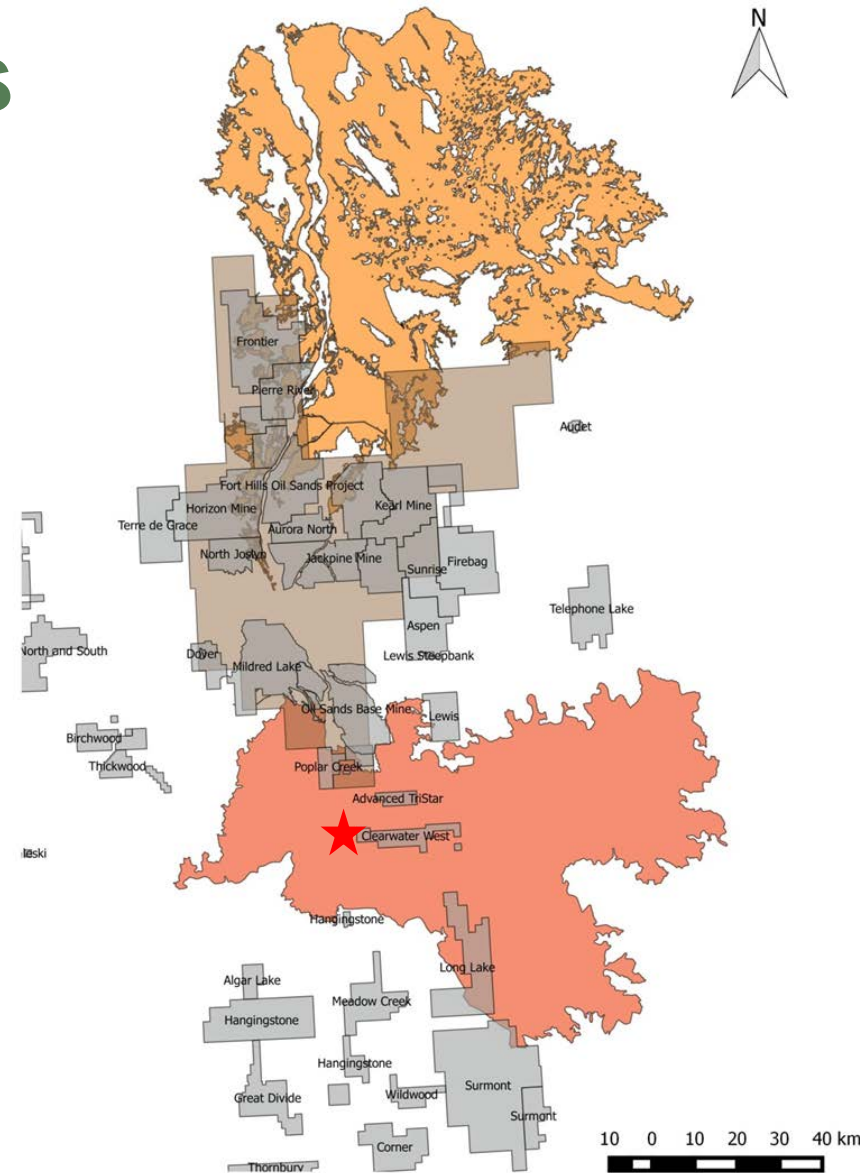


Oil sands at the surface of an old reclamation area.



Natural disturbances

- Richardson Fire
 - Spring 2011
 - 575,000 ha (1.4 M acres)
- Mineable Oil Sands
 - 7 active mines
 - Other industrial developments
 - Total area 480,000 ha
- Fort McMurray Fire
 - Spring 2016
 - Currently 530,000 ha (1.3 M acres)
 - Over 80,000 people evacuated
- Other disturbances
 - Flooding
 - Insects and diseases
- Reclamation



Oil sands upland reclamation

- Goal of land reclamation is to create ecosystems that are safe, stable and non-polluting. More specifically, the goal is to have self-sustaining, locally common boreal forest ecosystems.
- Tailings sand or overburden dumps are contoured and then capped with suitable soil material
 - Peat-mineral mix (PMM)
 - Forest floor-mineral mix (FFMM)
- The ecosystem that was present at a particular location before disturbance is not necessarily similar to what will be there afterwards

Constraints

- Amount of available reclamation soil, especially FFMM
- Operational considerations and costs

Research goal

- How to best utilize limited reclamation soils?
- What can we learn from past reclamation?



