Perched Peatlands: insights into eco-hydrologic roles of peatlands in water limited boreal environments.

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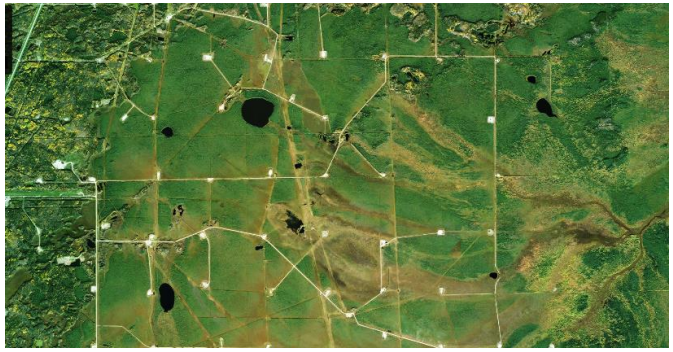
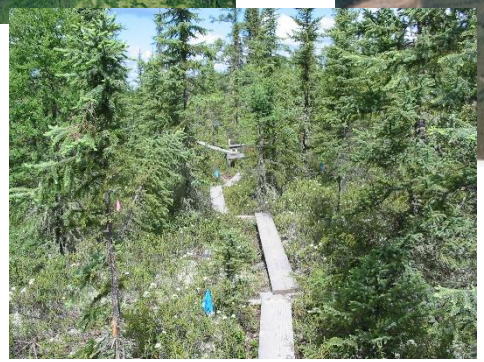


Objectives:

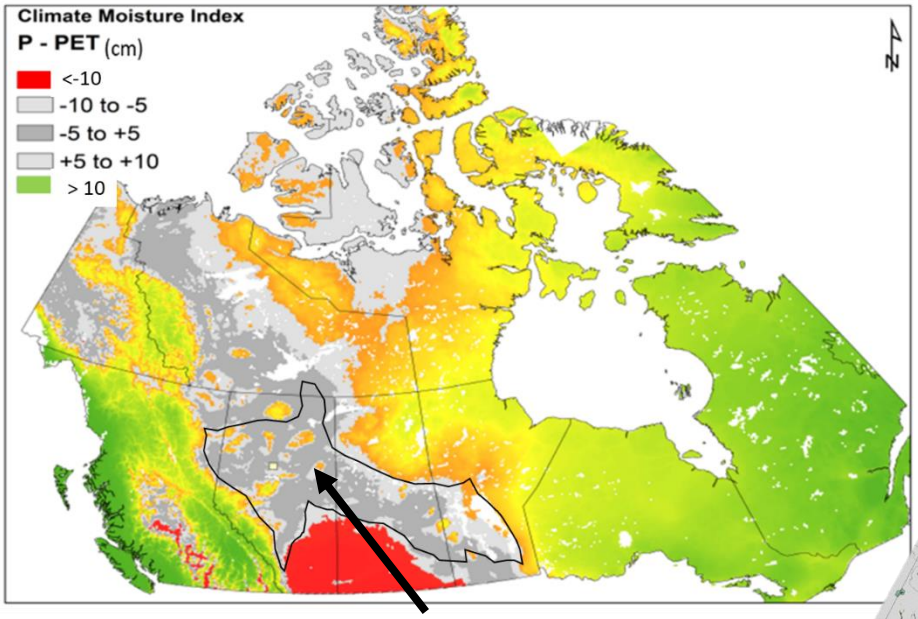
- Understand controls on peatland development in sub-humid climates (P<PET)
- Test general theories of internal vs external controls
- Implications peatland constructions Oil Sands, reclamation, susceptibility to disturbance (land-use, climate) in Alberta (drier climates)





