



Reclamation Islands – utilizing limited cover soils in oil sands mine reclamation

Brad Pinno, Ira Sherr, Ruth Errington and Krista Shea



brad.pinno@canada.ca
May 9, 2017



Natural Resources
Canada

Resources naturelles
Canada

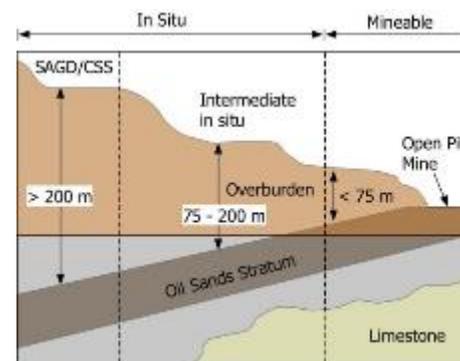
Canada

Oil Sands in Alberta

- Mining occurs where the bitumen deposit is thick and close to the surface, i.e. near the Athabasca River north of Fort McMurray
- In-situ thermal 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



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



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

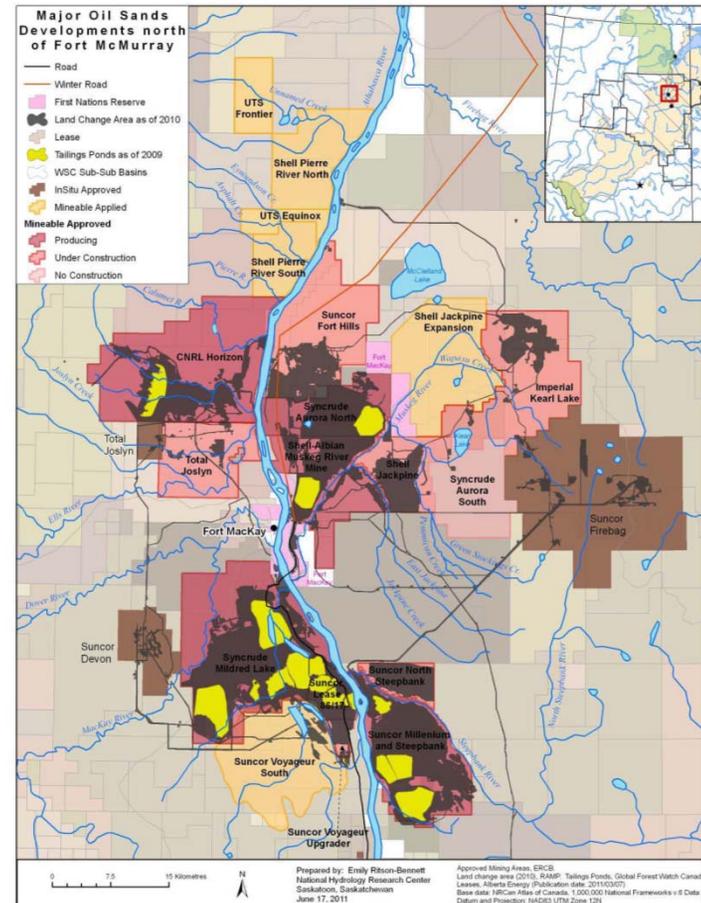


Fort McMurray Developments

- Major oil sands open pit mines and in-situ projects
- Approximately 1/4 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.



Alberta's regulatory context

- Public land
 - Provincial jurisdiction
- Requirements to reclaim but the landscape will be different
 - Equivalent land capability
 - Novel ecosystems
- Focus on ecosystem function rather than productivity
 - Locally common species

TERMS AND CONDITIONS ATTACHED TO APPROVAL



Province of Alberta

ENVIRONMENTAL PROTECTION AND
ENHANCEMENT ACT

CONSERVATION AND RECLAMATION
REGULATION

Guidelines for
Reclamation
to Forest Vegetation in the
Athabasca Oil Sands Region



Mineral Resources
Canada

Ressources minérales
Canada

Canada

Natural landscape

- Boreal forest on the interior plains
- Half uplands, half wetland bogs and fens
- Borderline sub-arctic climate
- Moisture limited environment (455 mm)
- Soil storage dominates the water cycle



Sedge dominated fen



Tamarack and black spruce bog



Aspen-spruce mixedwood on mesic sites



Jack pine on xeric sites



Oil sands upland reclamation

- Tailings sand or overburden dumps are contoured and then capped with suitable cover soil material
 - Peat-mineral mix (PMM)
 - Forest floor-mineral mix (FFMM)

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?



