

Thawing permafrost, landscape change, & consequences for northern ecosystem carbon cycling



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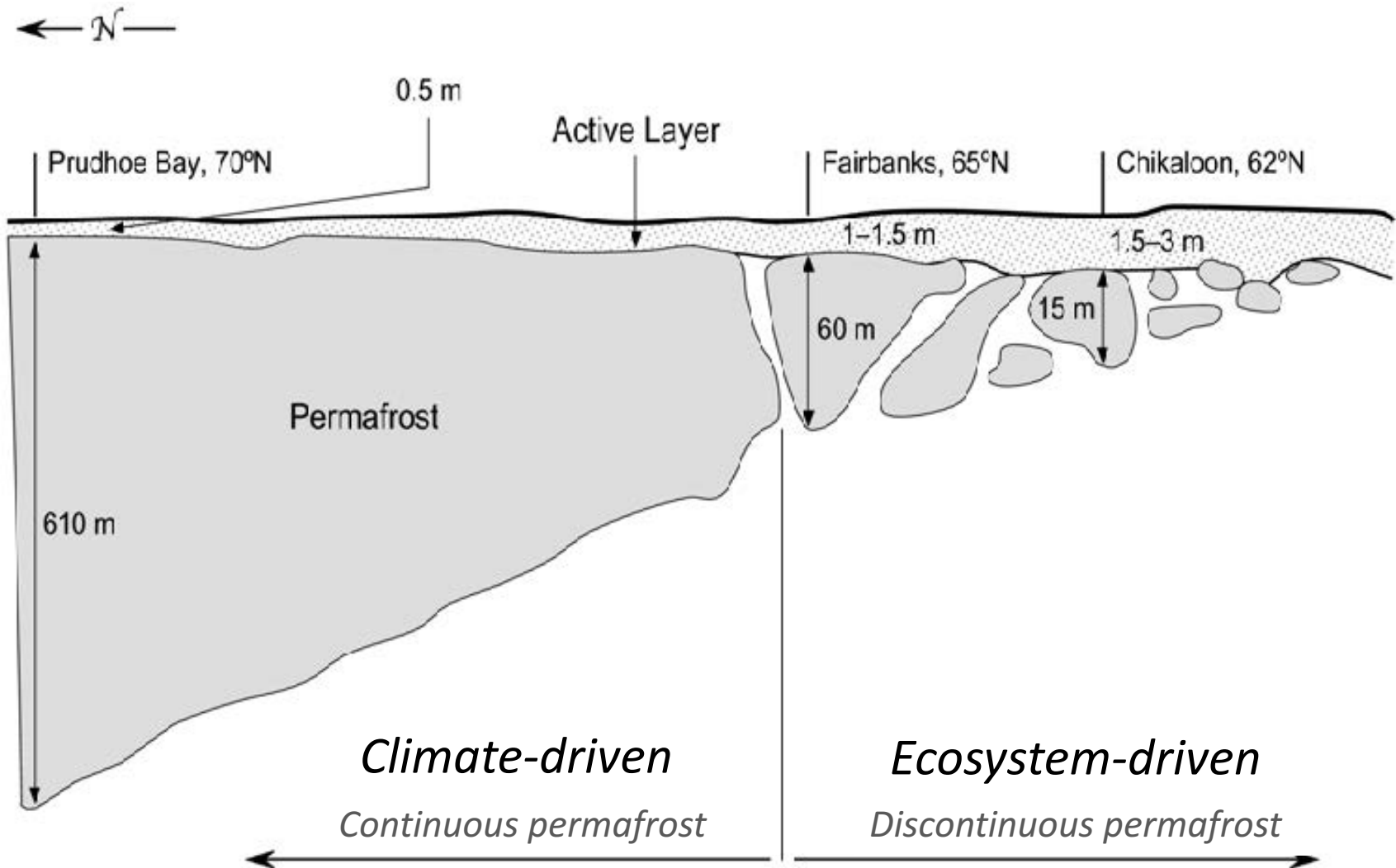
Department of Ecology and Evolutionary Biology

