

Patterns of tree and plant community development on a reclaimed oil sands mine site

Brad Pinno, Abigail Lewis and Ruth Errington

bpinno@nrcan.gc.ca

June 18, 2014



Natural Resources
Canada

Ressources naturelles
Canada



Canadian Natural

Canada 

Oil sands mine developments

- Oil sands mines in northern Alberta have currently disturbed 70,000 ha (170,000 acres) of boreal forest which is about 1/6 of what the total disturbance will be
- Boreal mixedwood ecoregion with upland forest of trembling aspen and white spruce mixedwoods
- Massive fire in 2011 burned part of the oil sands leases. We have incorporated this natural disturbance into our research design.



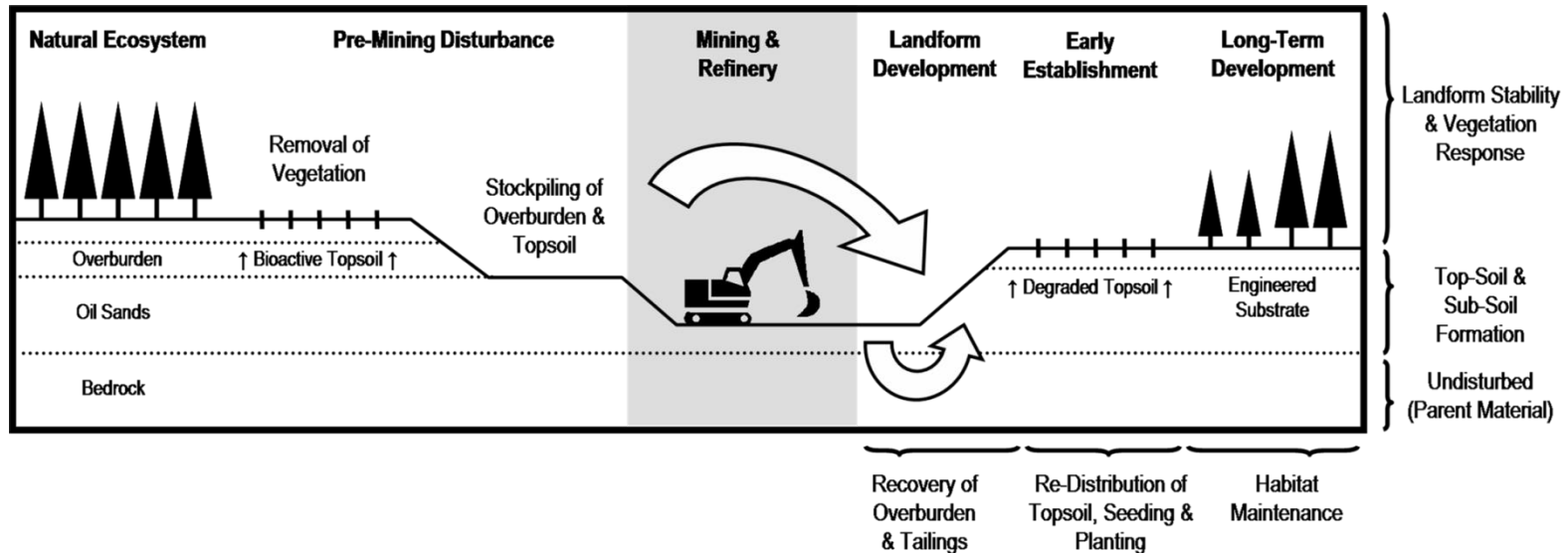
Note: 1 km² = 1 square kilometre = 0.39 square miles



- 6 active mines north of Fort McMurray
- Combined with other energy developments (i.e. in-situ extraction) and forestry make this a heavily disturbed landscape
- This project is based at the CNRL Horizon mine site



Oil sands reclamation



- Main cover soils used in reclamation consist of upland forest floor or wetland peat mixed with mineral soils
- One of the goals of reclamation is to re-establish native boreal plant communities

Study design

- 84 ha saline-sodic overburden dump
- 0.5 m of cover soil (FFMM or PMM) over 1.5 m of subsoil
- 4 reclamation treatments
 - 2 soil x 2 fertilizer
 - FFMM = forest floor – mineral mix
 - PMM = peat – mineral mix
- 2 natural comparison
 - Burned and mature
- Main response variables were tree seedling regeneration and plant species cover
- Comparison among reclamation treatments and to nearby natural forests 3 years after reclamation



Reclaimed area



Burned forest

Reference Condition Approach

- Response variables
- Environmental drivers

Mature forest



- End goal is to have a functioning forest ecosystem similar to current mature forests.
- More meaningful comparison is to compare reclaimed and naturally disturbed ecosystems to predict if reclaimed ecosystems are on the correct successional trajectory.



