Effects of permafrost thaw on food, water, and carbon security

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What is a key defining feature of Canada?

#PermafrostNation
Models do not account for abrupt thaw processes (thermokarst, thermo-erosion)
Abrupt thaw spatial mapping
Improving abrupt thaw maps: 
*Ground ice data rescue!*

Data from >7000 boreholes drilled by Geological Survey of Canada or industry

Permafrost and ground ice data on military lands in interior Alaska (NRCS)
Improving abrupt thaw maps: *Infrastructure failure as “test cases”*
Improving abrupt thaw maps: Local knowledge, community participatory work
Abrupt thaw affects the most C-rich soils

Turetsky et al. 2019 Nature
Conceptual models of change

hillslopes

thaw lakes

wetlands

undisturbed tundra → active thermokarst → stabilized thermokarst

undisturbed tundra → active thaw lake → stabilized thaw lake → drained lake basin (alas)

permafrost peatland → active thermokarst wetland → stabilized thermokarst wetland or drained lake → flowthrough fen
How does abrupt thaw compare to gradual thaw?

- By 2300, abrupt thaw could cover 2.5 million km$^2$ or ~15% of the permafrost region.

- Abrupt thaw emissions increase estimates of permafrost carbon release by ~50%.

McGuire et al. 2018
RCP8.5
How does abrupt thaw compare to gradual thaw?

- By 2300, abrupt thaw could cover 2.5 million km$^2$ or ~15% of the permafrost region.
- Abrupt thaw emissions increase estimates of permafrost carbon release by ~50%.
- Due to large CH$_4$ emissions, abrupt thaw could provide a similar climate feedback as gradual thaw emissions.
Meta-analysis of permafrost ecosystem services

Carolyn Gibson, ongoing PhD
Meta-analysis of permafrost ecosystem services

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HUMANS & WILDLIFE
Includes impact to archaeological sites, community relocations, community/individual economic loss, increased food insecurities, damage to infrastructure, reduced access to traditional travel routes, impacts on wildlife habitat and abundance, and impeded travel.

CARBON CYCLING
Upon thaw, previously frozen carbon reserves become mobilized and enter the atmosphere. May lead to increase in atmospheric CO₂ concentrations.

VEGETATION
Changes to nutrient cycling, hydrological regimes, and thermal conditions post thaw cause a shift in vegetation type, growth, and distribution.

SOIL CHEMISTRY AND MICROBES
Post thaw changes in the thermal, oxygen, and aquatic environments change microbial communities and soil chemistry. Including the concentration of mercury.

WATER GEOCHEMISTRY, FLOW, STORAGE
Carbon released upon moves into water bodies and affects the geochemistry. Thaw can also affecting the distribution and abundance of water across the landscape.
Thaw-related causal chains are being developed for impacts on:

- Caribou populations (provisioning service)
- Carbon storage (regulating service)
- Land access and land travel (cultural service)
Current food system in northern Canada

Buy

Gameti, NWT

Grow

Norman Wells, NWT

Harvest
There is both a **need** and an **opportunity** to grow more food in the north

*Hannah et al. in press*
NORTHWEST TERRITORIES AGRICULTURE STRATEGY

The Business of Food: A Food Production Plan
2017 – 2022

Current NWT Food Production

PRIVATE ENTERPRISE
GARDENS AND COMMUNITY GREENHOUSES
COMMUNITY-FOCUSED FOOD INITIATIVES

Future Vision for the Food Production Industry

COMMERCIAL
The Business of Food

FOOD PRODUCTION
SECONDARY INDUSTRY DEVELOPMENT

NON-COMMERCIAL
NON-PROFIT COMMUNITY-BASED INITIATIVES
• How is northern soil fertility affected by warming, fire, & thaw?
• How does cultivation affect soil C, nutrients, & water storage?
• Can we best balance food production with boreal forest health?
How does this work inform LTER research & understanding of cross-scale feedbacks?

Local inundation increases connectivity at a landscape scale and ultimately accelerates watershed drainage.
Regions with ice-rich permafrost historically was preferred for infrastructure and travel circuits. Now at high risk from thaw but also likely accelerates thaw.
Thank you

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We are all connected through our environment, including our shared atmosphere.

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