Reclamation in progress

Forest floor – mineral mix being spread on top of overburden

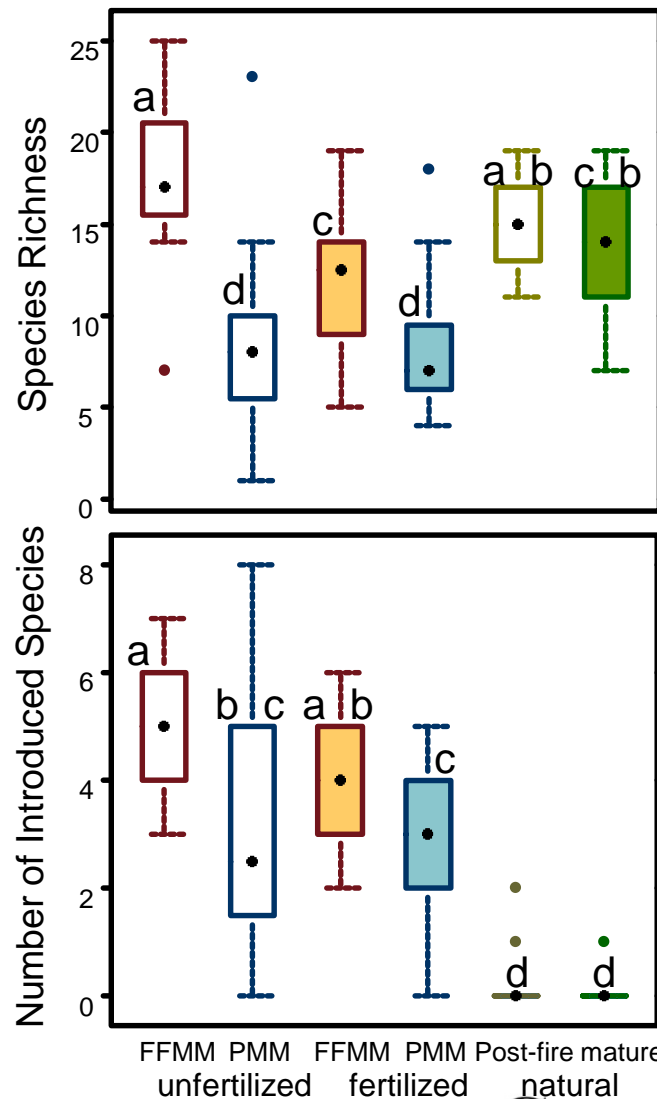
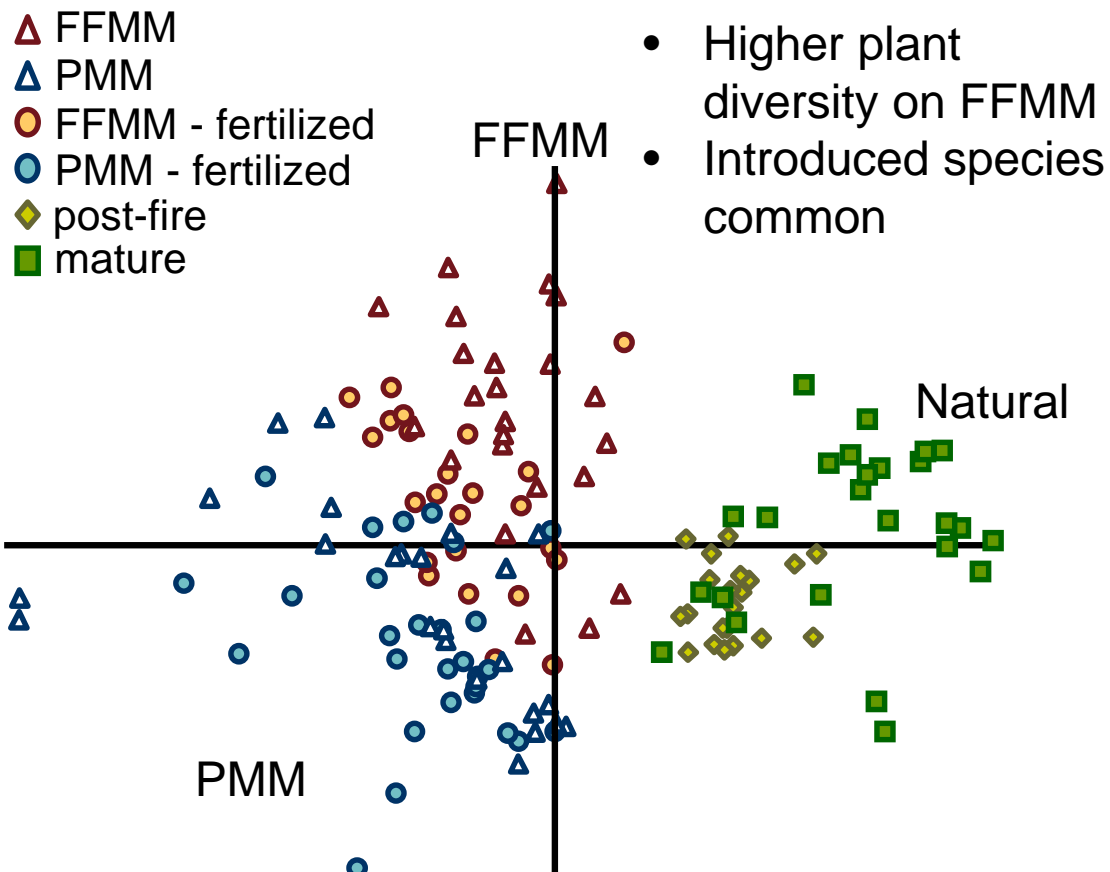