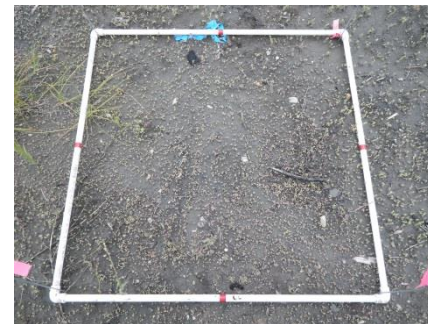
Trembling aspen

- Naturally regenerates from root suckers after disturbance
- Seedlings typically uncommon BUT lots of seedlings after some disturbances including reclamation
- Planting aspen can be challenging and expensive
- What reclamation treatments and environmental conditions optimize potential seedling establishment?



Plant Community

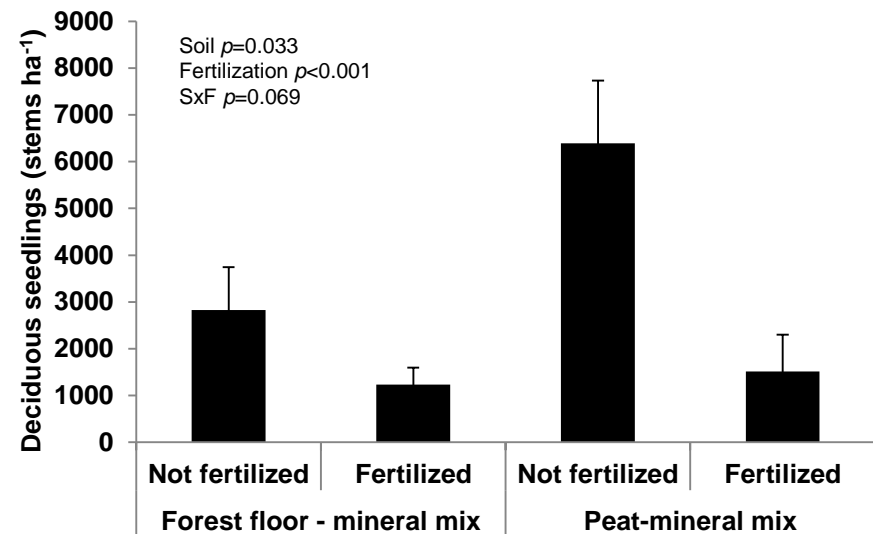
- Reclamation soils have differing characteristics which impact future plant communities
- Fertilization applications may also have an impact
- Compare reclamation treatments to each other and natural stands
- Expanding to look at specific species and plant interactions