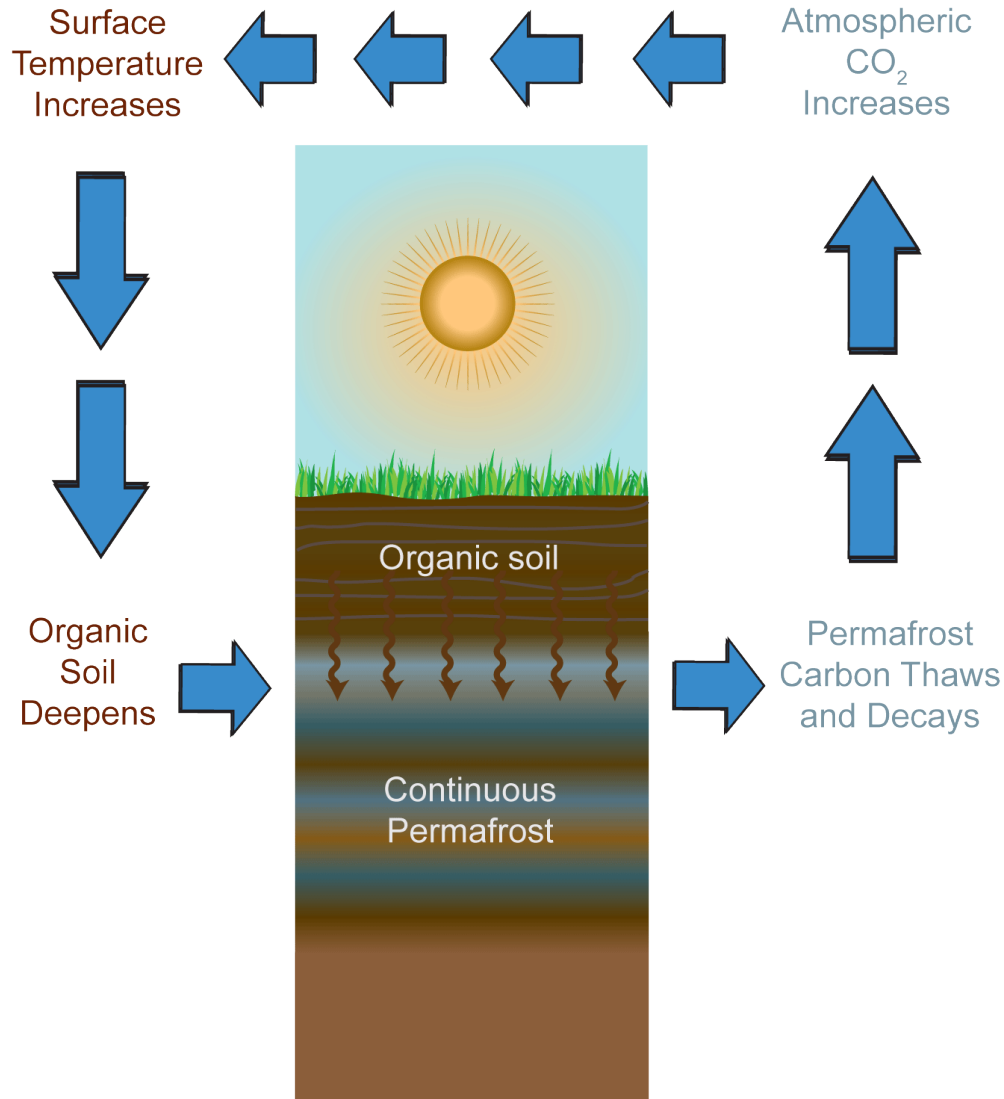
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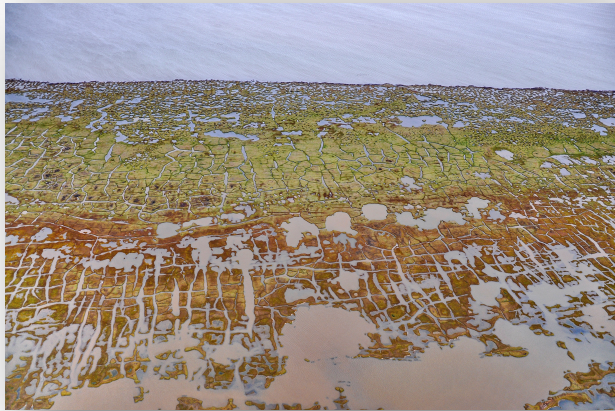
Permafrost is both climate and ecosystem driven