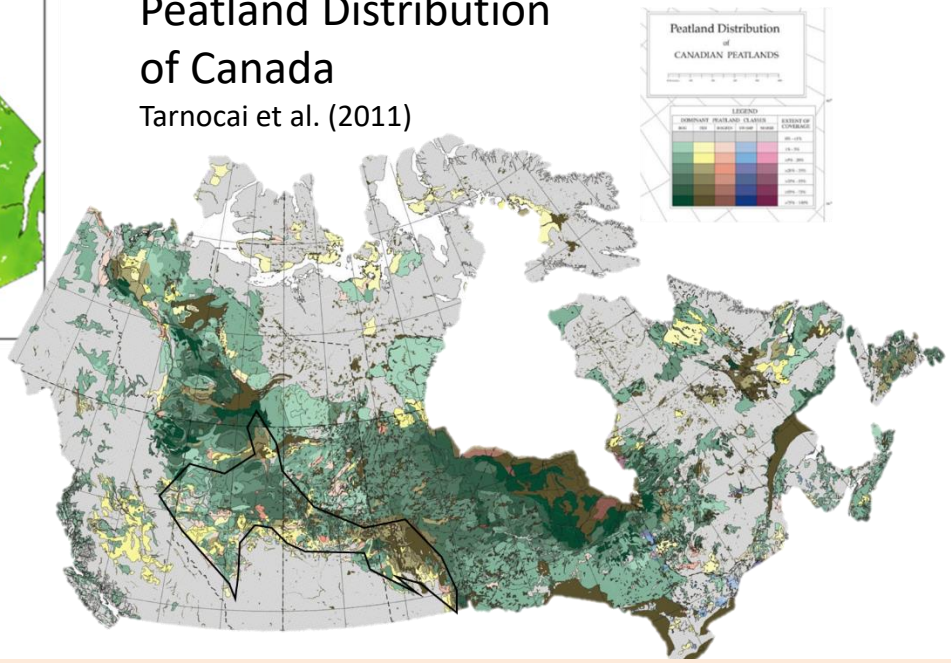



Paradox Boreal Plains:
Extensive Peatlands Sub-humid Climate



Boreal Plain

Peatland Distribution
of Canada
Tarnocai et al. (2011)

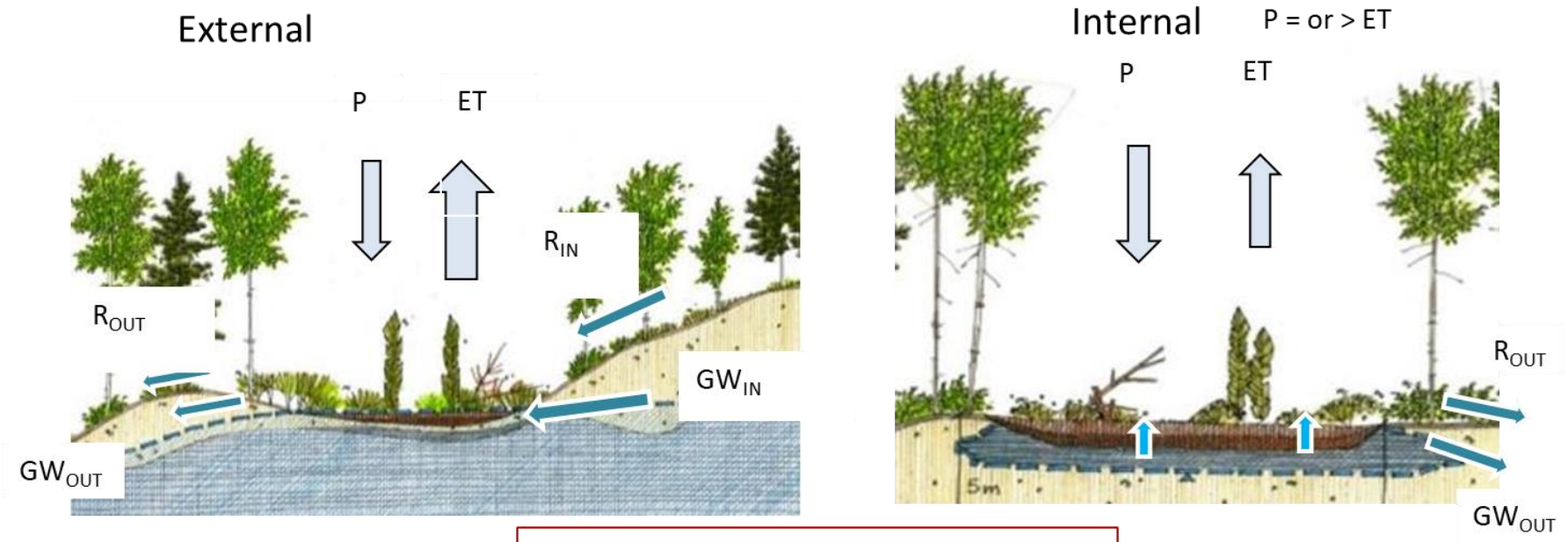


Sub-humid (P~ ET), small changes in vegetation, geology, and climate have big impacts on water balance