Aspen regeneration

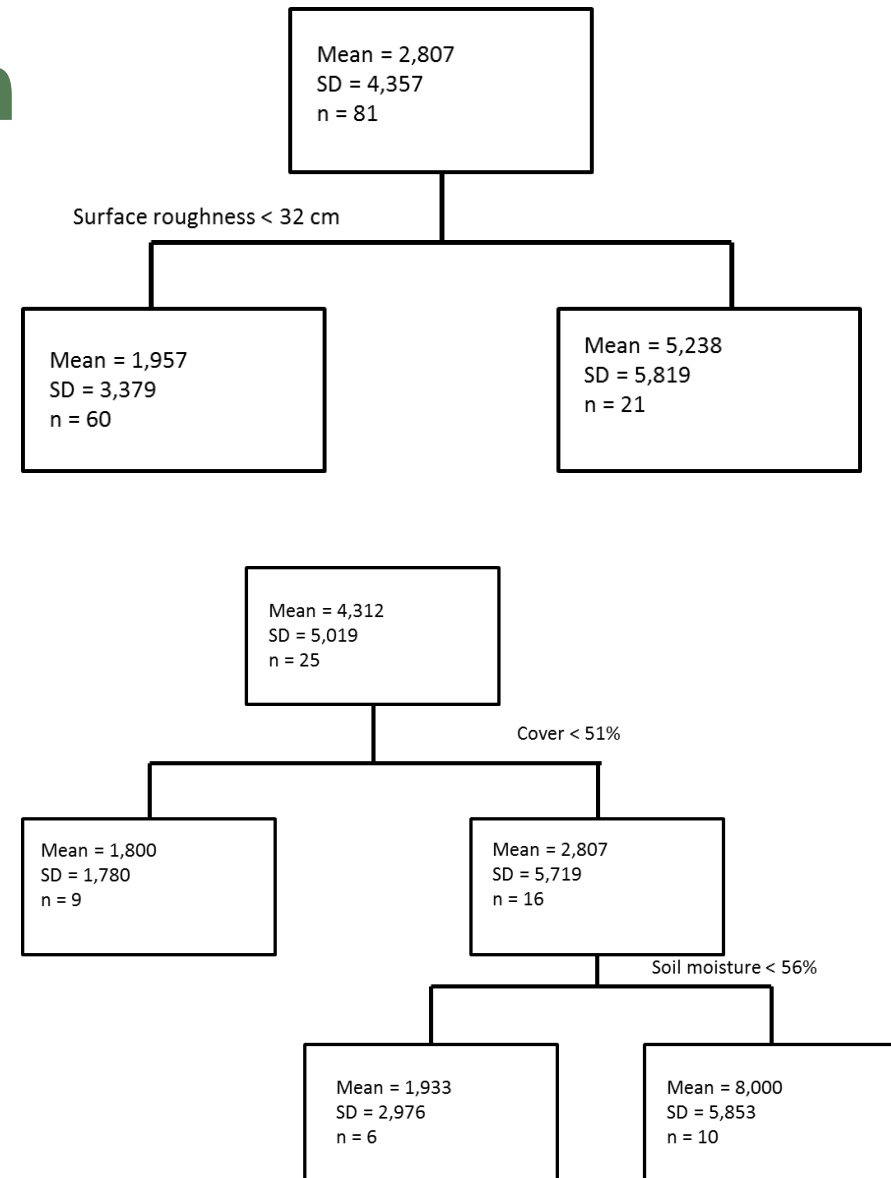
- Seedling regeneration on reclaimed areas
- Most seedlings on unfertilized PMM
- Fertilizer reduced regeneration
- Compare to burnt stands with 80,000 aspen suckers / ha
- In unfertilized areas, 82% of PMM plots > 2,000 sph compared to 43% for FFMM
- Can start to put probabilities of regeneration success on reclamation prescriptions

Trembling aspen seedlings



Aspen regeneration

- Surface roughness increases natural seedling establishment
- Excessive competition and soil moisture were both negatively related to seedling establishment
- Microsite variables (i.e. concavity, substrate, slope) were not related to seedling regeneration – seedling establishment was proportional to microsite availability