Current estimates of the permafrost C pool range from 1400-1600 Pg C in the upper 3 meters

Thermokarst is abrupt, typically involves local subsidence and wetting

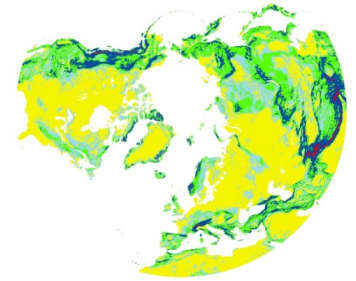


Models typically represent active layer thickening and not thermokarst

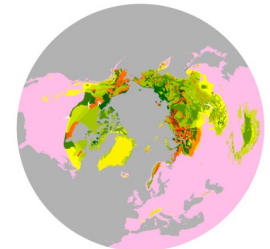
Step 1: Abrupt thaw predisposition mapping

Decision tree to identify landscapes experiencing or predisposed to:

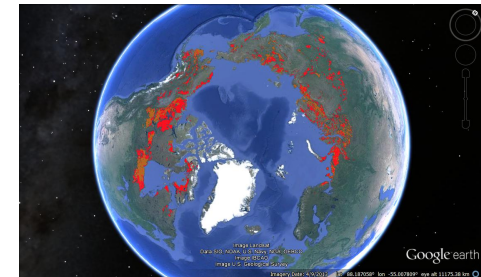
- Thaw lake expansion or drainage
- Wetland thermokarst (collapse bogs or fens)
- Hillslope erosional processes (detachments, slumps, gullies)



Topography (Gruber 2012)



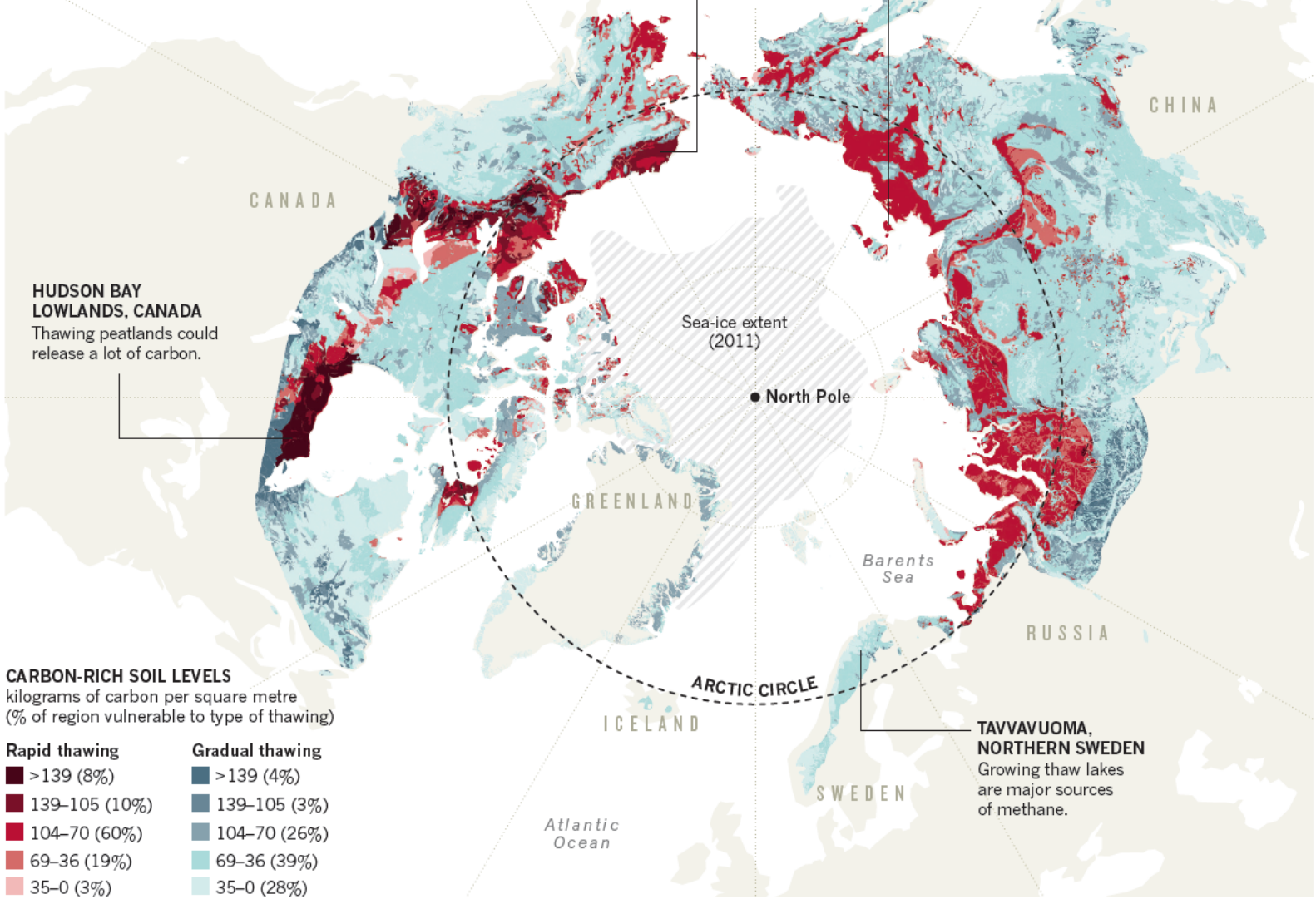
Permafrost zone, Overburden Ice content (Brown et al. 1998)