Past Reclamation

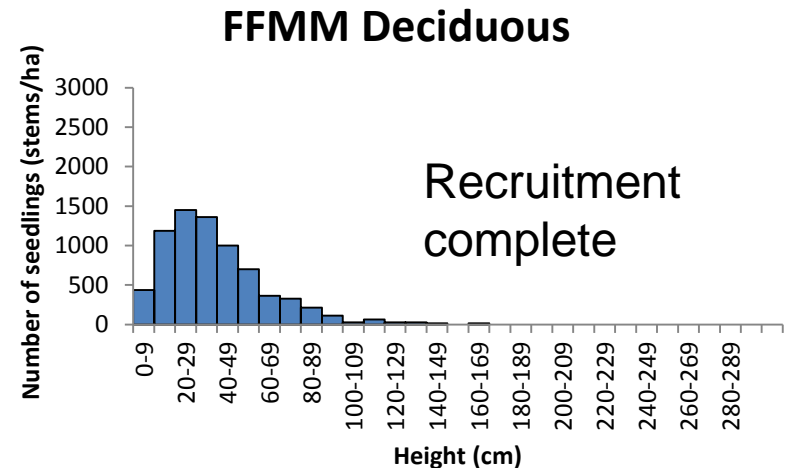
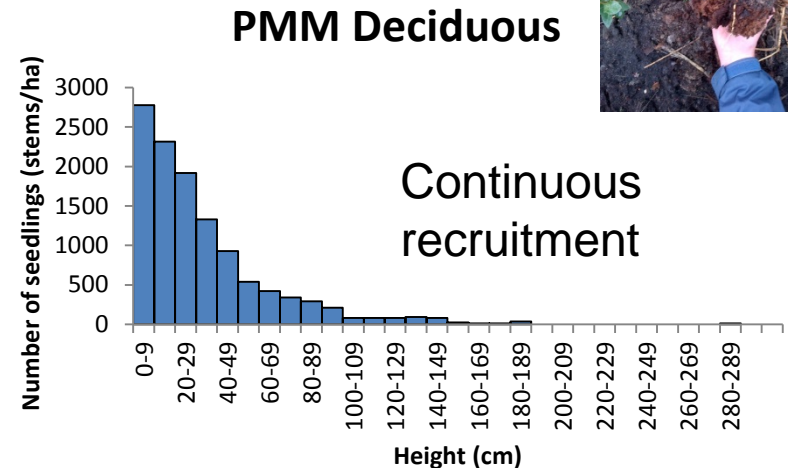
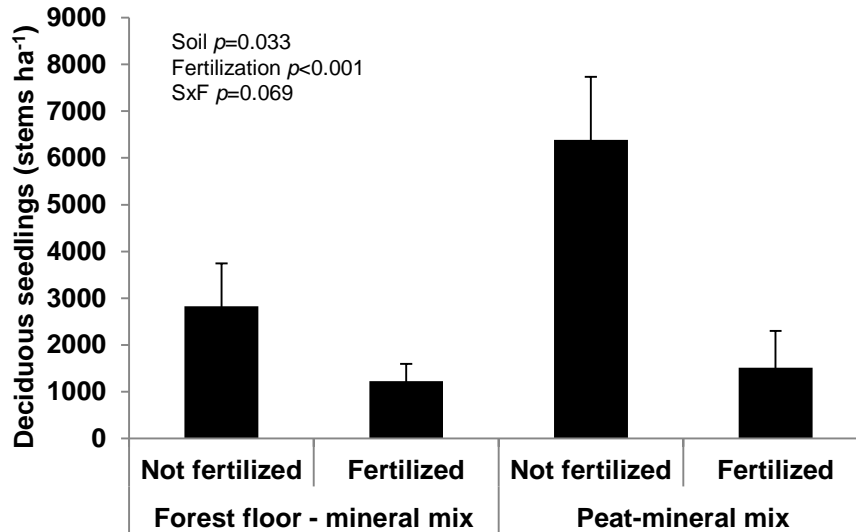
- RA1 (Reclamation area #1)
 - 88 ha overburden dump established in 2011
 - Large directly placed soil patches, ~ 20 ha each
 - 2 soil types x fertilization x CWD
 - PMM – Peat-mineral mix
 - FFMM – Forest floor-mineral mix
 - Studies on plant community, tree establishment and productivity, soil nutrients and microbiome, hydrology
- How can we use this information to inform future reclamation?



