Upland forest development in a reconstructed watershed after oil sands mining in northern Alberta, Canada

Brad Pinno, Fran Leishman, Ruth Errington, Morgane Merlin and Simon Landhäusser

Canadian Forest Service
brad.pinno@canada.ca
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UNIVERSITY OF ALBERTA

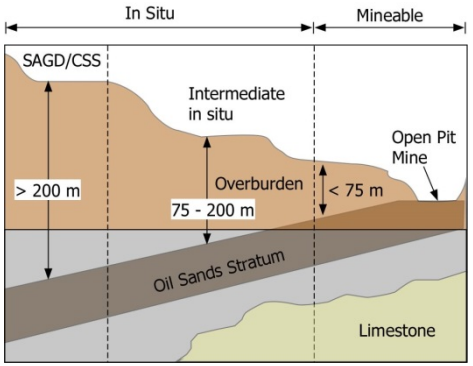
Syncrude

Canada

Oil Sands in Alberta

- Oil sands are in 3 main deposits in Alberta
- Mining used north of Fort McMurray, in-situ extraction used everywhere else
- Mining occurs where the oil deposit is thick and close to the surface, i.e. near the Athabasca River north of Fort McMurray
- Most of the rest of Alberta is underlain by conventional oil and gas deposits
- The cumulative impacts of oil & gas development, forestry, agriculture, recreation, other human uses and natural disturbances are very significant in Alberta

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



Mines are where overburden is shallow.

Alberta's regulatory context

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

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

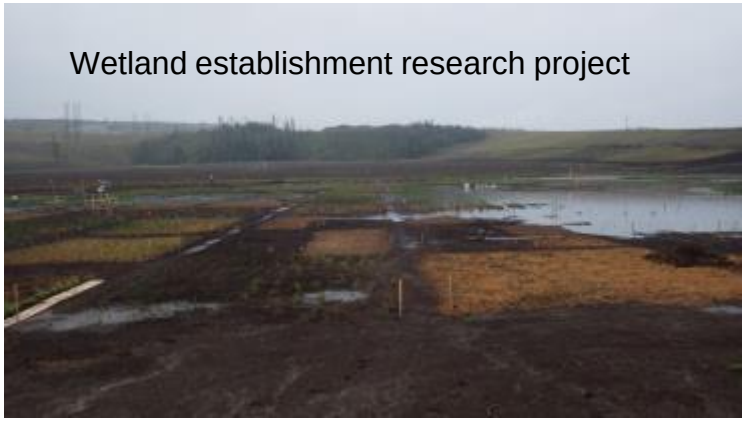
Aspen-spruce mixedwood on mesic sites

Jack pine on xeric sites

Reclaimed watersheds

- Priority for future reclamation is integrated upland – wetland watersheds
- Research in natural forests has highlighted the importance of wetlands for upland forest growth
- Reclaimed landscape will have more uplands and ponds but fewer bogs/fens than original landscape
- How is water partitioned between uplands and wetlands in this dry environment?

Natural lake surrounded by reclaimed forest

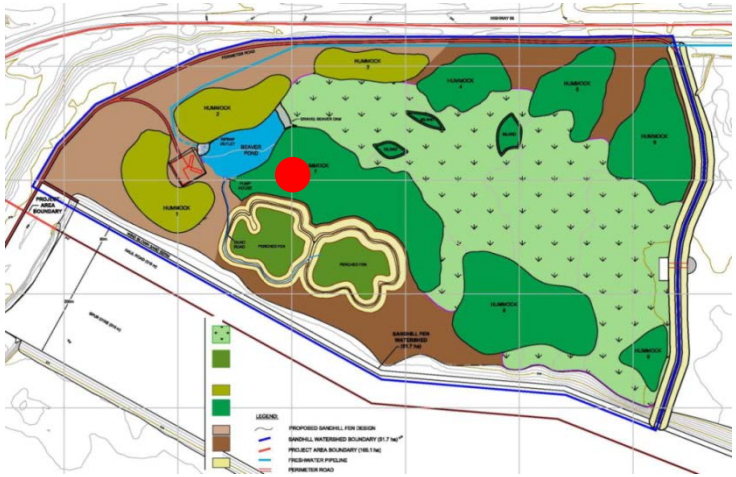


Wetland establishment research project

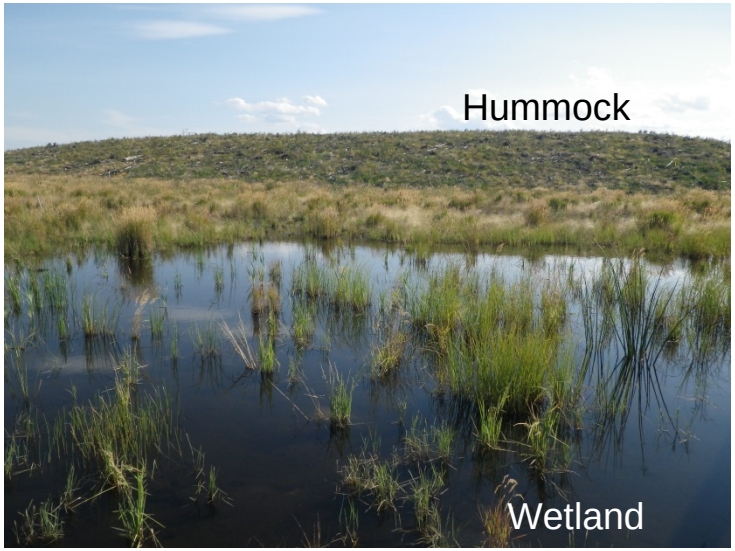
The same volunteer wetland 1 and 4 growing seasons after reclamation. These micro-wetlands form due to reclamation material subsidence and may be critical landscape features for keeping water on reclaimed areas.