Histel distribution (Tarnocai et al. 2009)

ARCTIC PERMAFROST

One-fifth of frozen soils at high latitudes are thawing rapidly and becoming unstable, leading to landslides and floods that release carbon into the atmosphere.



CARBON-RICH SOIL LEVELS

kilograms of carbon per square metre
(% of region vulnerable to type of thawing)

Rapid thawing	Gradual thawing
>139 (8%)	>139 (4%)
139-105 (10%)	139-105 (3%)
104-70 (60%)	104-70 (26%)
69-36 (19%)	69-36 (39%)
35-0 (3%)	35-0 (28%)

Step 2: Abrupt thaw inventory model



Lowland organic



Lowland mineral



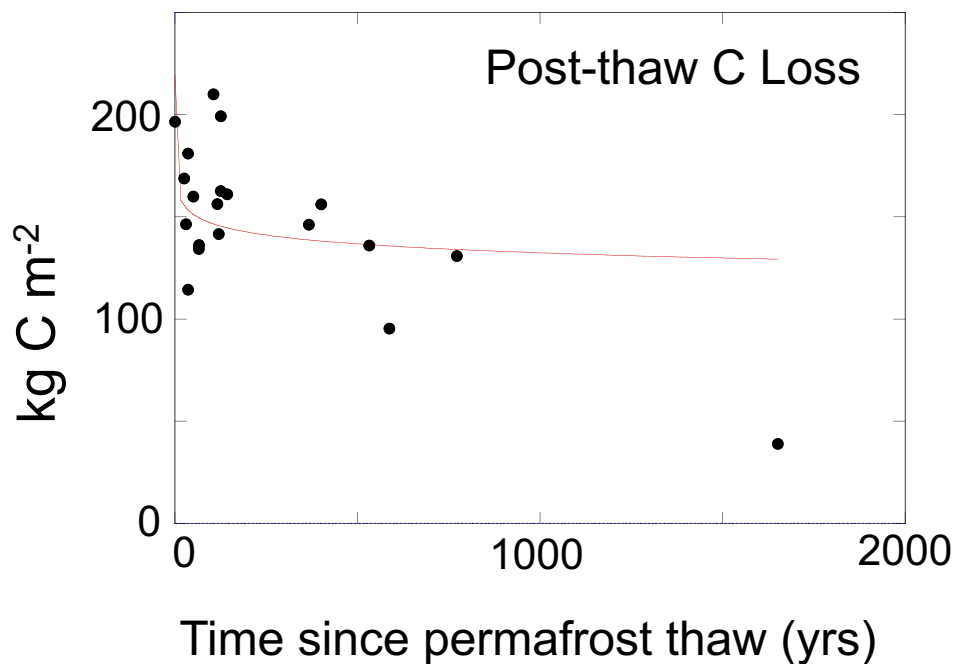
Upland mineral

We synthesized and scaled up data on:

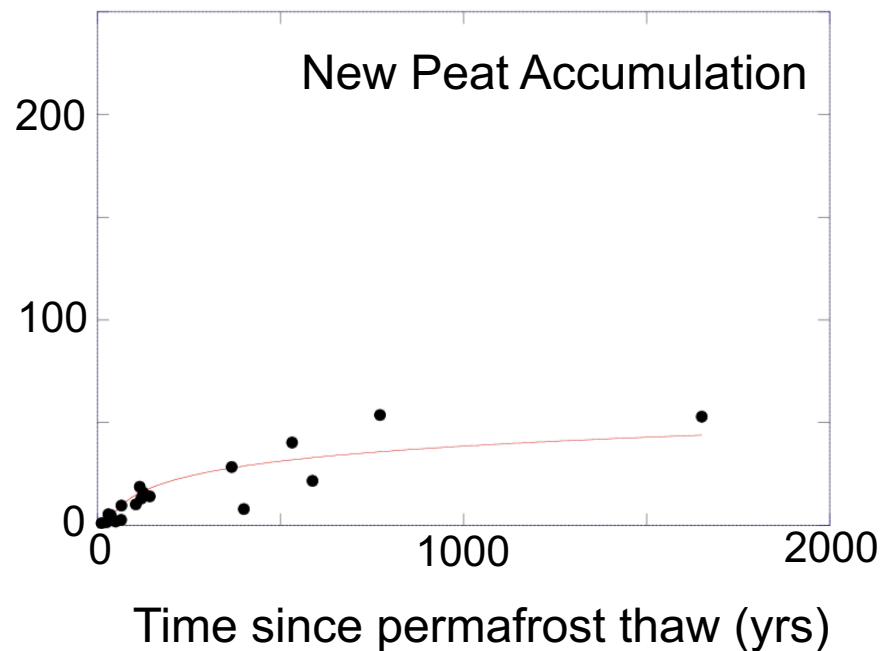
- spatial extent of active versus stabilized (mature) thaw states*
- transition rates that define rates of thaw and stabilization*
- carbon fluxes for each state including potential biomass offsets*