Sub-Humid Peatlands – Conceptual Model

Wetlands – persist within Landscape setting

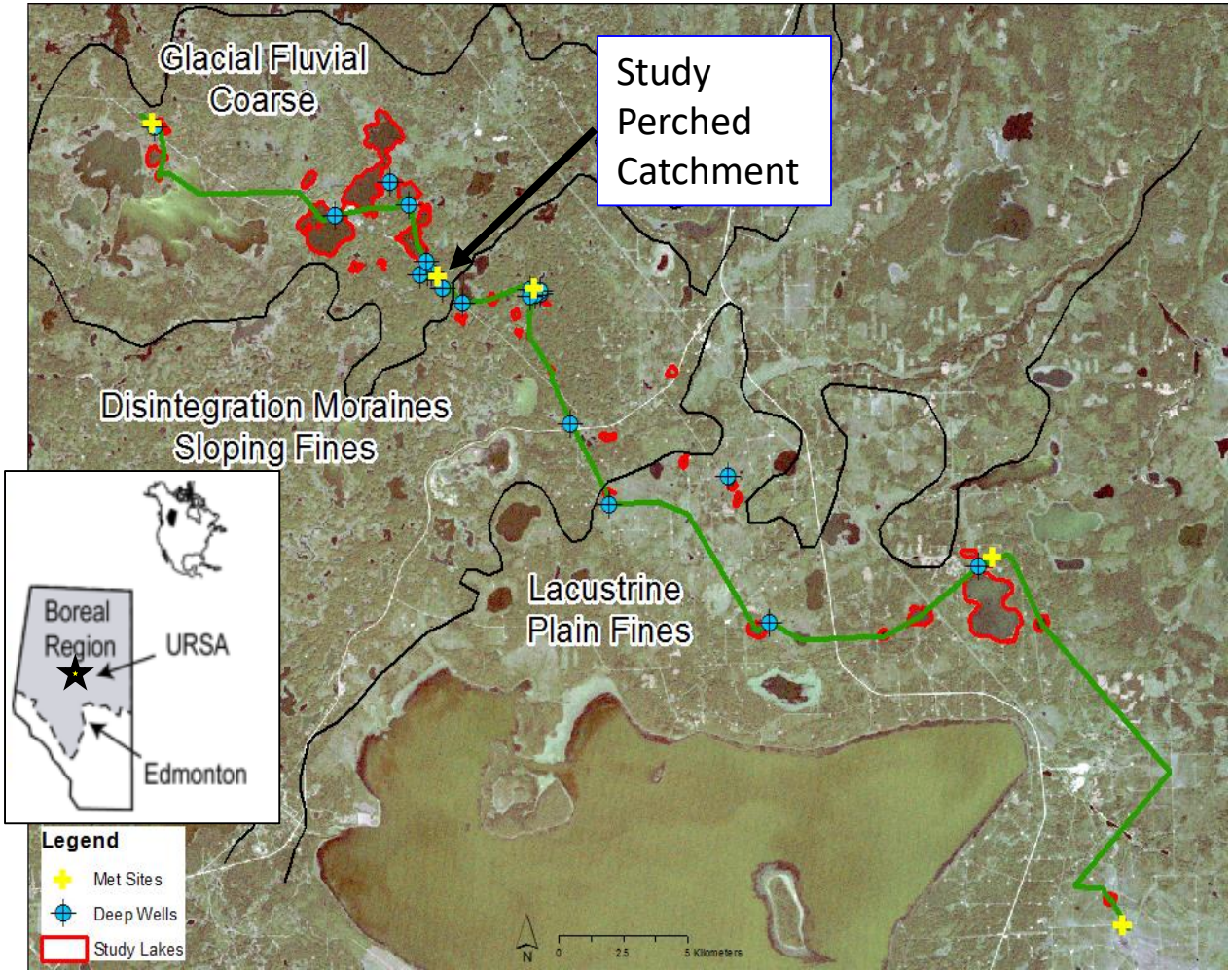
1) Allogenic (external) control: hydrogeologic setting catchment interactions
   a) S_{in} and GW_{in} compensate moisture deficit
2) Autogenic (internal) controls: wetland potentially form anywhere
   a) Lower AET – veg, moss/location → feedbacks compensate deficit
   b) Low storage (basin, soils) – frequent wetting, soil anoxia excludes forest vegetation –lower production)
   c) Thermal properties: Ice, seasonal reduce ET, exclude trees



$$\triangle S = P \leq ET + (R_{IN} + GW_{IN}) - (R_{OUT} - GW_{OUT})$$

Little-Devito et al. (2019)

Utikuma Region Study Area (URSA)



