Mass-wasting in the continuous zone of permafrost has minimal legacy effects on mercury export to the Churchill River

Lowland permafrost stores significant amounts of mercury (Hg), and permafrost related disturbances can lead to Hg mobilization methylmercury (MeHg) production. Landslides are occurring in the Hudson Bay Lowlands, but little is known about their long-term impacts on downstream aquatic ecosystems.

- Along a 25 km study transect of the Churchill River, 21 large landslides (>10,000 m^2) are present
- Previous literature shows large increases in aquatic Hg and MeHg downstream of retrogressive thaw slumps in the Western Canadian Arctic.
- Large quantities of sediment were released to the river during failure, and the impact on mercury and methylmercury export to the river is unknown.

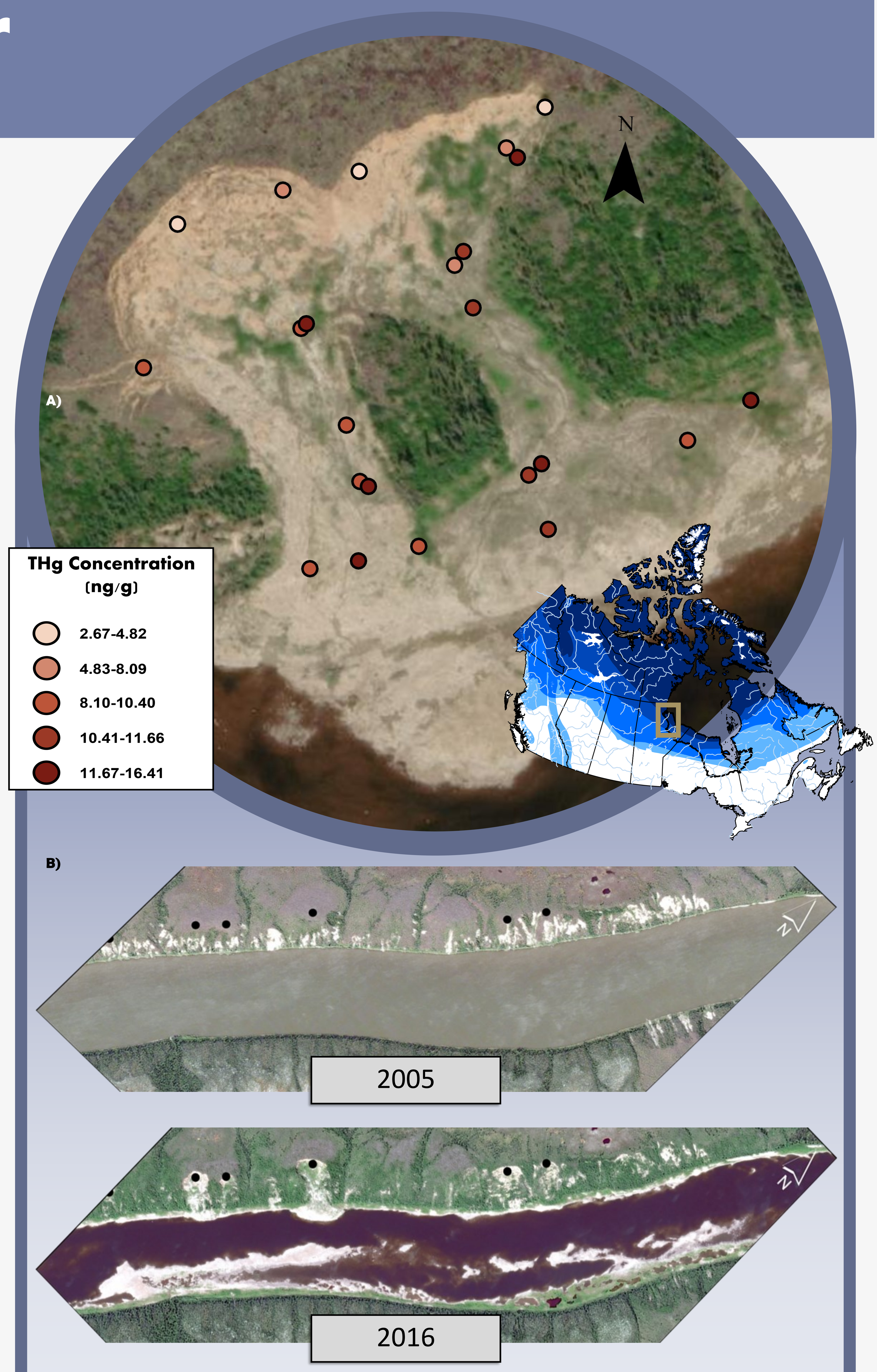
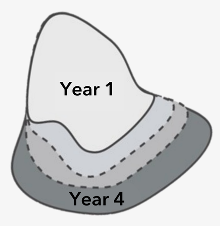


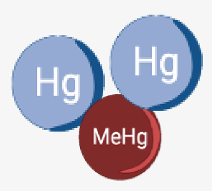
Figure 1: Examples of failures occurring along the Churchill river in Manitoba, Canada, along the continuous-extensive discontinuous transition zone. A) shows concentrations of total mercury (THg) from samples collected from the headwall, ridges, gullies, and from the slump lobe. B) shows the progression of slump growth between 2005 and 2016.

Questions



What is the growth rate of these mass-wasting features?

Do these permafrost thaw features generate environments conducive to Hg methylation?



Are there lasting impacts on mercury export to the river after failure?