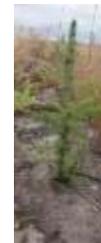
Reclamation in progress

Forest floor – mineral mix being spread on top of overburden

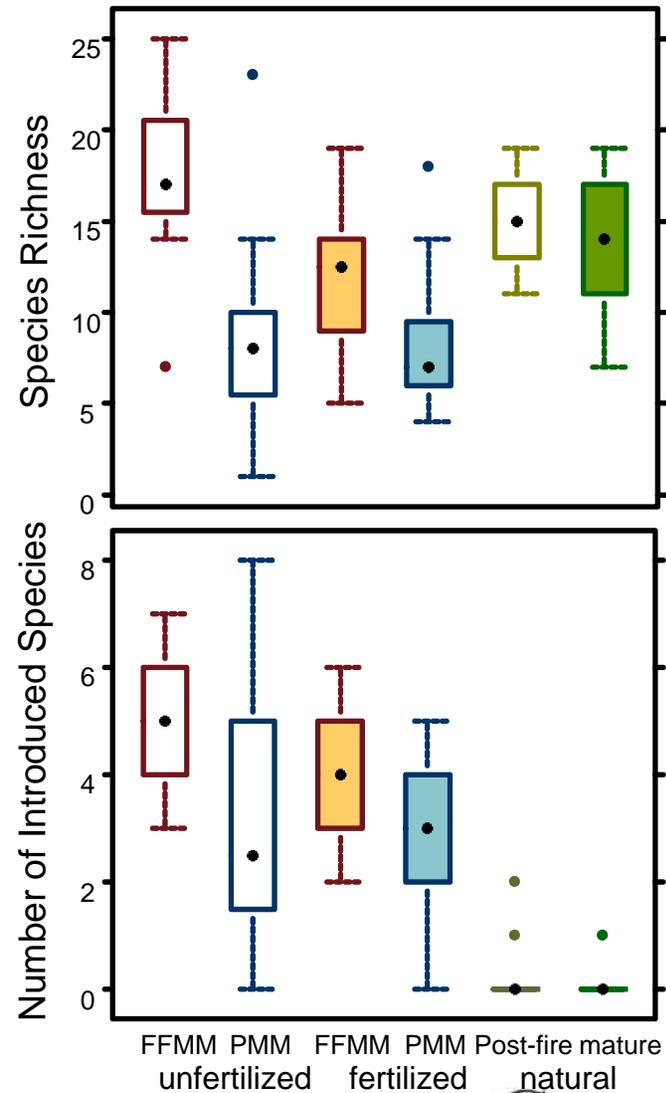
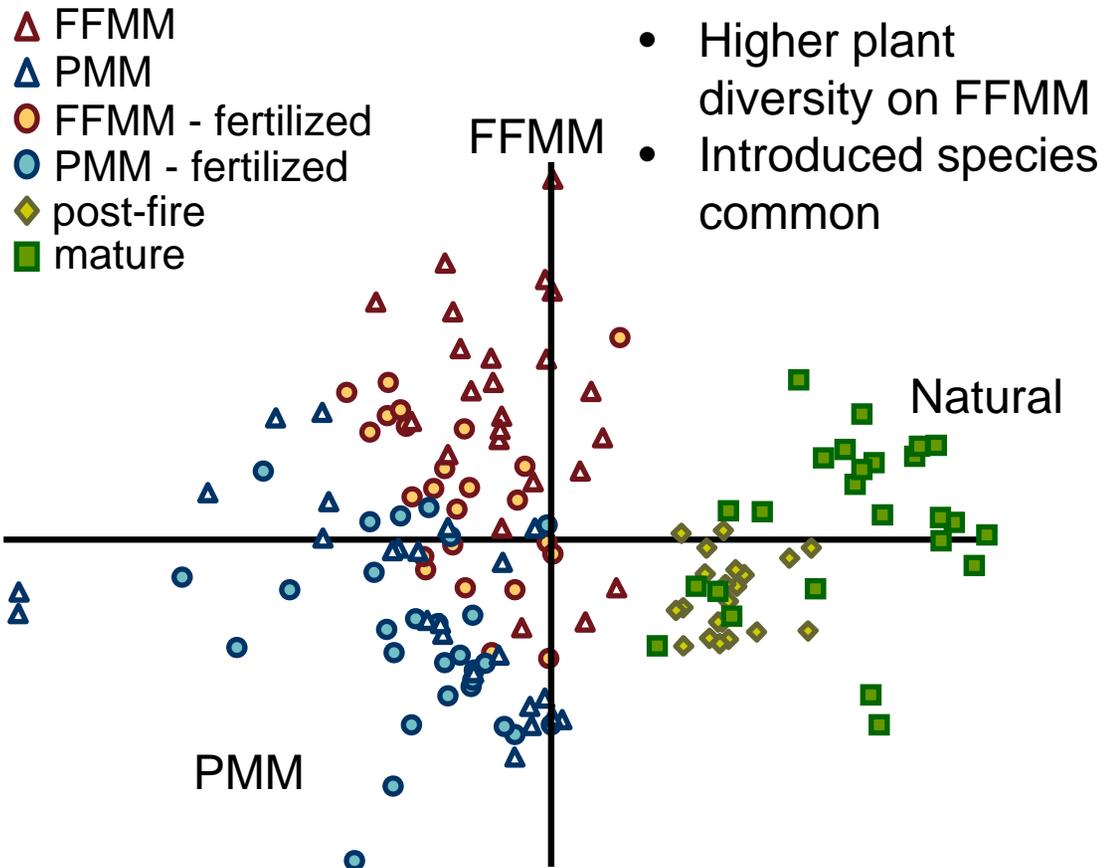