Sandhill Fen Watershed

- Reconstructed wetland – upland watershed
- 50 ha in total size
- Old mine pit filled with tailings sand
- Hummocks to create uplands, wetland in lower areas
- Hummocks capped with salvaged forest soils



- Goal is to create a functioning upland-wetland ecosystem
- Linkages between the uplands and wetland portions
- Integrated research project but focus here on the upland forest



2011 - Construction

Photo from Syncrude


2013
Photo from Syncrude

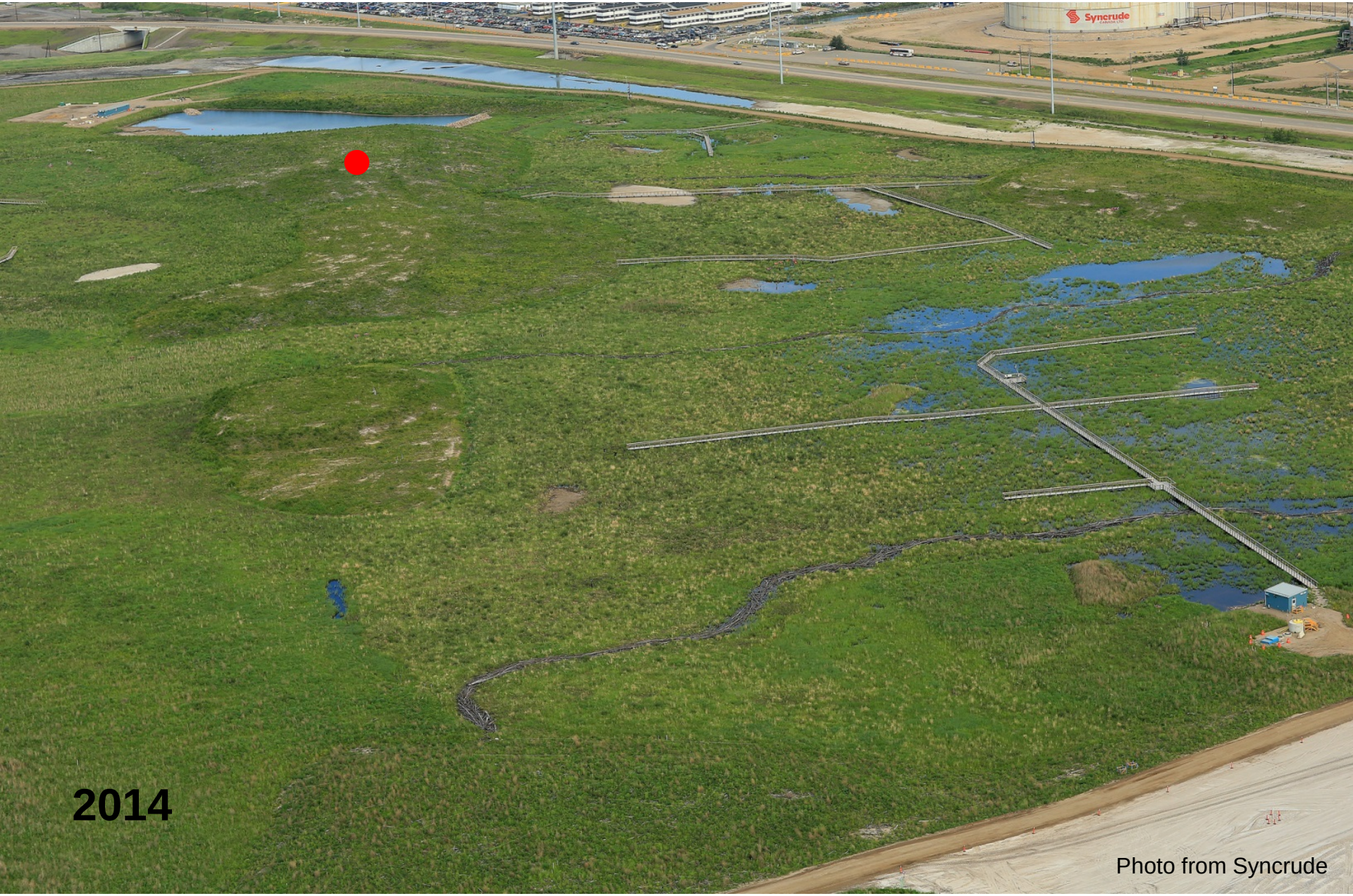


Photo from Syncrude