Slope failures develop over time

- Incipient failures (<2,500 m^2) were present in 2005, developing into larger failures (>10,000 m^2) by 2016 (Figure 1). Between 2016 and 2022 there was only marginal growth.
- No failures present in 2016 occurred where there weren't incipient failures present in 2005 imagery.
- Several incipient failures present in 2005 stabilized and did not grow into larger failures by 2016 or 2022.

Hg concentrations are low in water and sediment samples

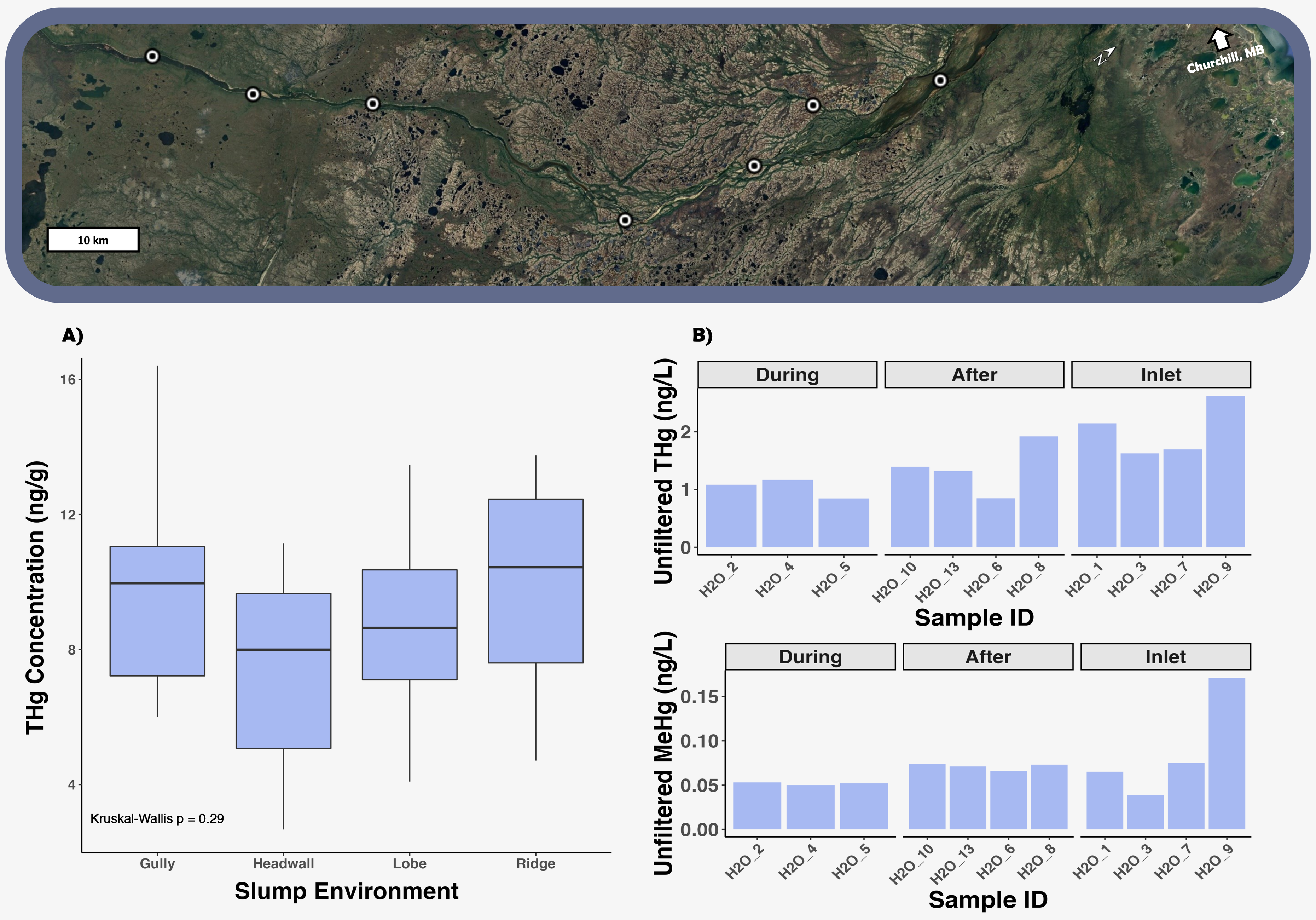


Figure 2: A) Distribution of THg concentration in ng/g from within-slump environments. Gullies, ridges, headwall, and slump lobe samples were taken from two case study sites (n= 5 at each site for each category). There is no significant difference in THg concentration between environments sampled. **B)** Concentrations of THg and MeHg from water samples taken along the Churchill River, during areas of slumping, after slumping had stopped, as well as from tributary streams that flow through thawing lowland permafrost in the HBL

- Concentrations of total mercury (THg) in samples of reworked slump sediment are low (2.6-16.4 ng/g; Figure 1a)
- Only very small increases of THg occur in water samples from after slumping sections of the river
- Sediment THg concentrations between within-slump environments (ridges, gullies, headwall, and slump lobe; Figure 2a) were not significantly different
- Methylmercury (MeHg) was below detection limits for 50 of 58 sediment samples within the slumps
- THg and MeHg is higher at inlets to the main channel from streams flowing through thawing lowland environments (Figure 2b)

➡ After initial failure, slumps likely deliver little THg and MeHg to the Churchill River, while thawing lowland thermokarst is a continuous source through drainage via inlets.

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