Abrupt thaw alters ecosystem C balance

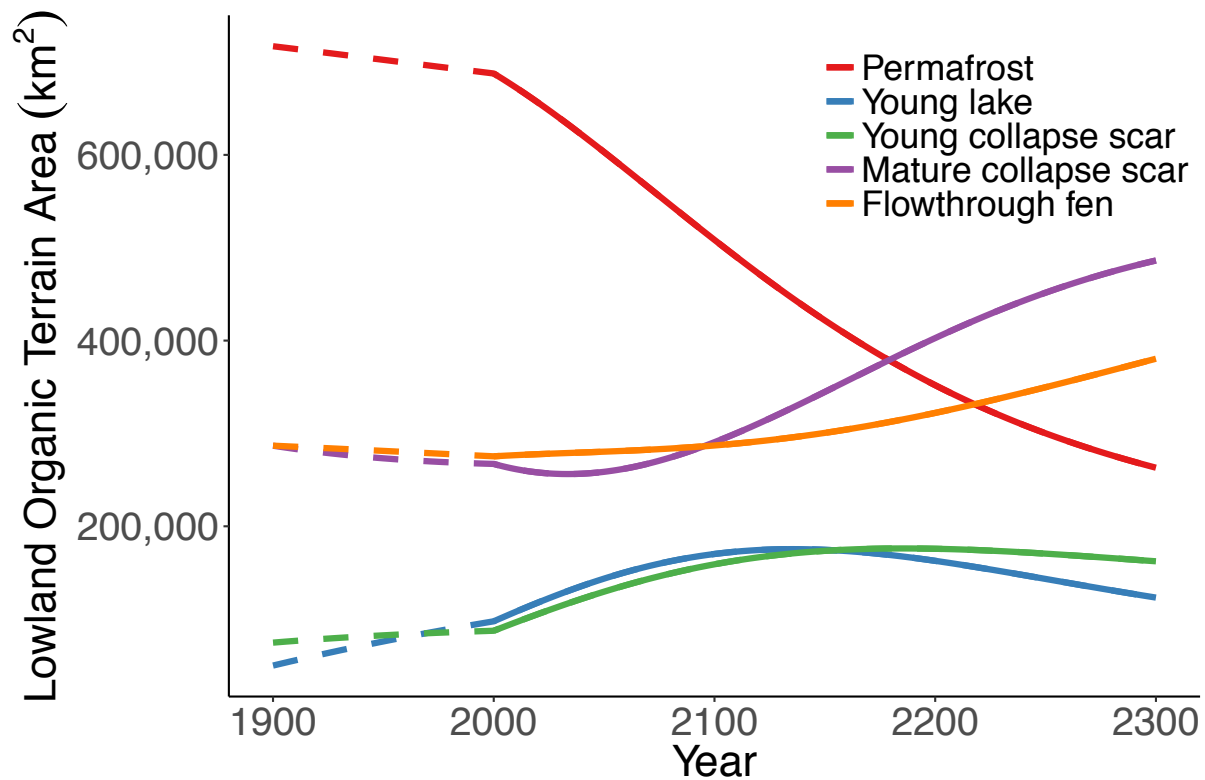
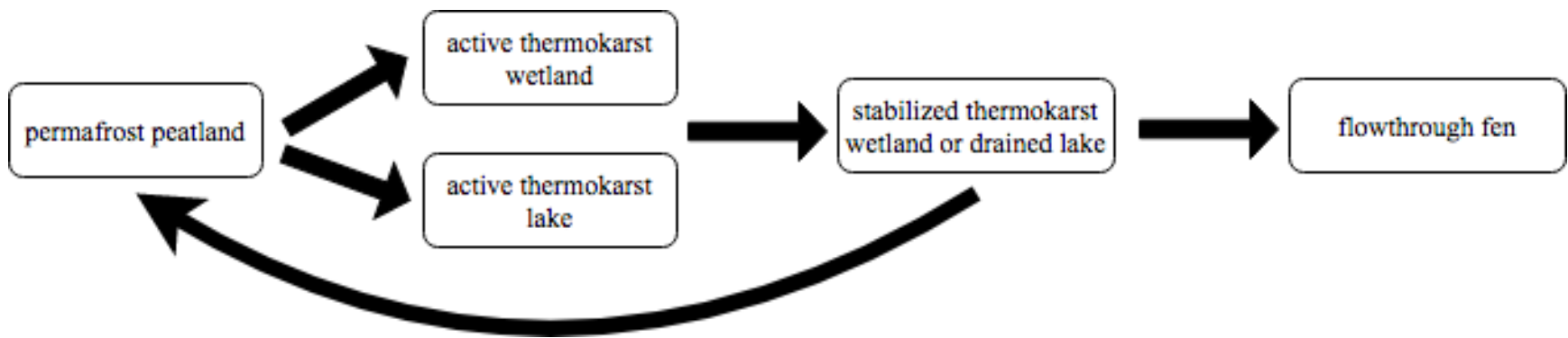
Rapid instability