Upland vegetation study

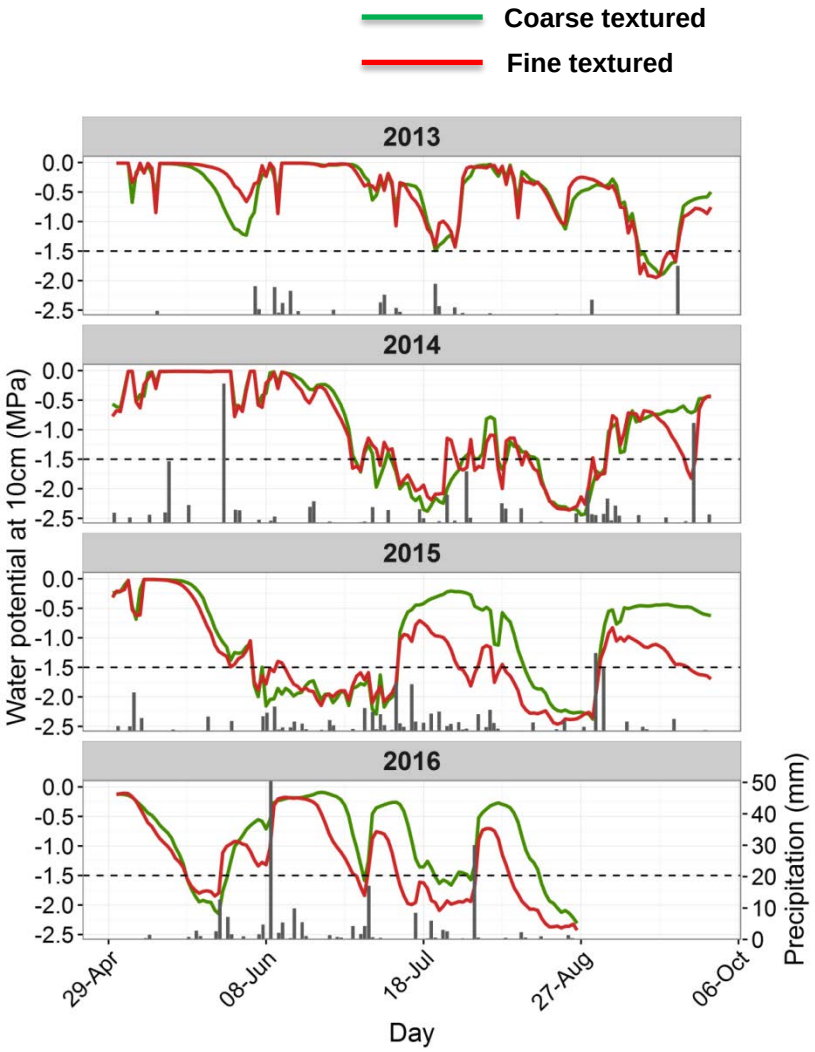
- 2 soil types
  - coarse and fine textured
- 2 main tree species
  - Trembling aspen and jack pine
- 3 planting densities
  - 0, 5,000, and 10,000 sph

- Environmental variables
- Tree growth
- Understory development

Soil water potential

- No difference between soils early on
- Soil moisture closely follows precipitation
- As vegetation develops the fine textured soil becomes progressively drier

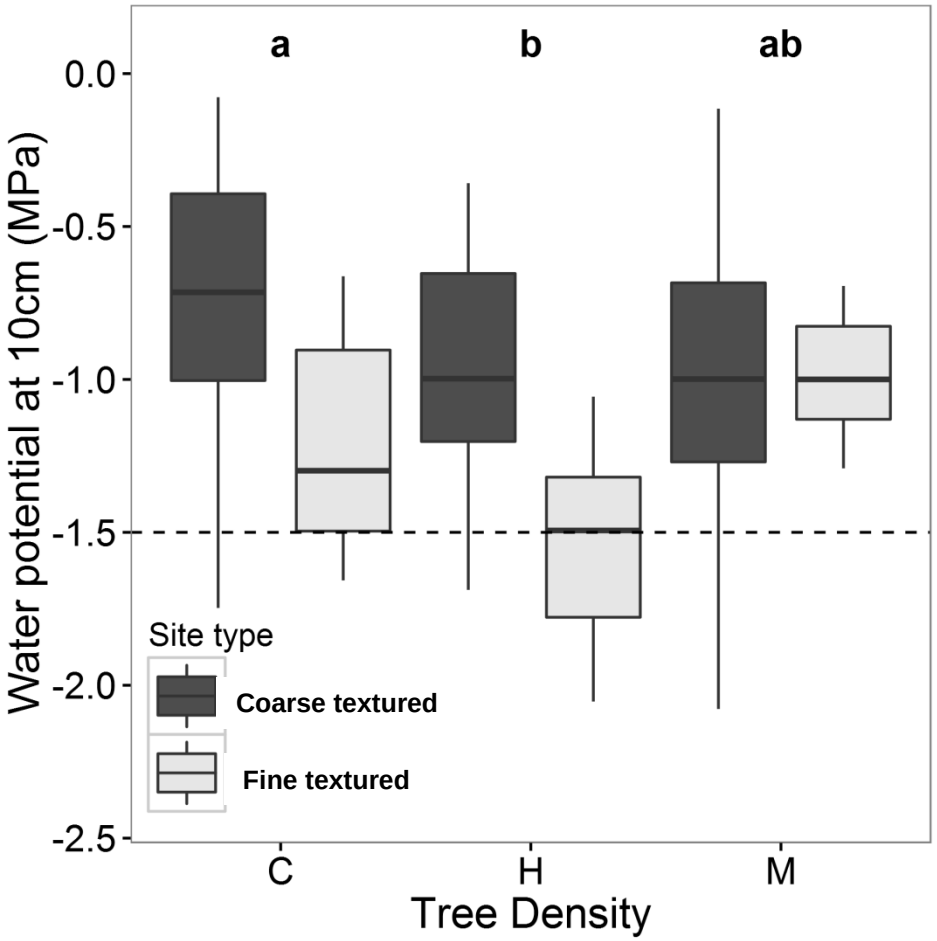
Reconstructed soil profile with water potential sensors