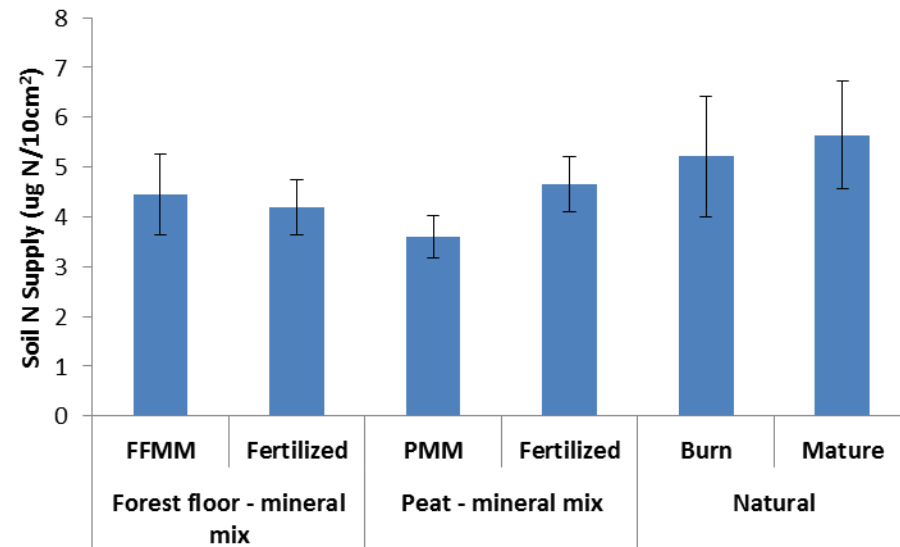
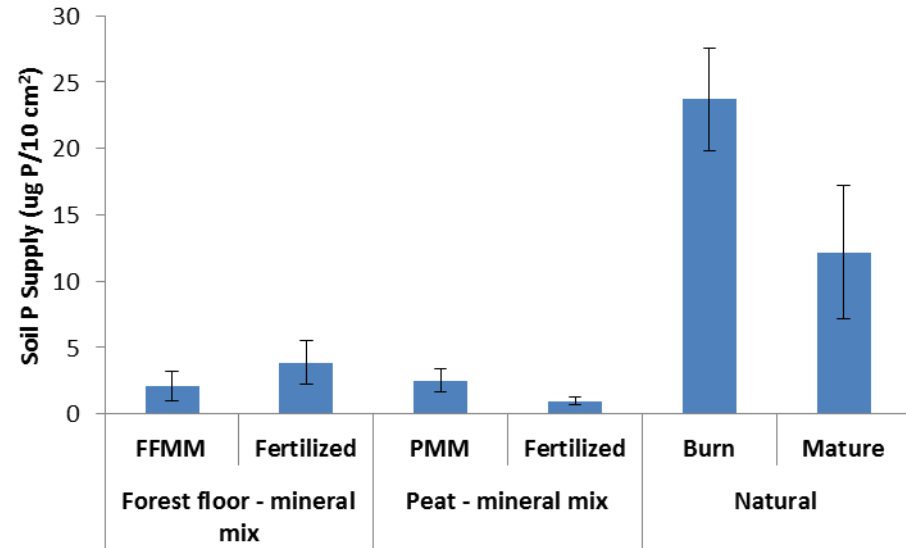
Aspen growth

- Growth rates similar among treatments, biggest impact was on regeneration density
- Average height after 3 years was 23 cm (range 2 – 160 cm)
- Average height of sucker regeneration post-fire was 164 cm



Soil Nutrients

- Soil P supply much higher in natural forests
- What does this mean for tree productivity or plant community diversity?
- Soil N supply did not change among any soil types
- No lasting legacy of fertilization
- Fertilization did not increase tree growth.
- Need to rethink high N fertilization?