Past Reclamation

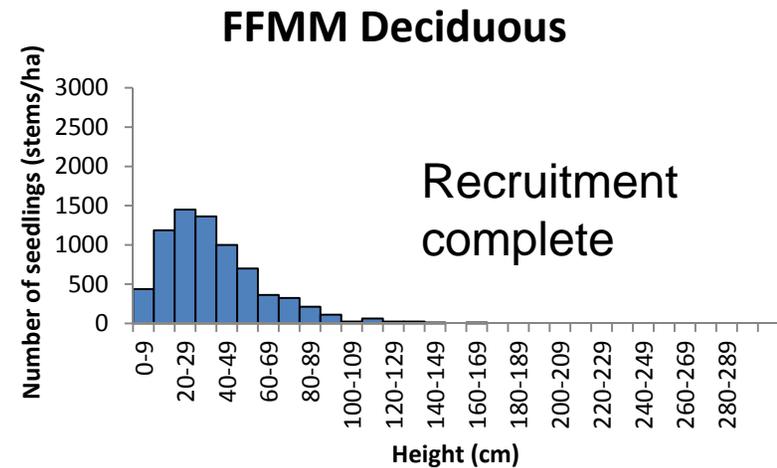
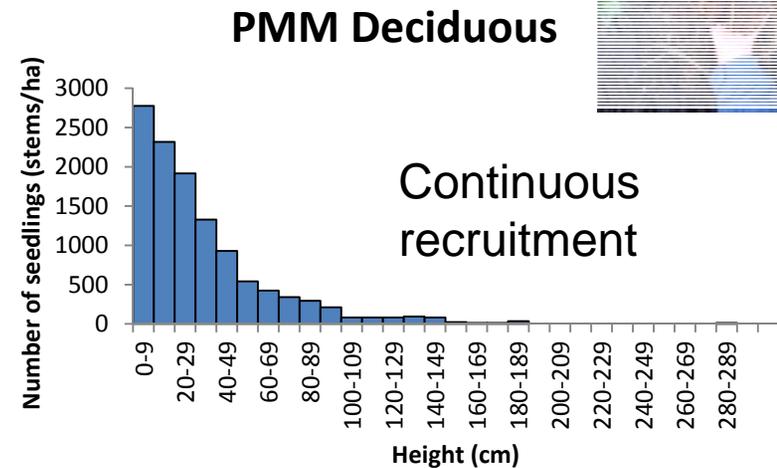
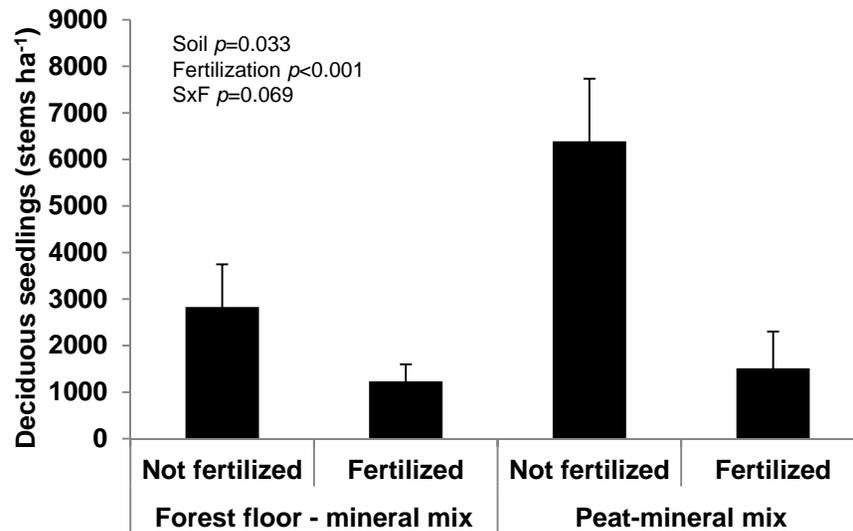
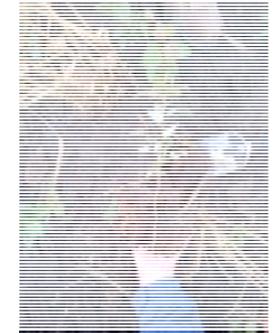
- RA1 (Reclamation area #1)
 - 88 ha overburden dump established in 2011
 - Large directly placed soil patches, ~ 20 ha each
 - 2 soil types x fertilization x CWD
 - PMM – Peat-mineral mix
 - FFMM – Forest floor-mineral mix
 - Studies on plant community, tree establishment and productivity, soil nutrients 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