RA1 plant community



Tree seedling establishment



- Much greater deciduous tree seedling establishment in PMM
 - Related to soil moisture, surface roughness and plant competition
 - Fertilization reduced tree establishment
- Continued recruitment of seedlings in PMM but not FFMM

RA1 Summary

- FFMM soil has greater plant diversity than PMM
- But...
- PMM has much higher recruitment of deciduous tree seedlings
- Past reclamation has been successful but can it be improved?
- How to integrate these soils across the landscape?



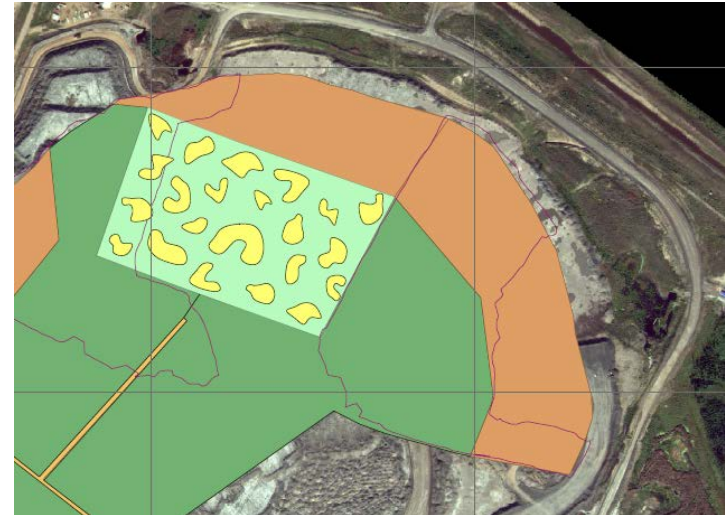
FFMM with higher plant diversity



PMM with higher tree density

Islands – new reclamation area

- Islands at North Toe Berm
 - 12 ha island area established in 2015
 - PMM matrix, islands of FFMM
 - Range of sizes and shapes of islands
 - Unfertilized
 - First attempt at integrating soil types on the landform scale
- Building off idea of forestry retention patches
 - Diversity centres, lifeboating of species