15+ years Studies

- 34 Ponds
- 20 streams
- 6 catchments

Hydrogeologic transect

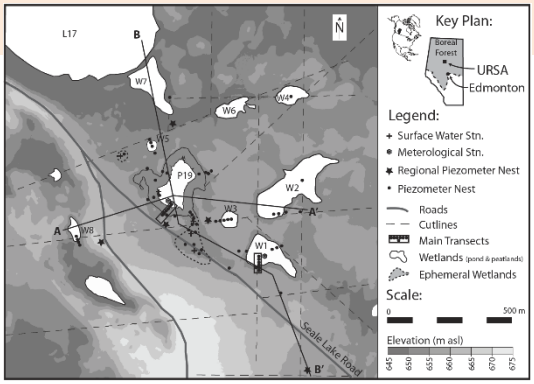
- 20 Deep Piezometer Nests

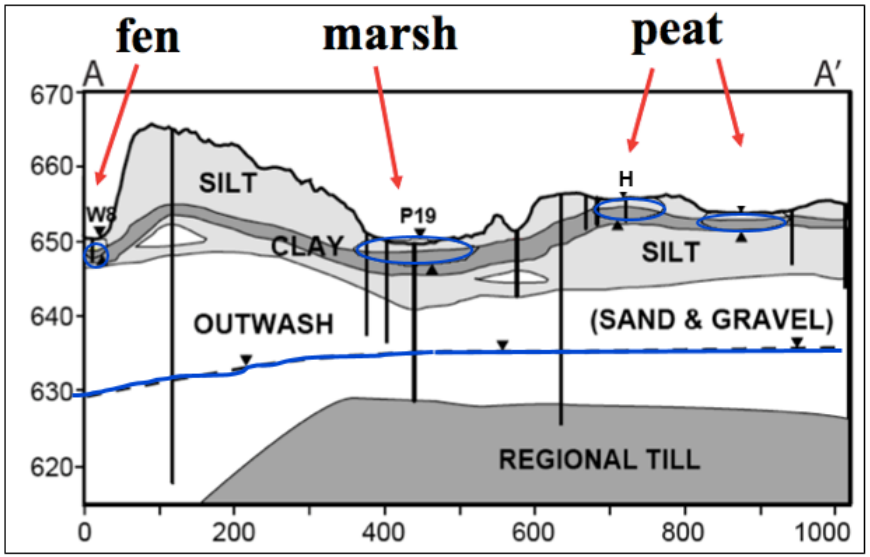
Devito et al. (2016)

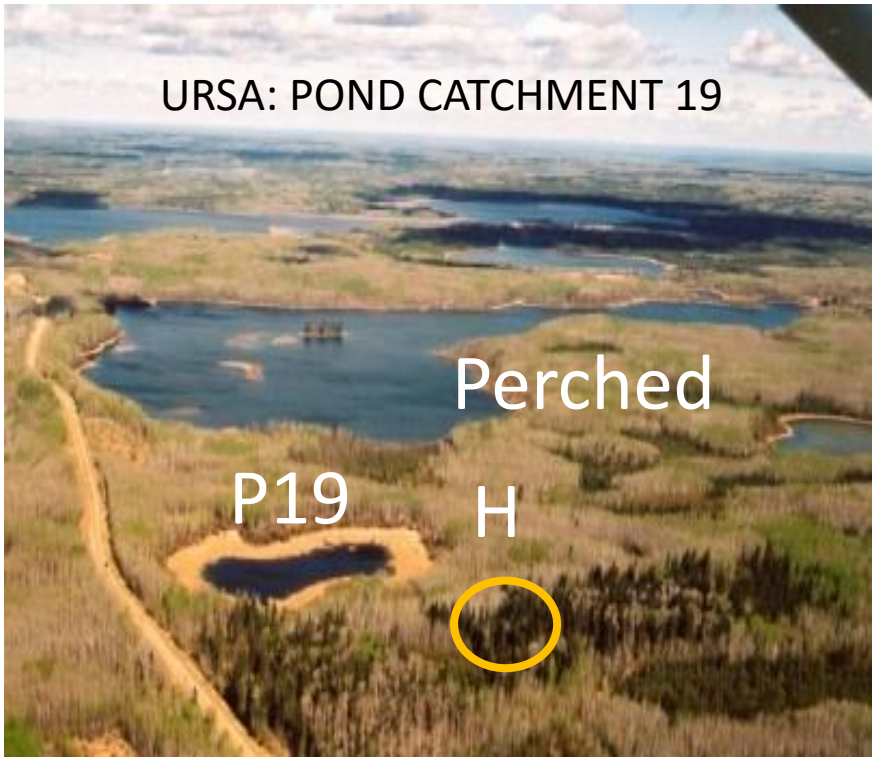
Address hypothesis internal vs external control:

-Choice of Site Location Critical = our singular test

- **20 m above the regional groundwater table (Perched)**
- **Top local hill, no local surface-groundwater (Isolated)**
- **14 years monitoring peatland and forest water levels , peatland to adjacent forest** Riddell (2008), Hokanson et al. (2020)**.**

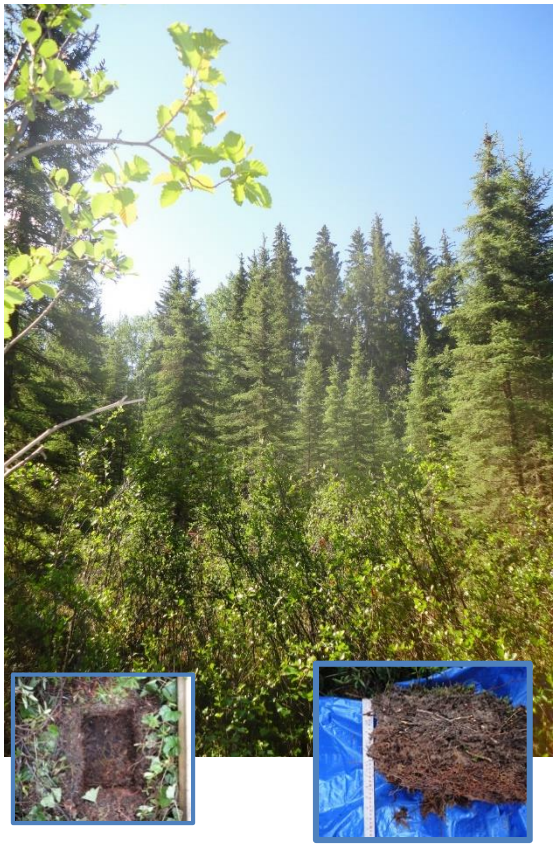






Two Distinct Wetland Zones – then Forest

Peatland



Margin swamp

Aspen Forestland

Peat-Swamp-Forest Water Balance

2014 – 2015 hydrologic year (Dry Year)

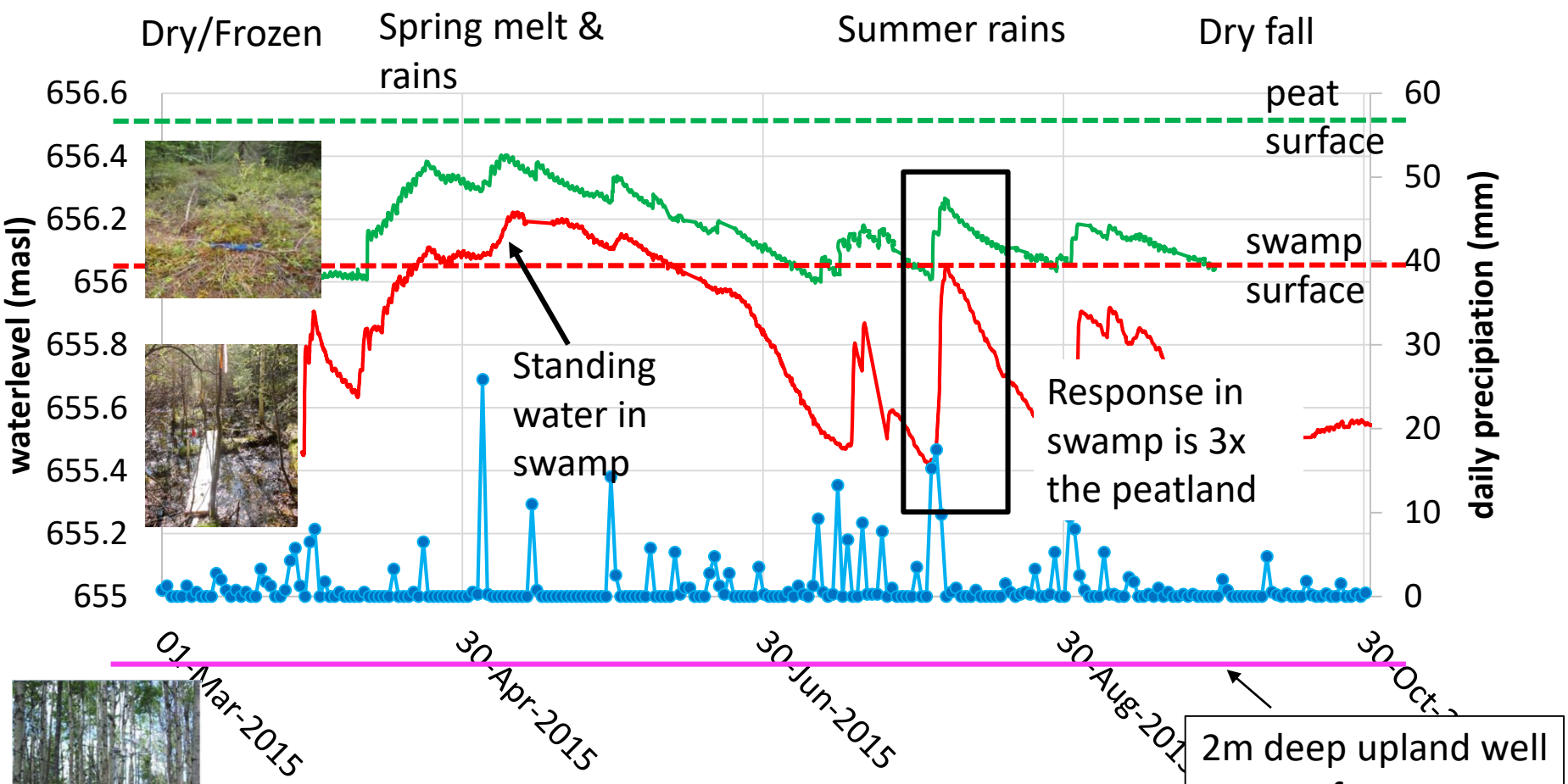
James (2017)