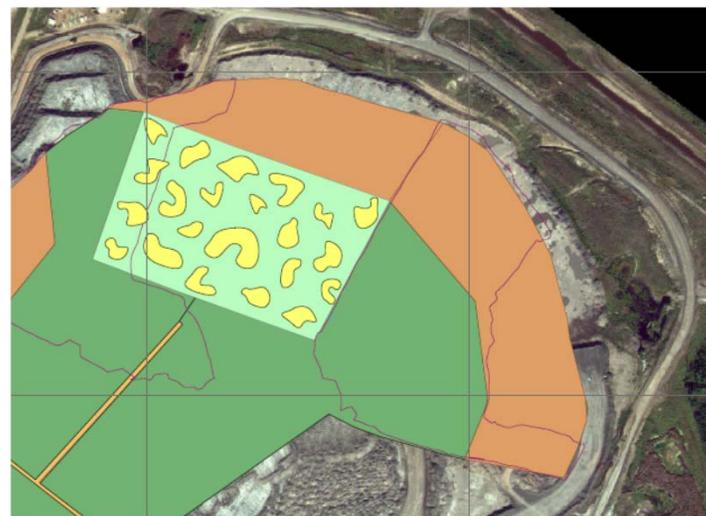


PMM with higher tree density



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

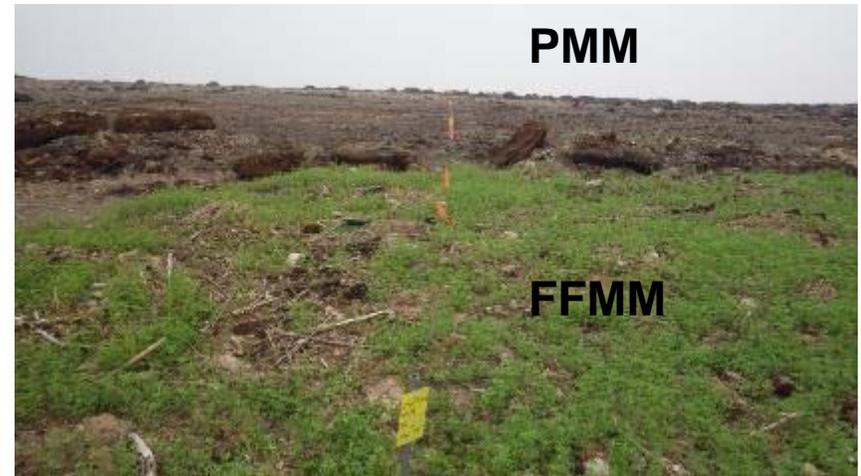