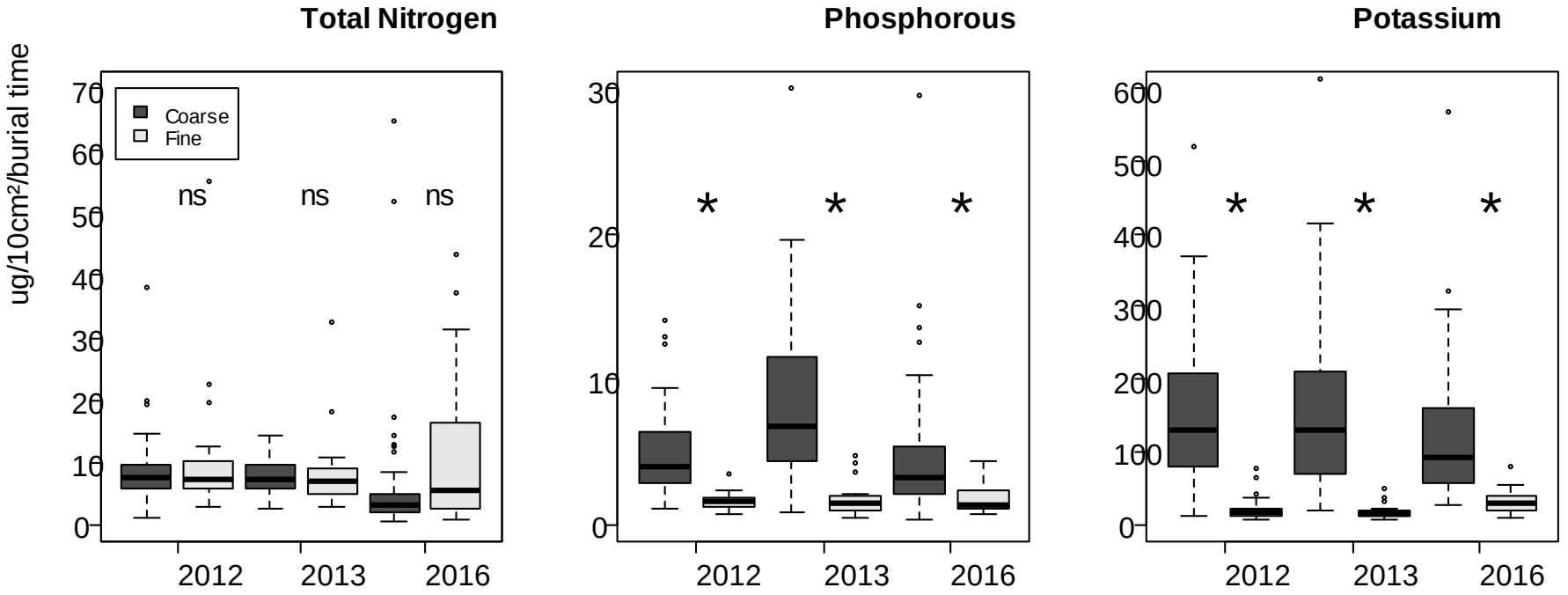
Tree density and water

- High tree density results in lower water potential
- Longer term implications of how much leaf area these sites can support

Medium density pine in the foreground, high density in the back



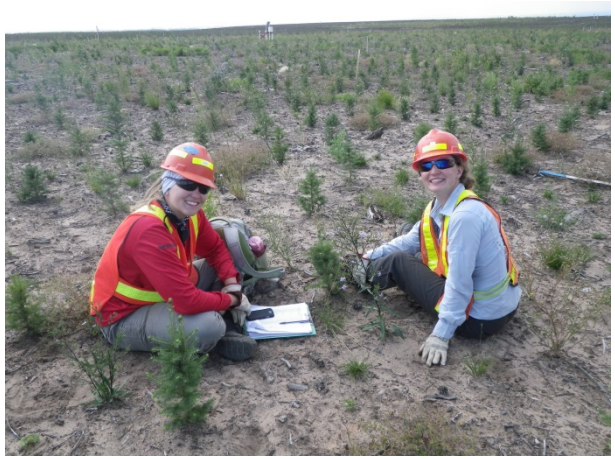
Soil nutrient supply



- Lower availability of P and K in the fine textured soils
- Inorganic nitrogen did not vary over time or by soil

Trees

- Trembling aspen and jack pine
- 0, 5,000, and 10,000 sph planting densities
- Growth and water use