What does this tell us?

- Self sustaining wetland capable of water generation in sub humid climate

Soil layers, storage & precipitation interactions

James(2017)



2m deep upland well = DRY for 15 years

Dry summer,

- Moderate Rain events →Frequent saturated & anoxic soils
- Shallow confining layer maintains peatland and swamp

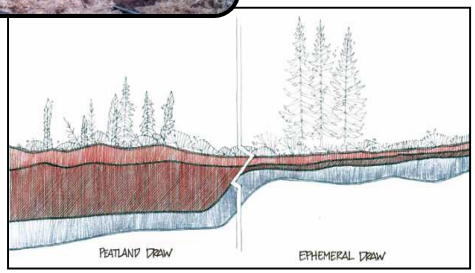
Autogenic Control:

soil layers, storage, vegetation & precipitation interactions

Field and Modelling Studies:

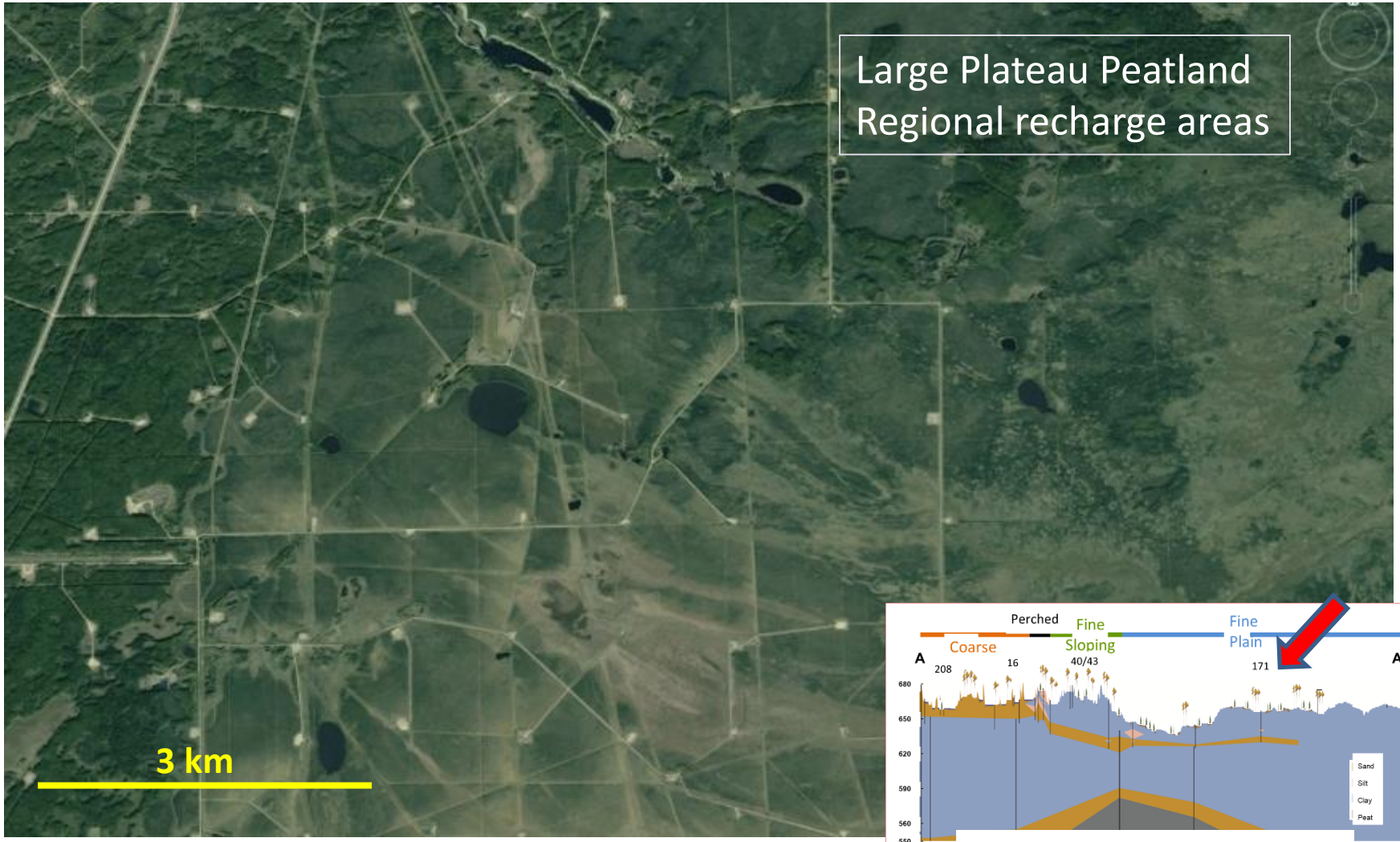
Riddell (2008), James (2017), Dickson et al. 2017, Kettridge et al (2017), Devito et al. (2017), Hokanson et al. (2020)