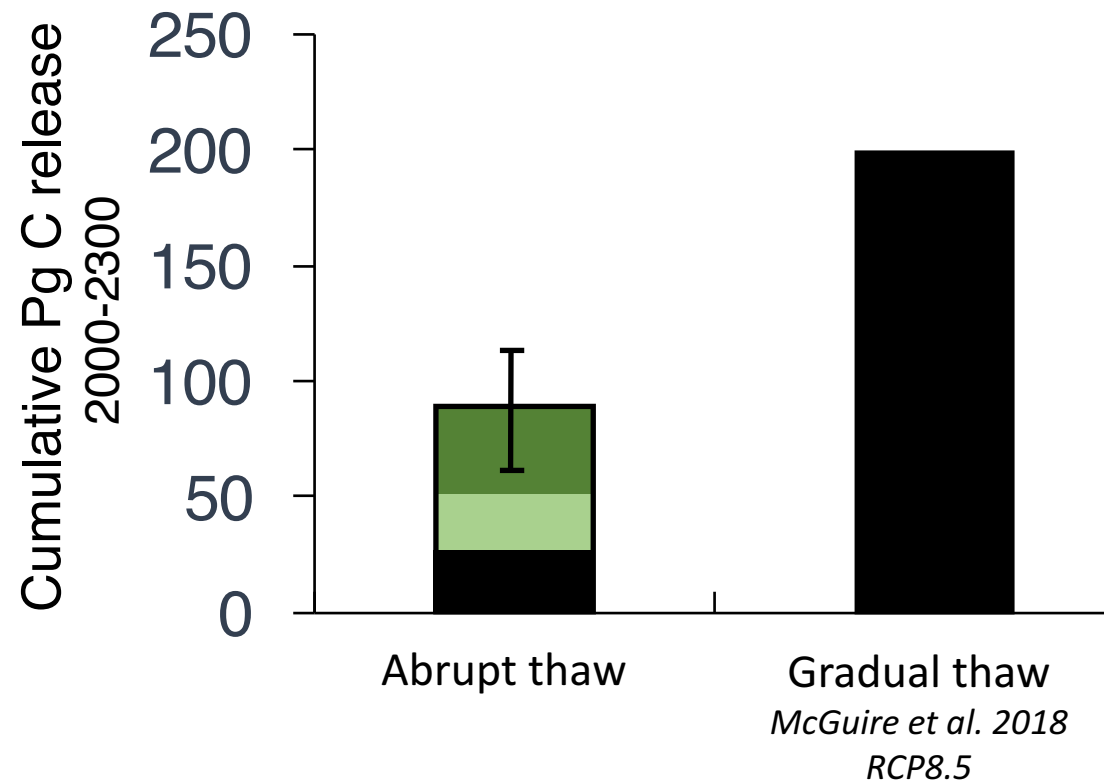
New equilibrium



O'Donnell et al. 2012; Jones et al. 2017; Olefeldt unpublished; Turetsky unpublished

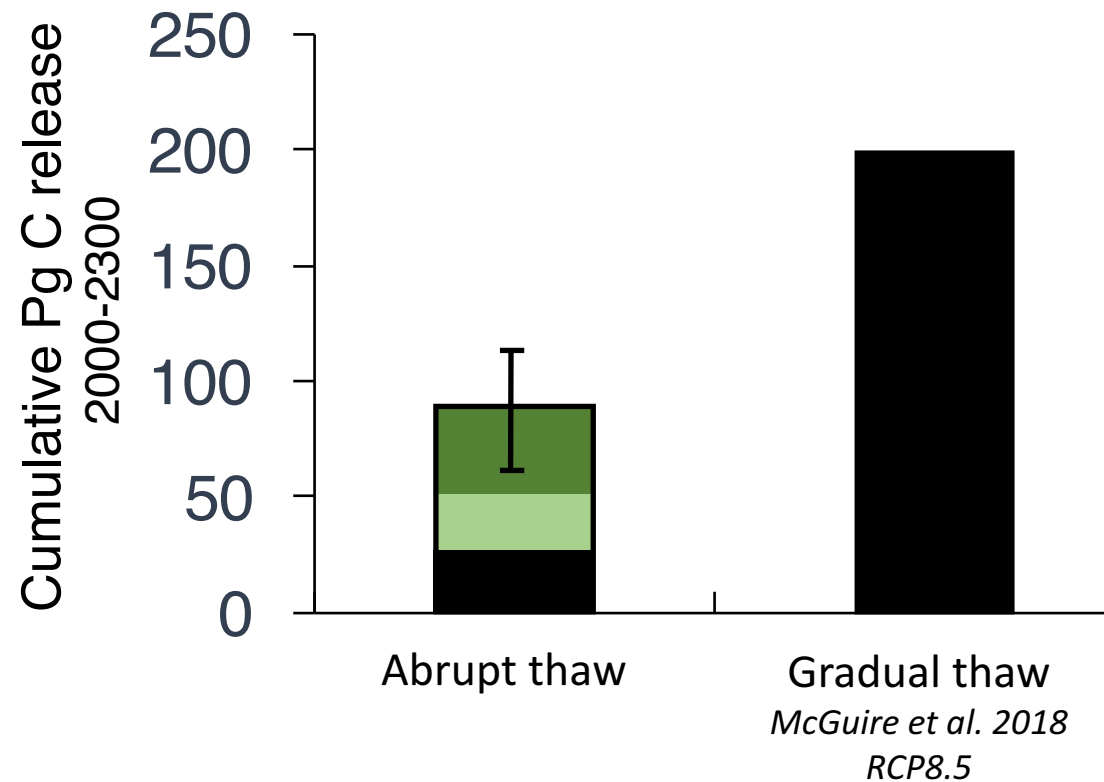


How does abrupt thaw compare to gradual thaw?