Plant community composition



Forest species

Grasses



Low cover

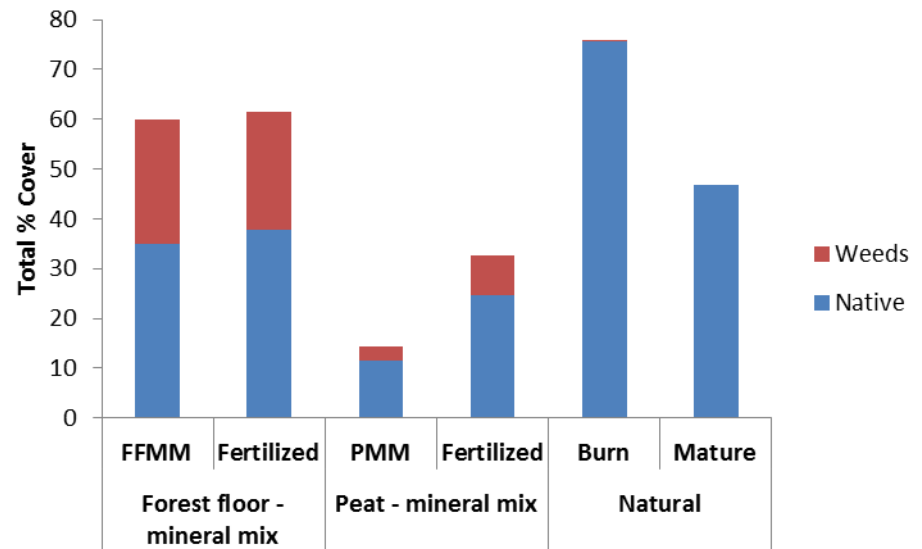
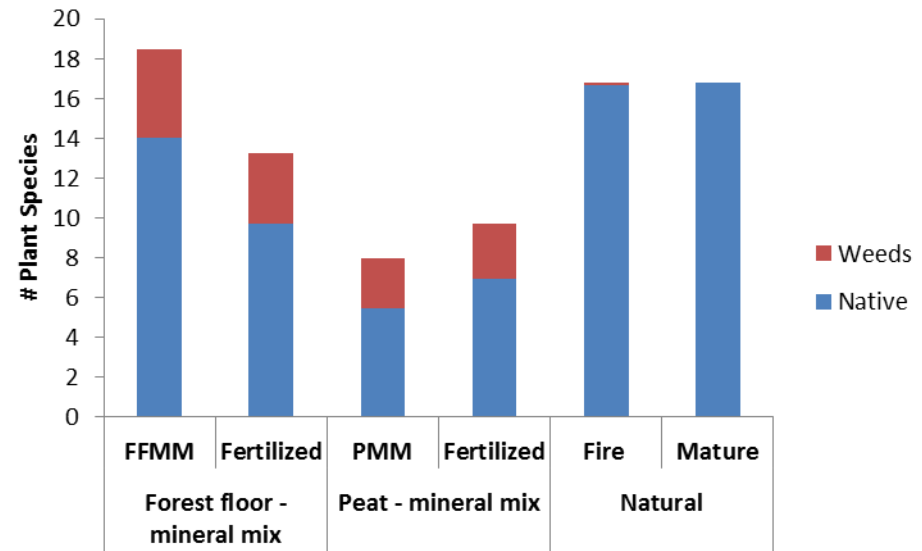
Weeds

- Which reclamation treatments are most similar to the burned forest?
- What factors control plant community composition on reclaimed sites?
- What are the successional trajectories of the different reclamation plant communities?