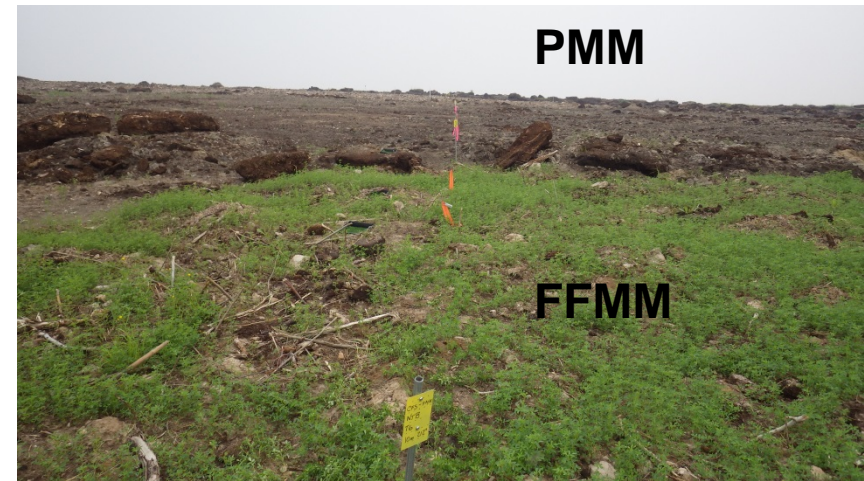


Islands of green FFMM within PMM matrix



Islands research

- Size of patches?
- Spacing of patches?
- How quickly are plants spreading out of FFMM patches?
- Mechanisms of plant community development
 - Seed bank
 - Seed rain
 - Seed bed
 - Vegetative expansion
 - Competition



Transect
across soil
types

Initial plant community response

- Soil types had expected tree and plant community responses
- FFMM had higher species diversity
 - FFMM avg 7.2 native sp/m²
 - PMM avg 4.0 native sp/m²
- PMM had higher natural tree establishment
 - PMM avg 19,114 trees/ha
 - FFMM avg 631 trees/ha
- Focus now on the impact of soil spatial pattern



Aspen seedlings on PMM



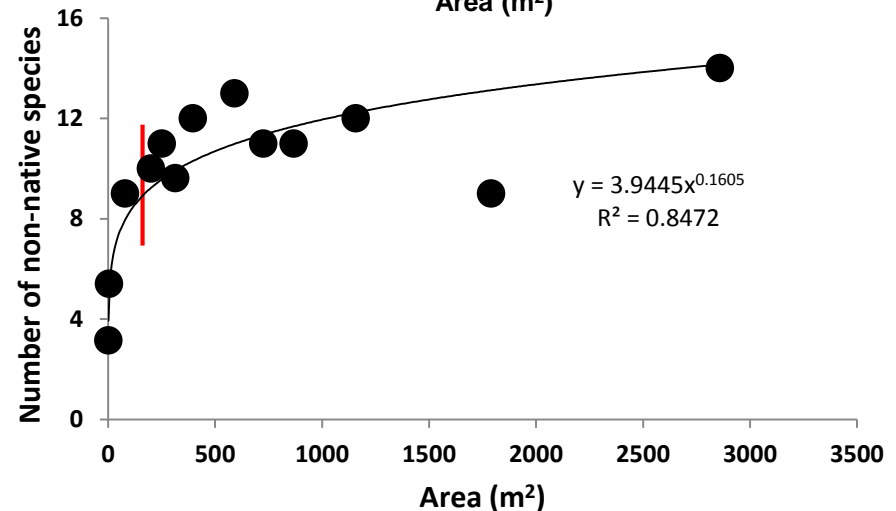
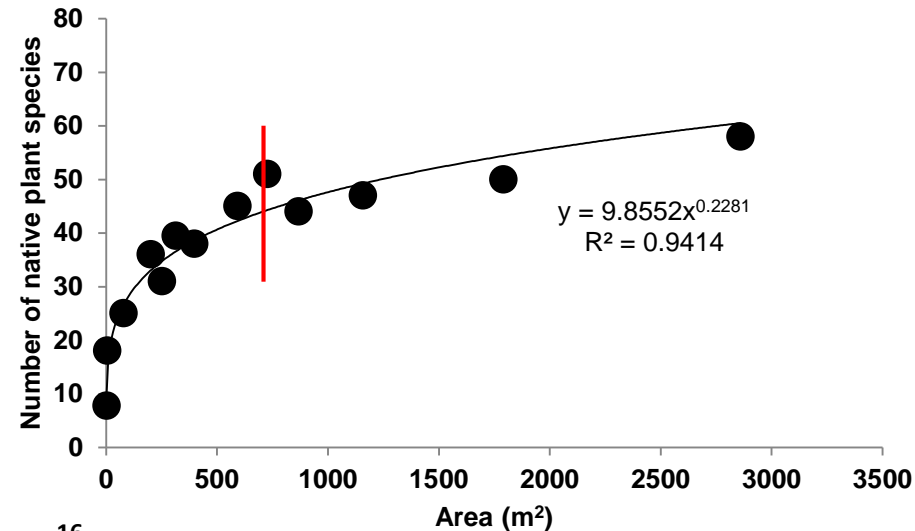
High diversity plant community on FFMM