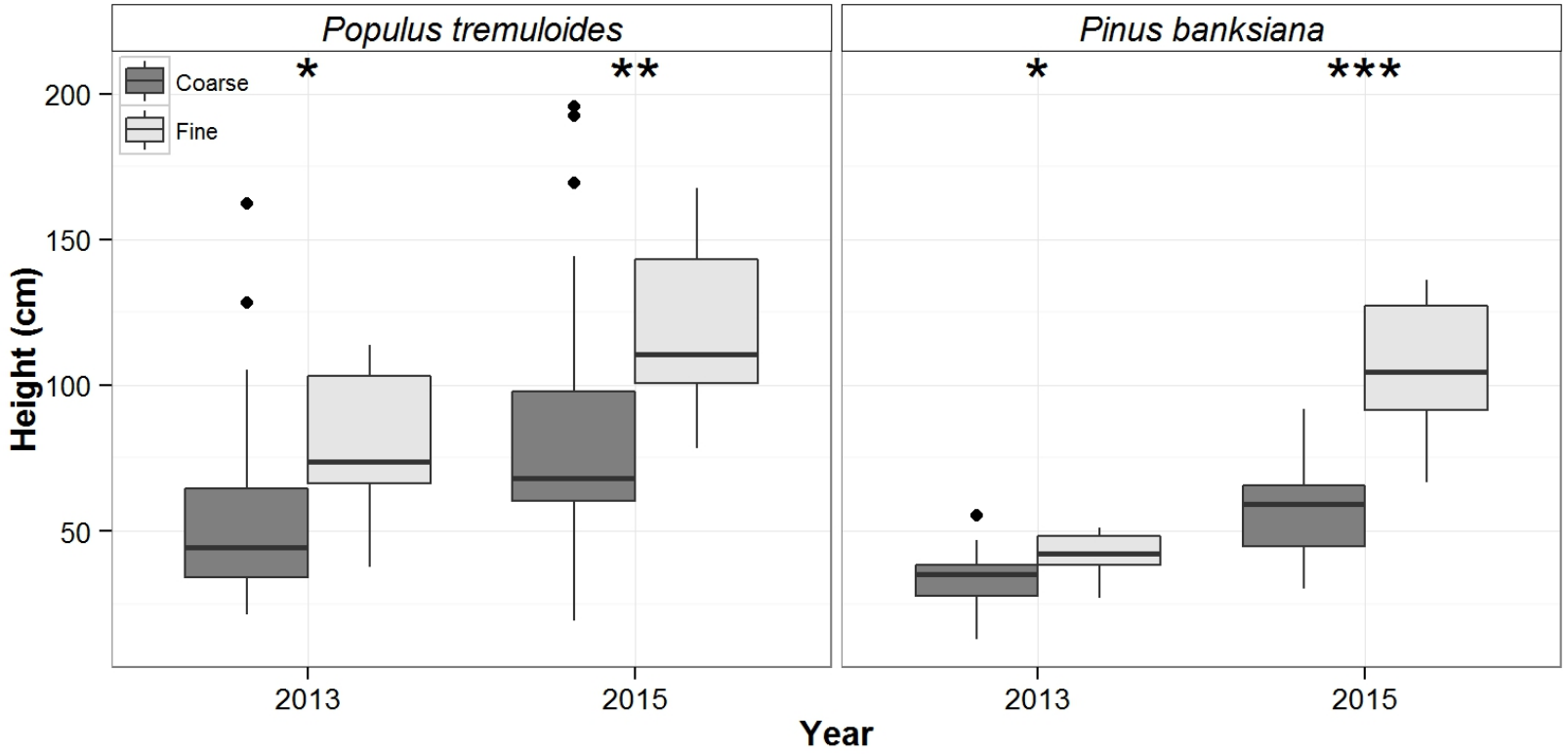


High density jack pine planting after year 1 and year 5

Trembling aspen

Jack pine

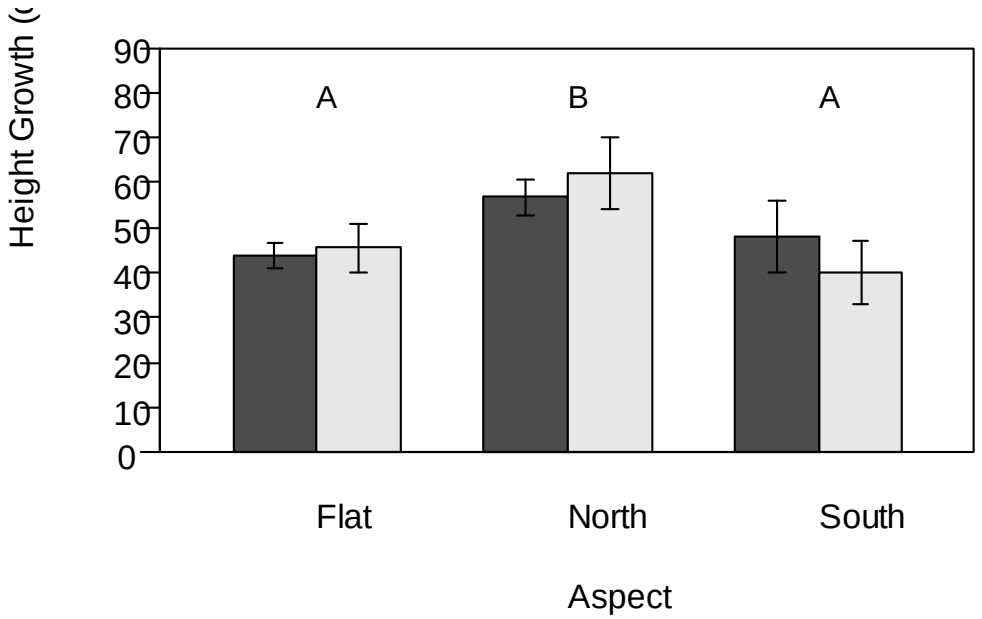
Tree growth



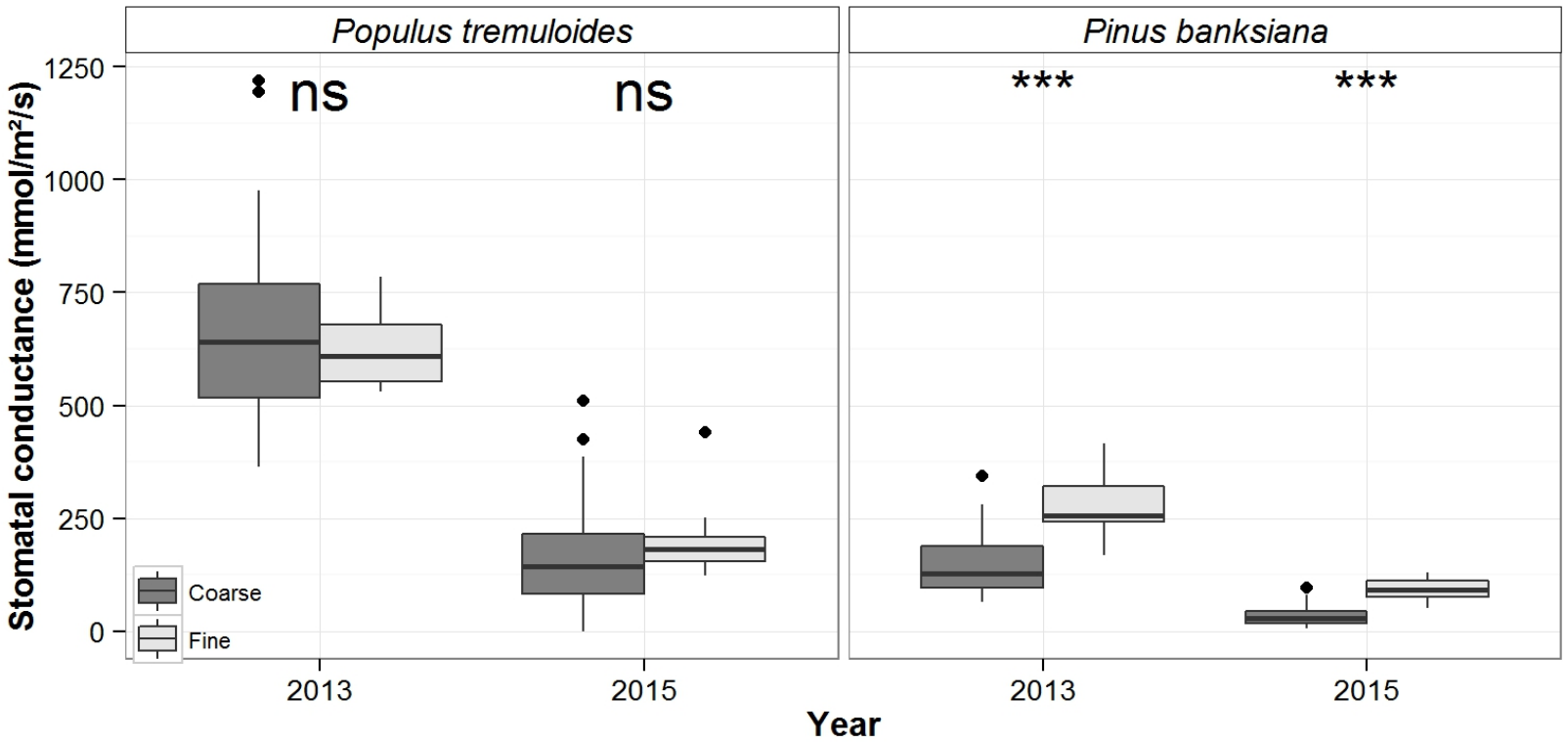
- Greater growth on fine textured soils, difference becoming greater over time