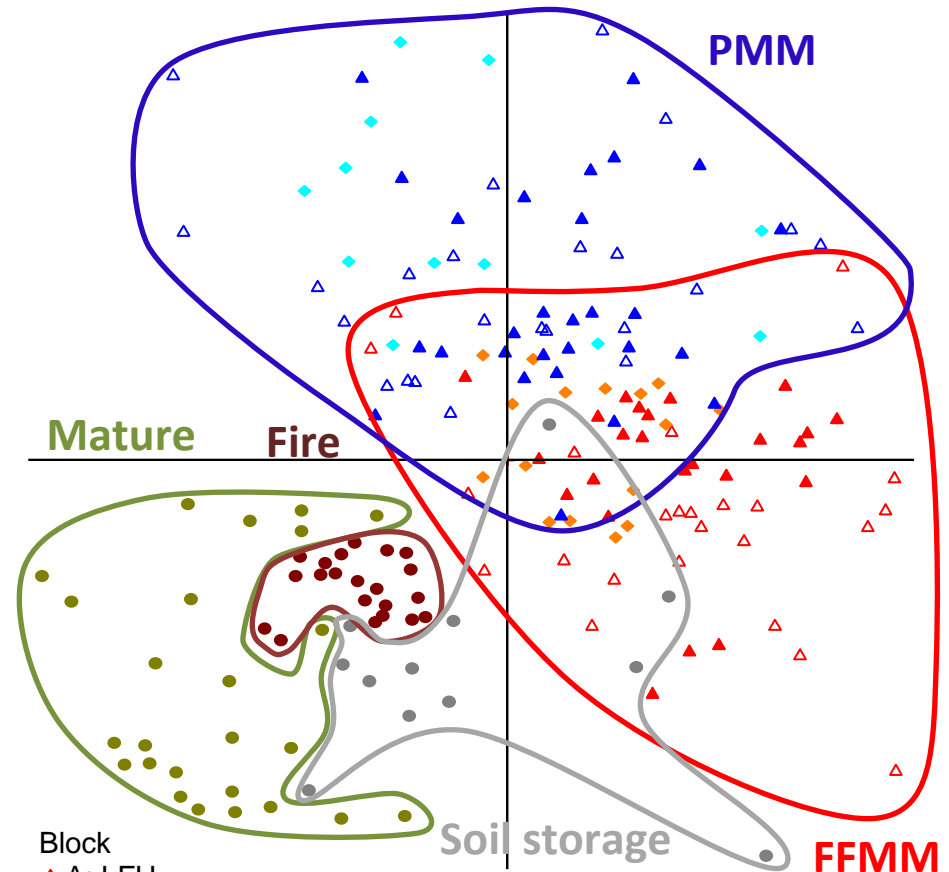
Species Richness

- Similar number of species in Natural and FFMM
 - No weeds in natural forests
- More native species in FFMM compared to PMM
 - Source of propagules important
- Fertilization decreases native species in FFMM but not PMM
- Fertilization increased cover in PMM but not FFMM



Plant community composition

- Reclamation distinct from natural stands
- Little variability in burned forest – how is variability going to change over time
- FFMM appears to have a more similar plant community to the natural stands than the PMM
- Soil storage area (10 year old soil dump) bridges the reclaimed and natural stands
- Fertilization tends to homogenize the reclaimed plant community
- Disturbance and soil type are the largest controllers of plant community composition

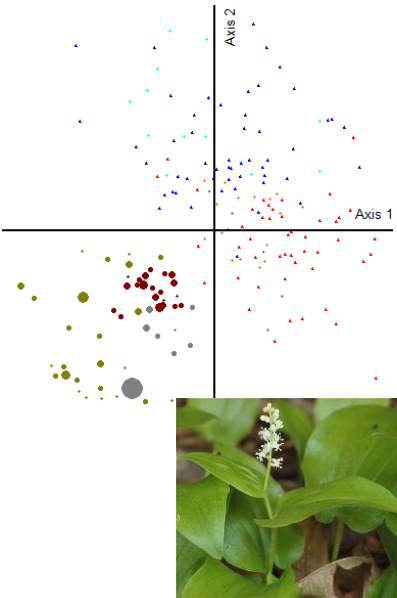


- Block
- △ A: LFH
 - △ B: PMM
 - ◇ C: LFH, Fert, Debris
 - △ D: LFH, Fert
 - ◇ E: PMM, Fert, Debris
 - △ F: PMM, Fert
 - G: Fire
 - H: Mature
 - T: Topsoil



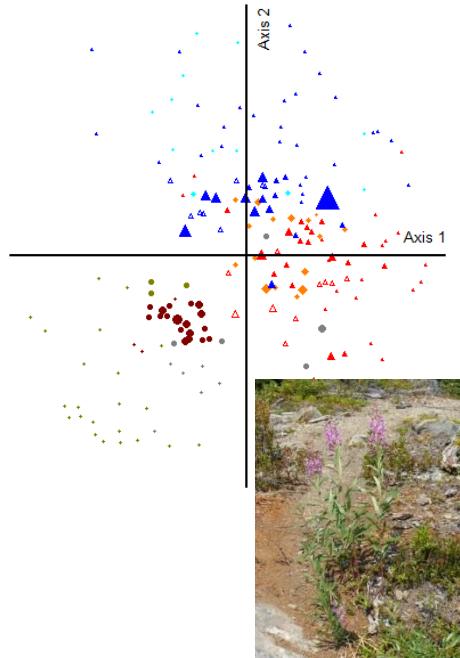
Species groups

Maianthemum canadense
Wild lily of the valley



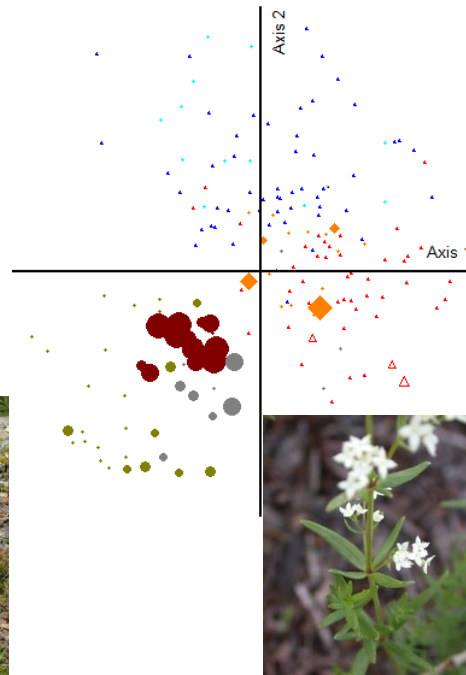
Native boreal plant species commonly found in natural stands but not in reclaimed stands.