How big should patches be?

- Developed species-area curves for FFMM reclamation patches
- 75% of native plants found in patches 671 m² and larger
- Smaller patch sizes needed for weedy species (170 m²) while woody plants need larger patches (960 m²)

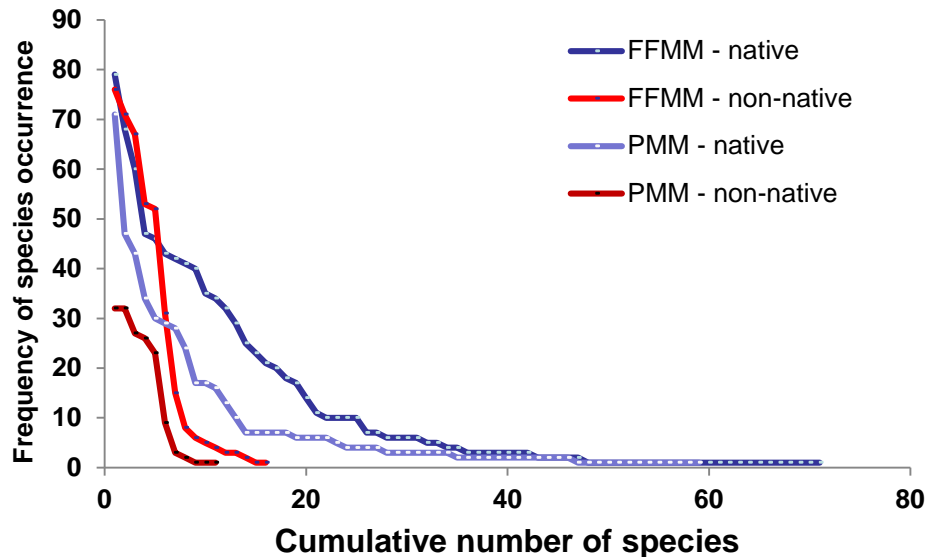


FFMM soil island being placed in the winter.