- Trembling aspen has more variable growth

Pine growth varies with aspect

- Pine larger on north facing plots
  - Cooler and wetter sites
- Aspen growth not influenced by aspect or planting density at this time

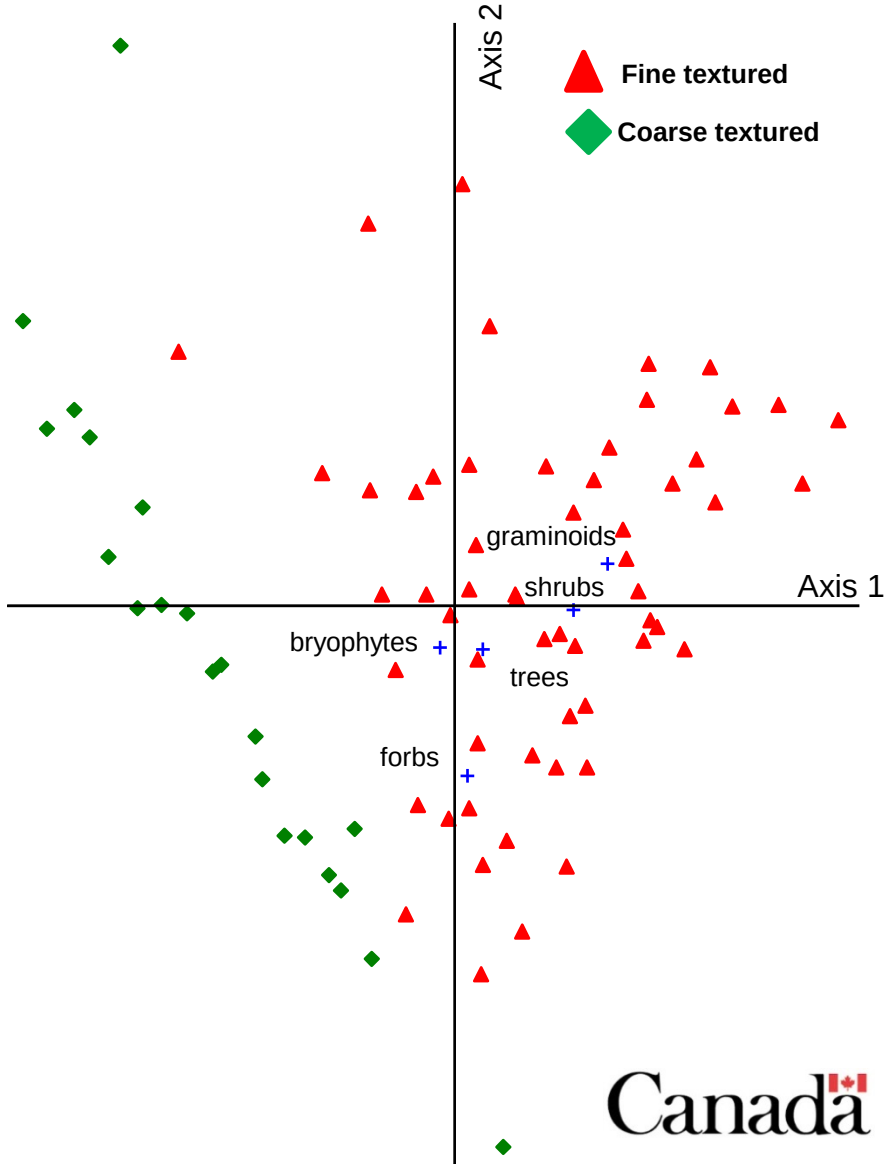


Tree water use (Stomatal conductance)