Chamerion angustifolium
Fireweed



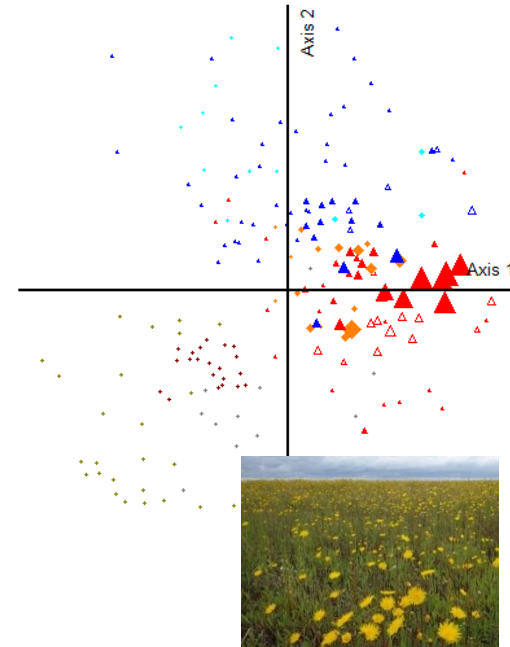
Native boreal species found in all disturbed areas.

Galium boreale
Northern bedstraw



Native boreal species found in natural and FFMM. Biological legacy of the forest floor.