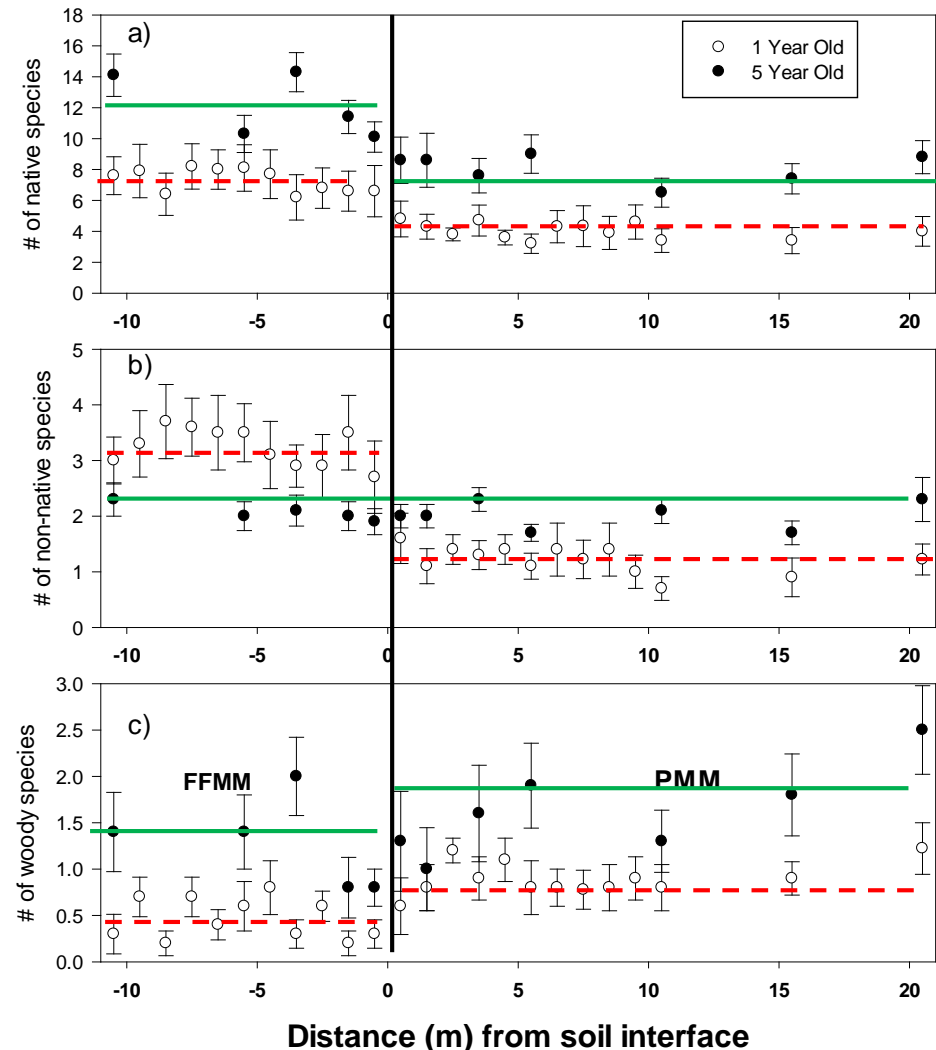
Common vs rare species

- Most native plants are quite infrequent
- Non-native plant community dominated by a few ubiquitous species
- Related to modes of dispersal and establishment



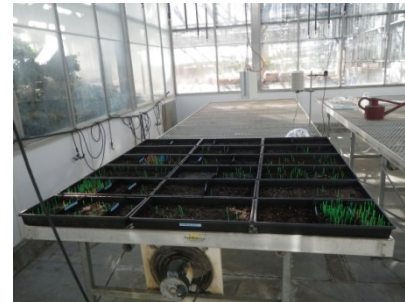
Are plants expanding?

- Differential responses over time between plant groups
- Native species higher on FFMM and difference increasing
 - 5 year old PMM similar in species diversity to 1 year old FFMM
- Weeds level out over time
 - Only a few weedy species are likely to have a significant impact
- Woody species greater on PMM and difference increasing over time



Where are plants coming from?