Islands of green FFMM within PMM matrix



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

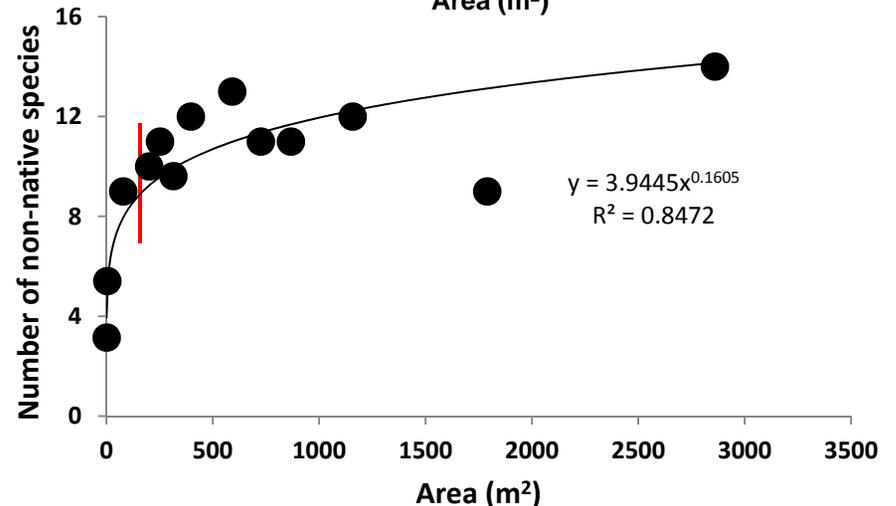
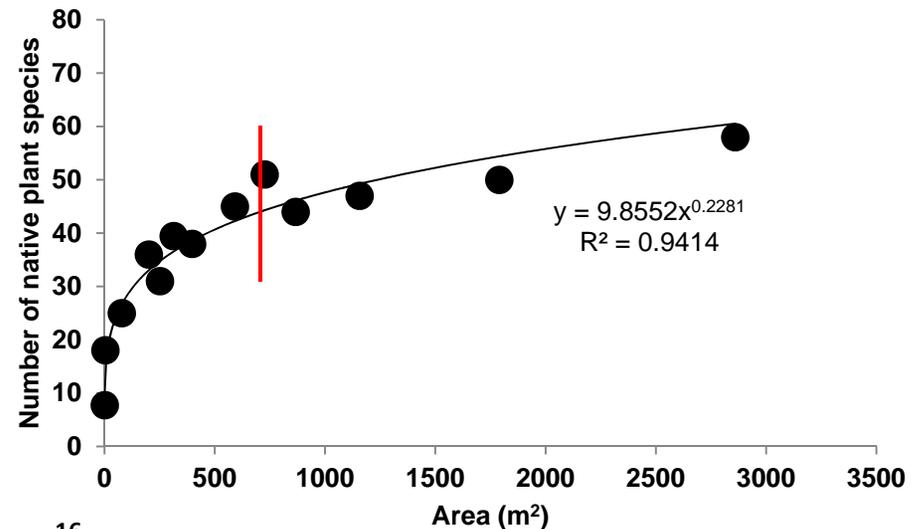


How big should patches be?