- Shallow soil storage (clay) promotes rapid surface saturation
  - Frequent soil anoxia, lower production & AET
- Surface vegetation debris reduce conserve water (reduce AET)
- Protection wind / shading
  - Late snow melt, late ice (June-July), less productivity & AET



Implications: Peatland Complexes Boreal Alberta

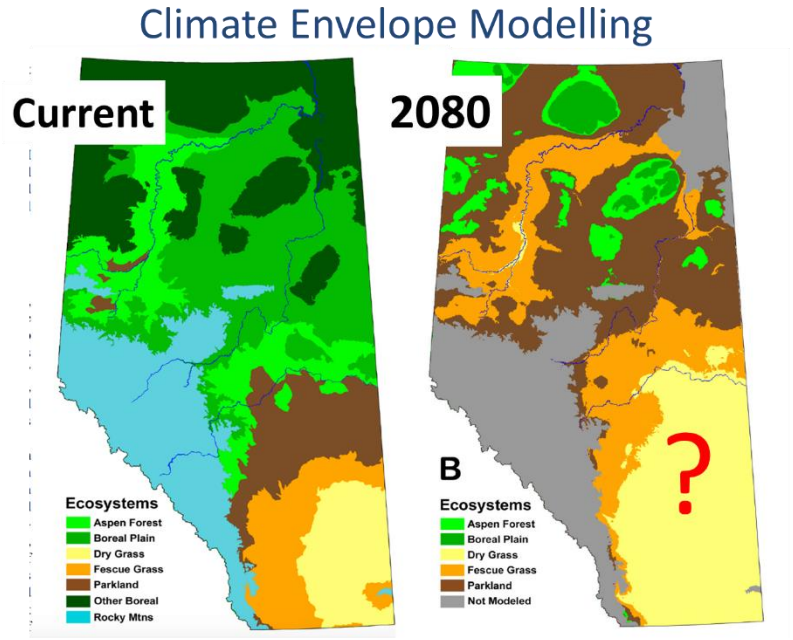
Groundwater can not support extensive peatlands
- proportionally too large for recharge areas (autogenic processes?)