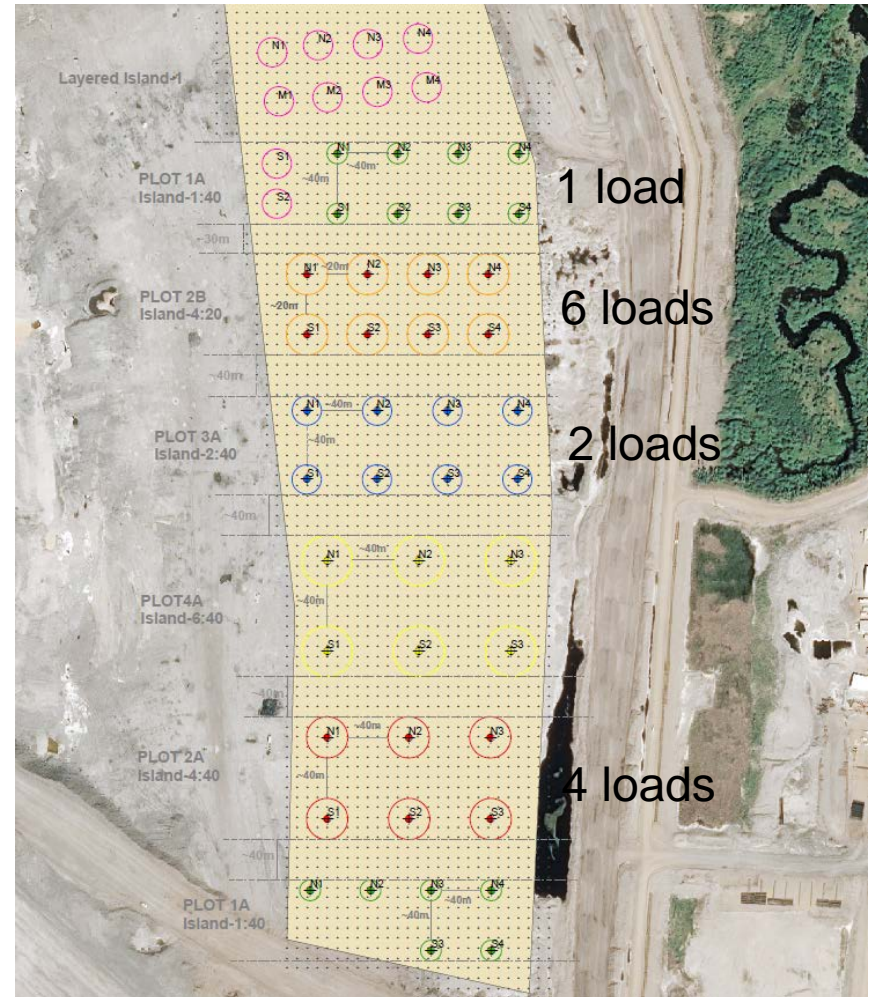
- Seedbank from FFMM placed during reclamation operations?
 - Soil cores from natural forests and from directly placed reclamation material.
- Seeding in from offsite?
 - Seed traps placed across soil type boundary.
- Vegetative expansion?
- Germinating in greenhouse to determine species and abundance.
- Trying to determine the mechanisms of plant establishment.
- Next step is quantifying competition.



What are other potential designs?

Operational Islands

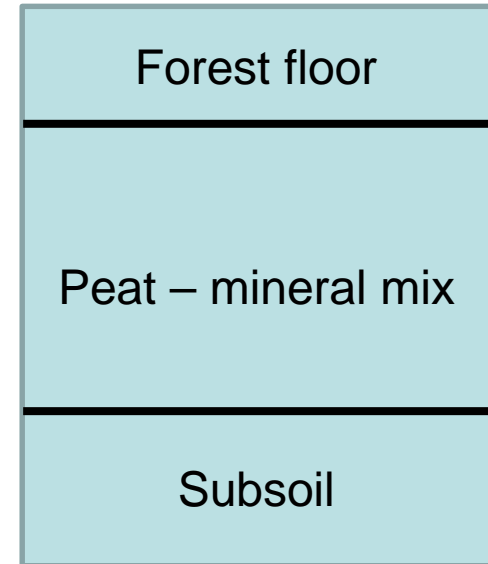
- More operational approach based on number of loads of FFMM
- Same “Island” principles hold in terms of size of islands and spacing
- Boundaries between soil types will be less “sharp” as soil will be mixed during placement



What are other potential designs?

Layering

- Base of PMM overlain with a thin layer of FFMM everywhere
- Similar to natural forest soils with organic LFH layer
- May optimize seed bank potential of FFMM by placing a higher proportion in the germination zone
- Potentially increased operational costs and compaction due to multiple passes



Management implications

- There are different ecological benefits of using different reclamation soils – both will be used in the final reclamation landscape
- Need to maximize the benefits of both soil types across the landscape
- What other spatial soil arrangements are possible?
- What plant species need extra help to establish?
- Which weed species are a true hindrance to native plants?



Thanks!



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