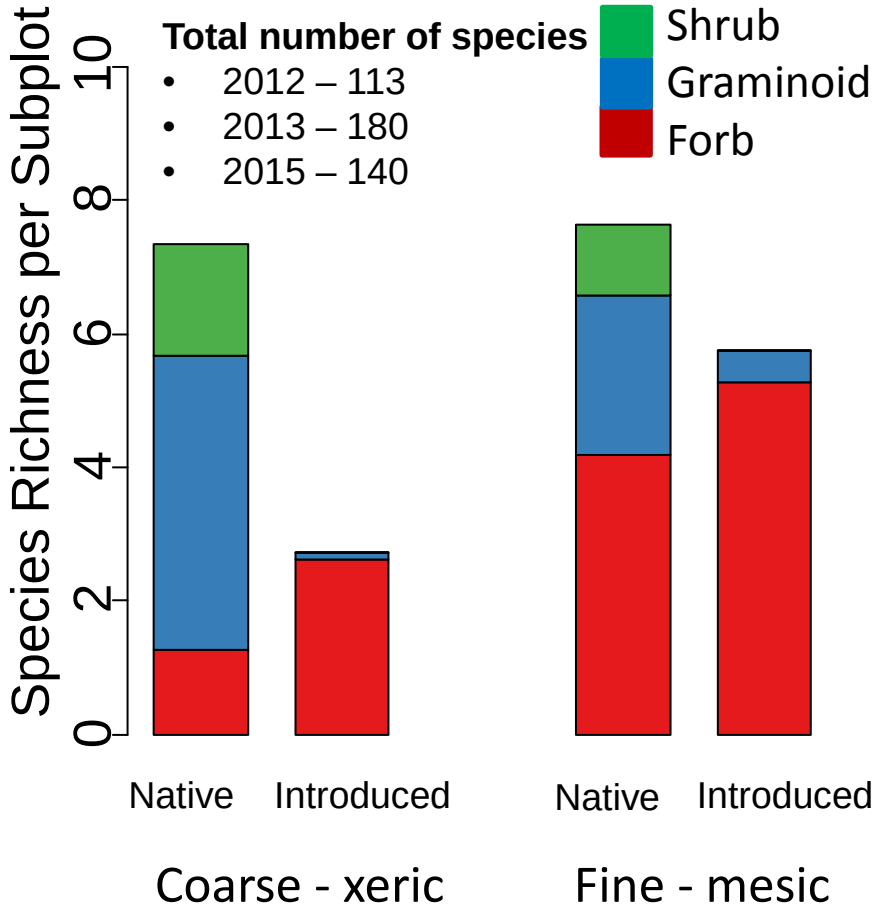
- Aspen has high water use and does not respond to soil
- Jack pine is more responsive to soil conditions
- Link to the long term water balance of the site

Plant community composition



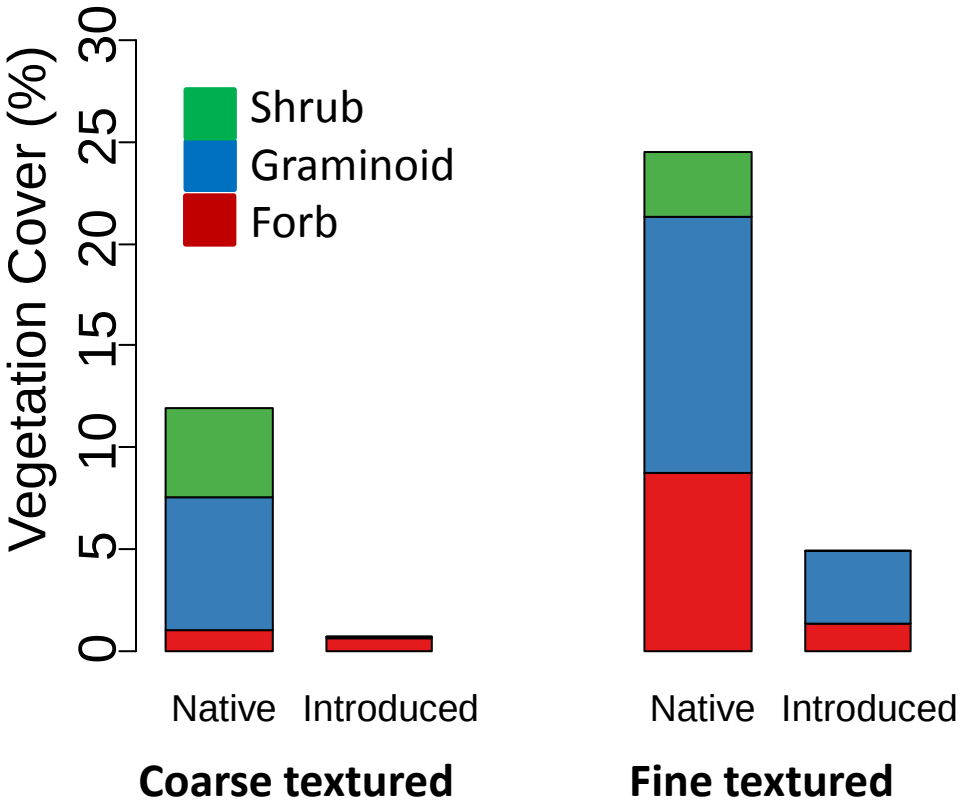
Understory species richness

- Similar species richness between soil types
  - Coarse soil → grasses
  - Fine soil → forbs
- More introduced species on fine textured soil
- Higher diversity with higher density planting treatments and with north facing aspects