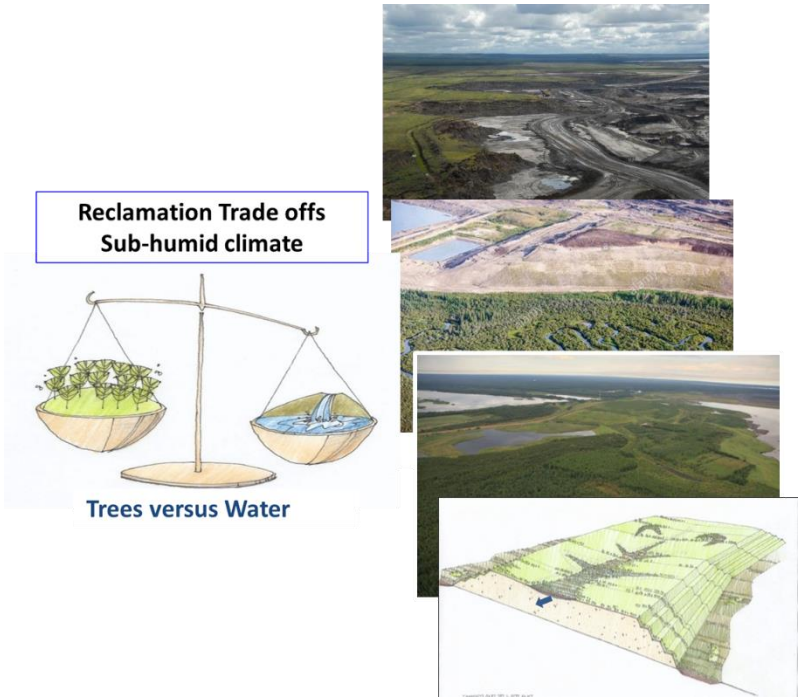


Hokanson et al. (2019)

Implications

- Manage for internal controls as well as impacts on sources
- Internal (i.e soil Layering) can control wetland formation
  - Isolated systems less susceptible to climate change?
- Landscape Scale Reclamation mega-projects
  - Functional role wetlands, much cheaper design





Acknowledgements

Madison Chamzuk, Jayce Eardie,
Brittnay Hynes, Emily Jones,
Joe Hopkins,Luke Potrais,
Joe Riddel (MSc), Jessica Ritz,

References

Devito K, C Mendoza, RM Petrone, N Kettridge, JM Waddington. 2016. Utikuma Region Study Area (URSA) – Part 1: Hydrogeological and ecohydrological studies. *The Forestry Chronicle*, 92: 57-61

Devito, KJ, KJ Hokanson, P Moore, N Kettridge, A Anderson, L Chasmer, C Hopkinson, MC Lukenbach, CA Mendoza, J Morissette, DL Peters, R Petrone, U Silins, B Smerdon, JM Waddington. 2017 Landscape controls on long-term runoff in sub-humid heterogeneous Boreal Plain catchments. *Hydrological Processes*. 31(15)2737-2751, DOI: 10.1002/hyp.11213

Dixon, S.J.; Kettridge, N.; Moore, P.A.; Devito, K.J.; Tilak, A.S.; Petrone, R.M.; Mendoza, C.A.; Waddington, J.M. 2017. Peat depth as a control on moss water availability under evaporative stress. *Hydrological Processes*, 31(23):4107-4121.10.1002/hyp.11307.

Hokanson, KJ, CA Mendoza, KJ Devito. 2019. Interactions between regional climate, surficial geology, and topography: Characterizing shallow groundwater systems in subhumid, low-relief landscapes. *Water Resources Research*, 55, 284–297. DOI: 10.1029/2018WR023934

Hokanson, K J, E S Peterson, K J Devito, C A Mendoza1. 2020. Forestland-peatland hydrologic connectivity in water-limited environments: hydraulic gradients often oppose topography. Environ. Res. Lett. 15 (2020) 034021. DOI: 10.1088/1748-9326/ab699a

James, Lindsay. 2017. Formation and maintenance of permanent perched wetlands in the Boreal Plain of Western Canada. M.Sc. Thesis, Biological Sciences, University of Alberta, Edmonton, Alberta. 148pp

Kettridge N, Lukenbach MC, Hokanson K, Hopkinson C, Devito KJ, Petrone RM, Mendoza CA,Waddington JM. 2017. Low evapotranspiration enhances the resilience of peatland carbon stocks to fire. *Geophysical Research Letters*, 44(18): 9341–9349, DOI: 10.1002/2017GL074186

Little- Devito, M., CA Mendoza, L Chasmer, N Kettridge, KJ Devito. 2019. Opportunistic Wetland Formation on Reconstructed Landforms in a Sub-humid Climate: Influence of Site and Landscape-scale Factors. Wetlands Ecology and Management, 27:587-608. doi:10.1007/s11273-019-09679-y

Riddell, J. 2008. Assessment of surface water-groundwater interaction at perched boreal wetlands, north-central Alberta.M.Sc. thesis, Earth and Atmospheric Sciences, University of Alberta. 106p.