- By 2300, abrupt thaw could cover 2.5 million km² or ~15% of the permafrost region.
- Abrupt thaw emissions increase estimates of permafrost carbon release by ~50%.

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- Due to large CH₄ emissions, abrupt thaw could provide a similar climate feedback as gradual thaw emissions

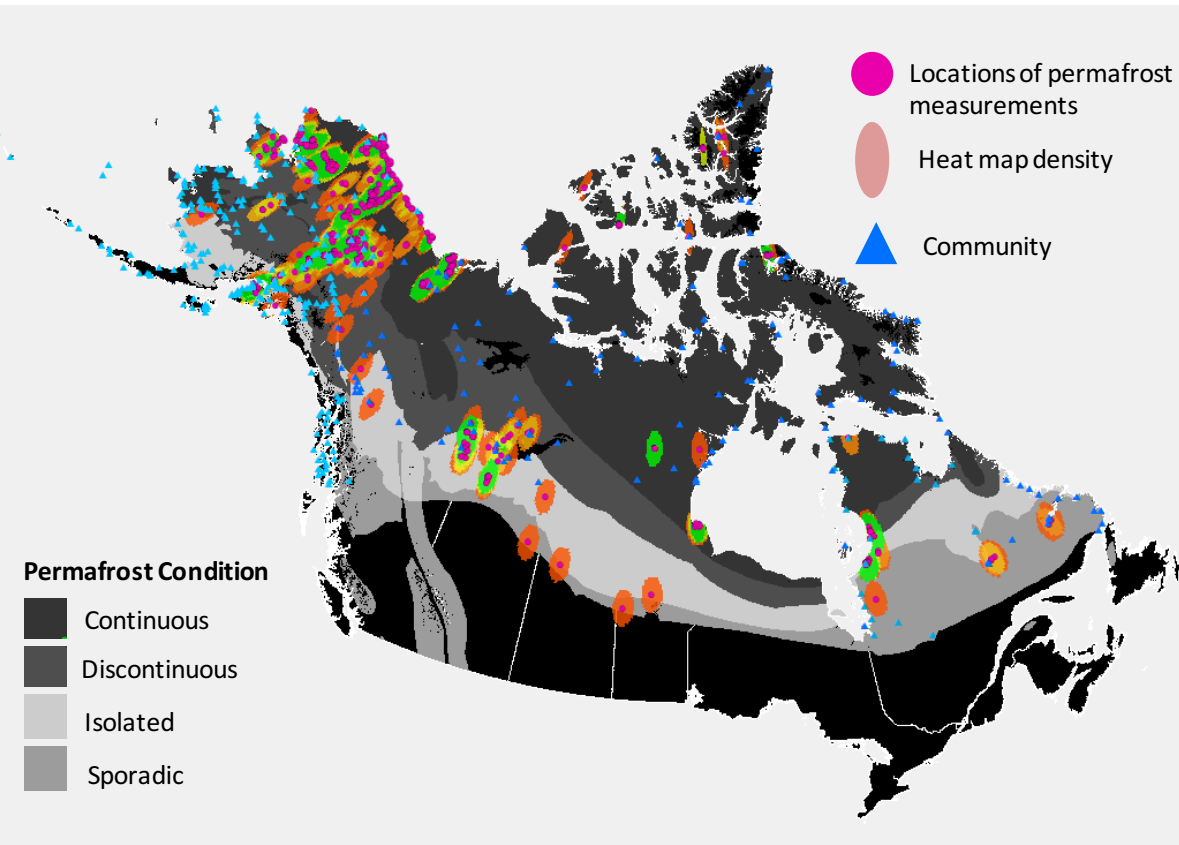
Infrastructure



Wildlife/Hunting



Slope Failure/Erosion





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Thank you