- 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)

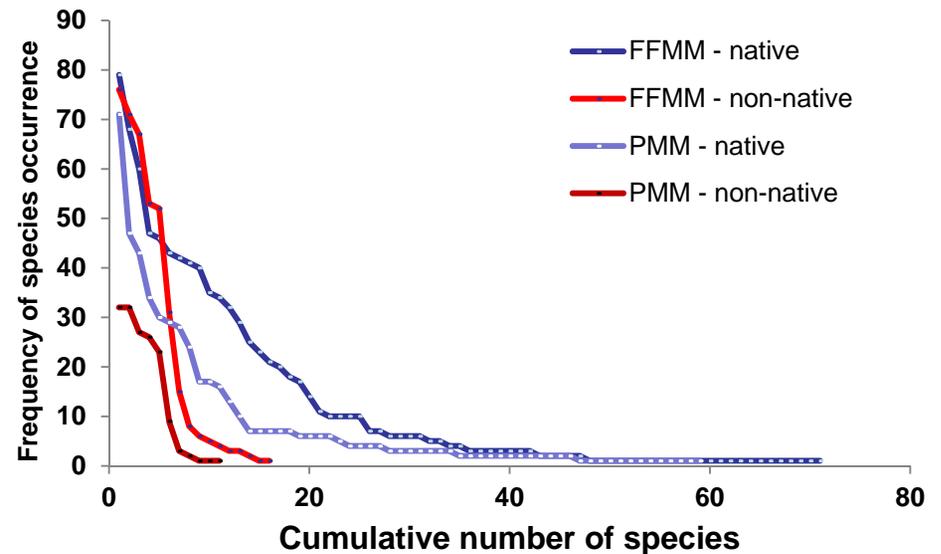


FFMM soil island being placed in the winter.



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



Where are plants coming from?

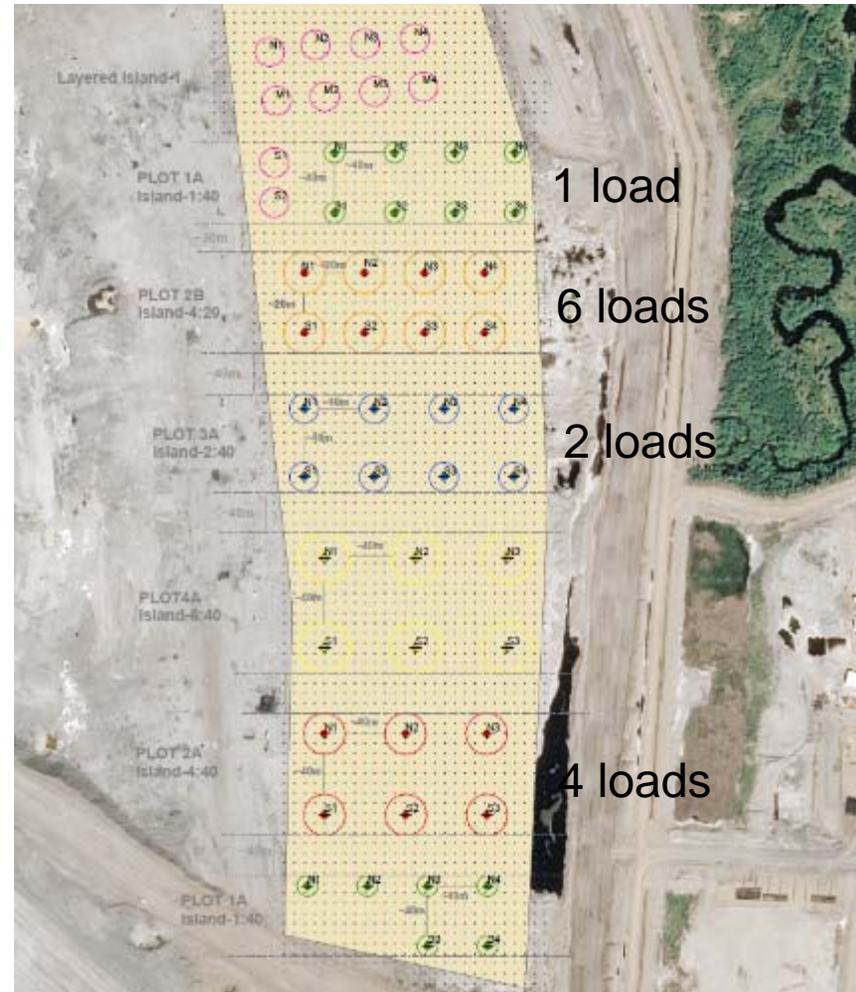
- Seedbank from FFMM placed during reclamation operations?
 - Soil cores from natural forests and from directly placed reclamation material.
- Seeding in from offsite?
 - Seed traps placed across soil type boundary.
- Vegetative expansion?
- Germinating in greenhouse to determine species and abundance.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



What are other potential designs?