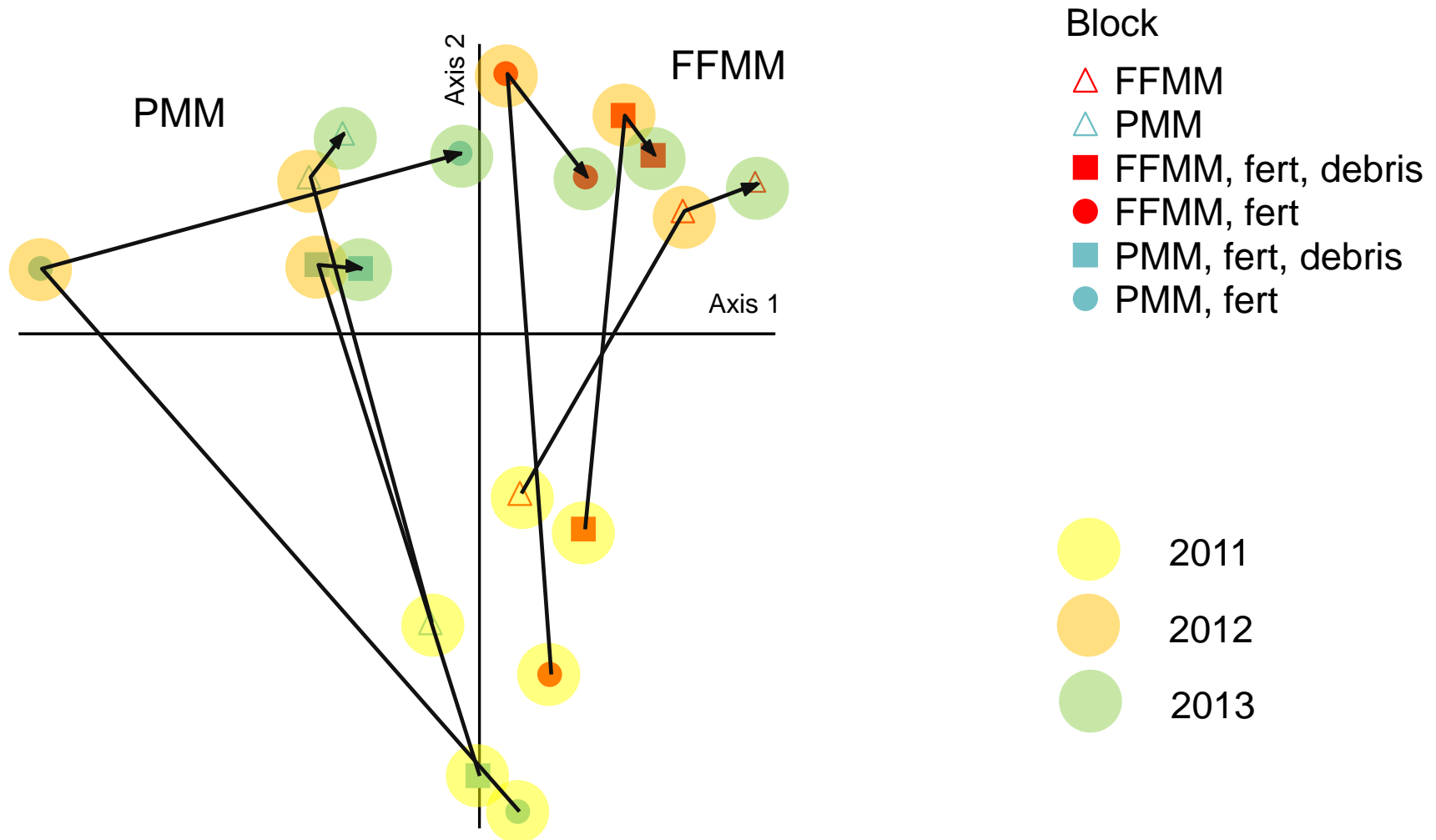
Sonchus arvensis
Perennial sow thistle



Weed species found only in reclaimed areas, particularly when fertilized.



Plant community through time





Forest floor – mineral mix

Peat – mineral mix



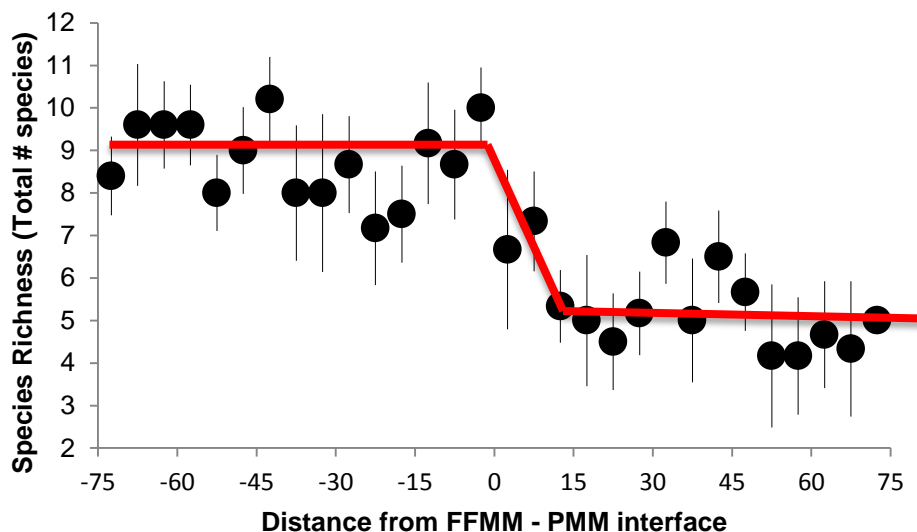
Natural Resources
Canada

Ressources naturelles
Canada

Canada

FFMM – PMM interface

- Series of transects across the FFMM – PMM interface
- Distinct species richness profiles for each soil type
- Transitional area between soil types?
- Extra species in the transitional area are forest floor species such as strawberry
- Will species from the FFMM colonize the PMM?



Management Implications

- Initial reclaimed plant communities are different than naturally regenerating stands
- Forest floor – mineral mix is more similar in species composition to natural stands than peat – mineral mix, likely due to the stored seed bank
- Natural aspen seedling regeneration and growth potential can be maximized by using peat-mineral mix and increasing the surface roughness
- Fertilization does not enhance native species diversity or tree establishment
- Can PMM and FFMM be combined spatially to maximize the benefits of each?



Thanks!



Natural Resources
Canada

Ressources naturelles
Canada

Canada