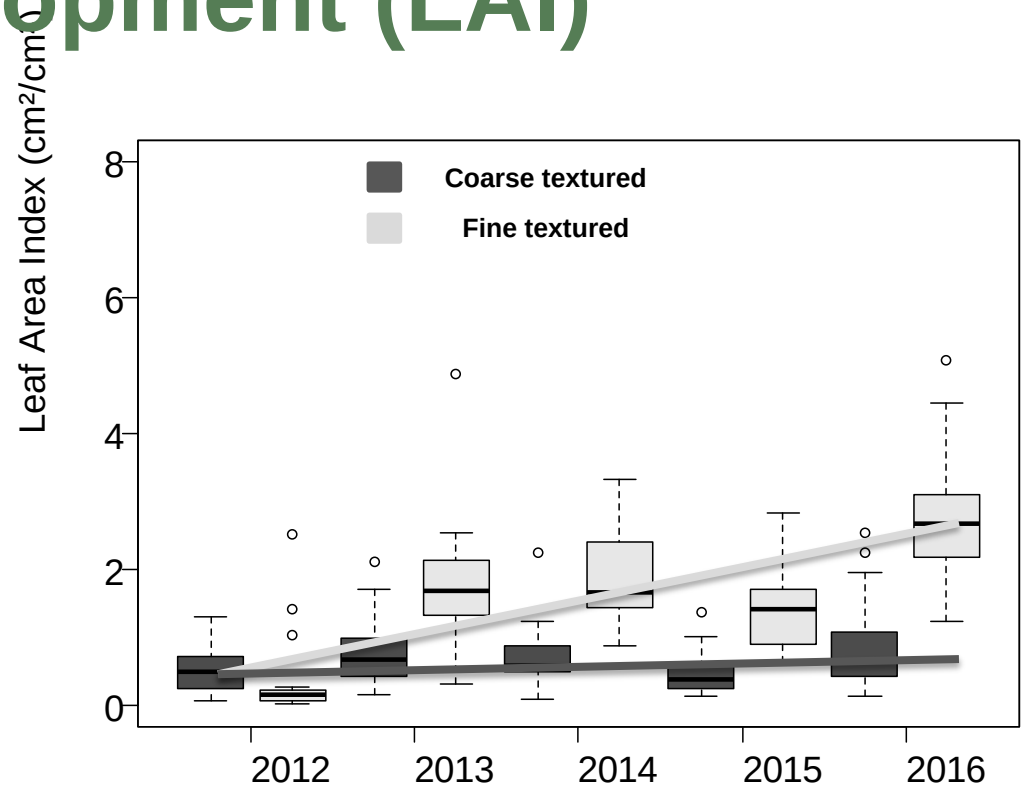
Understory vegetation cover

- Higher vegetation cover on fine textured soil, particularly native forbs
- Higher shrub cover on coarse textured soil



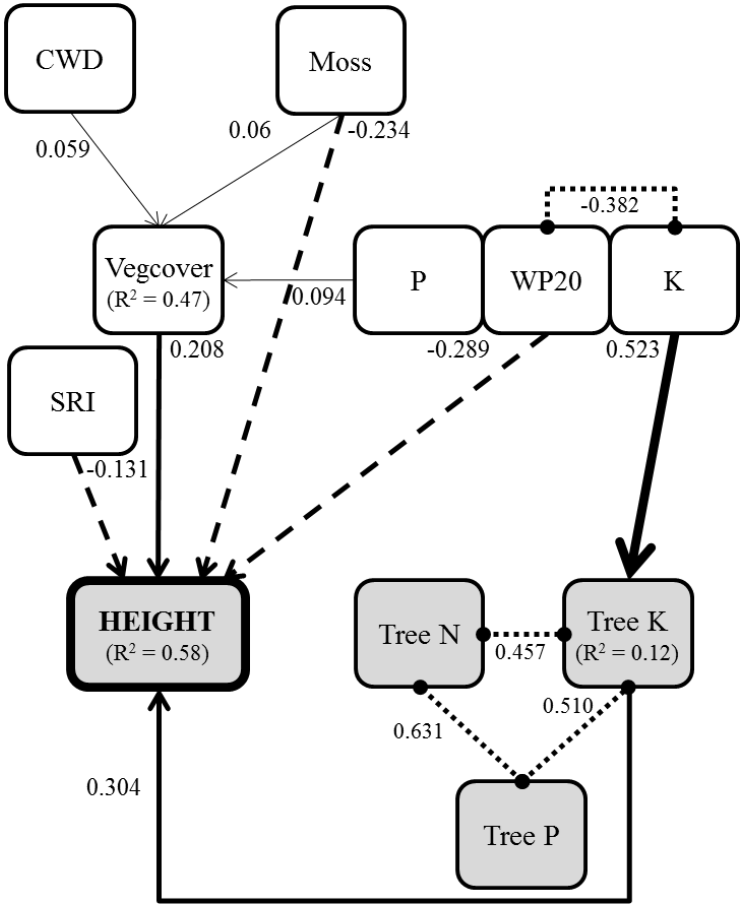
Vegetation development (LAI)

- Higher overall leaf area on fine textured soil
- Difference is increasing over time
- Tree leaf area becoming a more important component, particularly in high density plantings



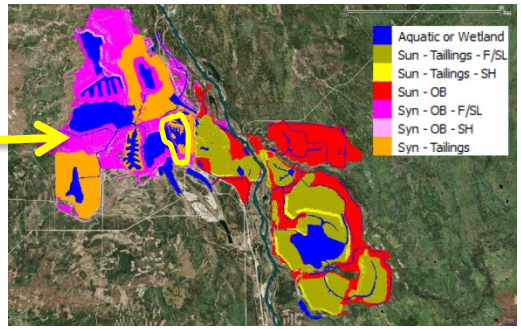
Next steps

- How are soils, water, plants and trees interacting?
- How are the uplands and wetlands interacting?
- How are reclaimed ecosystems developing?



Structural equation modelling

Operational implications



East In Pit
- 100s of ha of tailings to be reclaimed in the coming decades

1,000s more ha of tailings to be reclaimed across the mine lease and the mineable oil sands region

Thanks!