Operational Islands

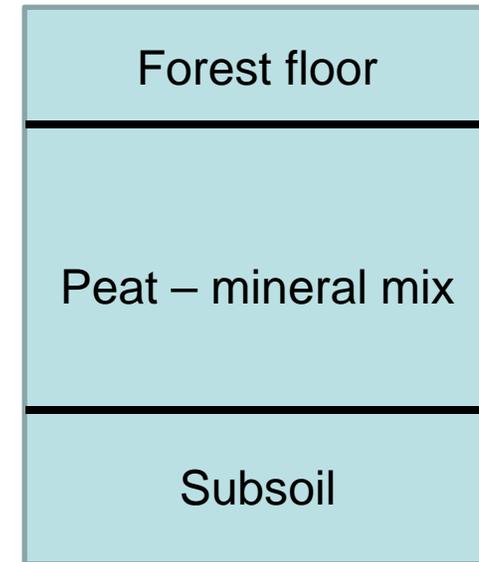
- More operational approach based on number of loads of FFMM
- Same “Island” principles hold in terms of size of islands and spacing
- Boundaries between soil types will be less “sharp” as soil will be mixed during placement



What are other potential designs?

Layering

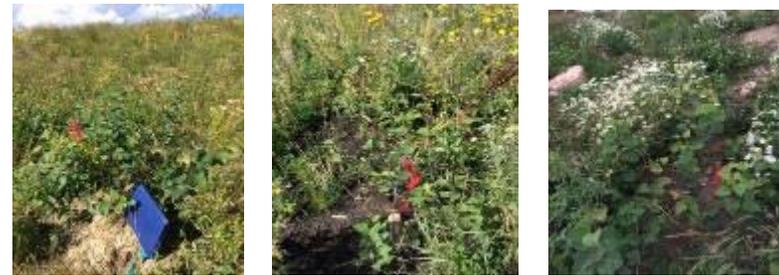
- Base of PMM overlain with a thin layer of FFMM everywhere
- Similar to natural forest soils with organic LFH layer
- May optimize seed bank potential of FFMM by placing a higher proportion in the germination zone
- Potentially increased operational costs and compaction due to multiple passes



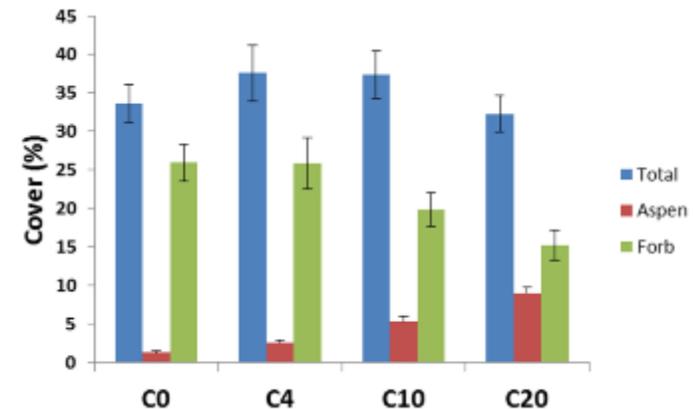
What are other potential designs?

Cluster Planting

- Soil type may be the same but can create spatial diversity by planting trees in clusters
- Clusters favour the development of tree canopy cover while helping to control competing understory vegetation
- Clusters could support forest vegetation sooner and serve as a colonization centre



Cluster of 4, 10 and 20 aspen seedlings



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?
- How does topography interact with soil to create reclamation ecosites?
- What plant species need extra help to establish?



Thanks!



Ministère des Ressources
Canada

Recursos Naturales
Canada

Canada