

THAWING PERMAFROST, CHANGING COMMUNITIES IN CANADA

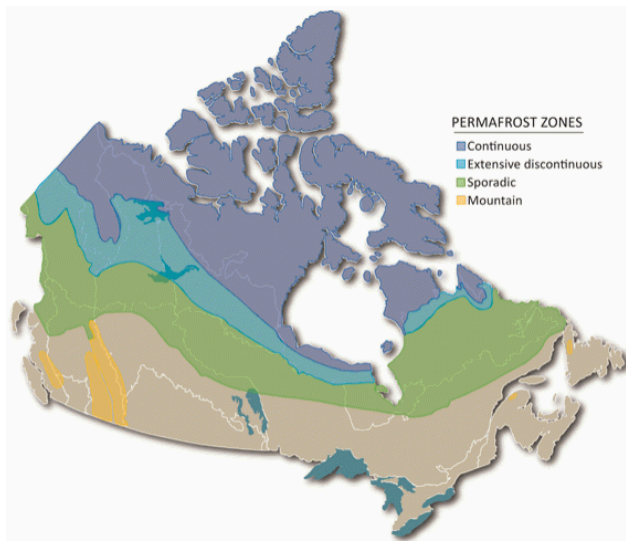
An Infographic by Grace Ma

70%

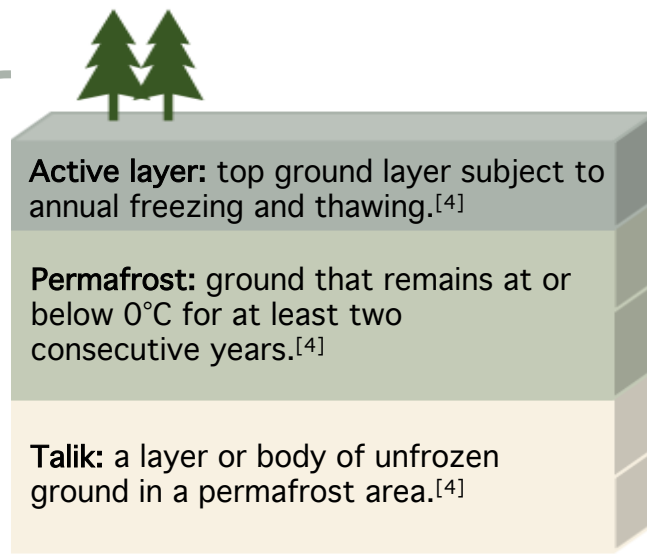
Of Canada's area is considered "permafrost region", mainly in the Arctic.^[3]

4°C

Estimated warming of the Arctic if global temperatures warm by 2°C.^[11]



Apart from the light brown area, all other coloured areas are permafrost regions in Canada.^[17]



Estimated changes by the year 2100:

Increase by 0.3–0.7 m (41%–104%).^[16]

Decrease of 16.0–19.7% in extent.^[16]
Decrease of 1.9–5.0 m in thickness.^[16]

Increase exponentially in areas of persistent permafrost.^[16]

CARBON & MERCURY

Permafrost serves many physical and environmental functions, including acting as storage to elements. With thaw, elements like carbon and mercury will be released.

Carbon (C)

50%

Percentage of world's soil carbon found in Arctic soils.^[3]

2040

Before this year, biomass increase might override release of carbon from thawing permafrost. Longer timescales show carbon release surpassing biomass gains.^[3]

IMPACTS

- Possible positive feedback loops of carbon release (such as with methane) from thawing permafrost could exacerbate global warming.^[8]
- The entire global community will be impacted.

Mercury (Hg)

793 Gg

The estimated amount of Hg frozen in permafrost. This is twice the Hg in all other soils, ocean and atmosphere combined.^[12]

Hg(0)

Reduced form of mercury that can easily evaporate into atmosphere due to high volatility.^[2]

IMPACTS

- Inhalation of vaporized mercury.^[6]
- Mercury being introduced in river systems, which could introduce mercury to food sources.^[6]

COMMUNITY INFRASTRUCTURE

Nearly 4 million people and 70% of current infrastructure in permafrost areas belong in areas where thaw of near-surface permafrost is likely by 2050.^[5]



Two Affected Communities:

Tuktoyaktuk, NT

- One of the first communities in Canada facing relocation due to coastal erosion from permafrost thaw and sea level rise.^[10]
- In 2018, the town received 800 000\$ to move 4 houses 6 km away.^[10]

Inuvik, NT

- House stilts now need to be driven down fifteen to twenty metres for a stable foundation – before, five to six meters was enough.^[7]

IMPACTS

PHYSICAL HEALTH

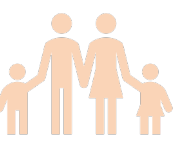
- Structural and pipe damage in water storage facilities due to thawing permafrost can lead to:
- Contamination of water supply.^[15]
 - Inoperable water distribution system.^[15]

RELOCATION

- Difficulties in adapting to new ways of living.^[15]
- Potential unemployment.^[15]
- Losses in traditional and cultural practices.^[15]

MENTAL HEALTH

- "Being on the land" enhances mental health of Inuit youth.^[9]
- Changing landscapes due to permafrost thaw, from erosion to drained lakes^[14], might negatively impact mental health of local people.



\$51 million

Estimated cost of public infrastructure damage due to thawing permafrost in the North-West Territories every year.^[1]

MOVING FORWARD WITH PERMAFROST RESEARCH

Incorporate Indigenous Knowledge in research. Dene people call this: *łeghágots'enetę*, which means "learning together."^[13]

Fund more monitoring sites for permafrost measurement.^[14]

Build more holistic models of permafrost thaw.^[14]

SOURCES

- [1] Beers, Randi. (2017, Nov 20). Thawing permafrost causes \$51M in damages every year to N.W.T. public infrastructure: Study. *CBC News*. Retrieved from <https://www.cbc.ca/news/labrador>.
- [2] Ci, Z., Peng, F., Xue, X., & Zhang, X. (2016). Air-surface exchange of gaseous mercury over permafrost soil: an investigation at a high-altitude (4700 m a.s.l.) and remote site in the central Qinghai-Tibet Plateau. *Atmospheric Chemistry and Physics*, 16(22), 14741–14754. doi: 10.5194/acp-16-14741-2016
- [3] Christenson, T.R., Søren Rysgaard... Jorien E. Vonk. (2017.) Arctic Carbon Cycling. In *Snow, Water, Ice and Permafrost in the Arctic (SWIPA) 2017*. Retrieved from <https://www.amap.no/documents/download/2987/inline>
- [4] Harris, S.A., H.M. French, J.A. Heginbottom, G.H. Johnston, B. Ladanyi, D.C. Sego, R.O. van Everdingen. (1988) Glossary of Permafrost and Related Ground-Ice Terms. National Research Council Canada. Retrieved from http://globalcryospherewatch.org/reference/docs/permafrost_and_ground_terms_canada.pdf
- [5] Hjort, J., Karjalainen, O., Aalto, J., Westermann S., Romanovsky, V.E., Nelson, F.E... Luoto, M. Degrading permafrost puts Arctic infrastructure at risk by mid-century. *Nature Communications* 9.
- [6] Ji, X., Abakumov, E., & Polyakov, V. (2019). Assessments of pollution status and human health risk of heavy metals in permafrost-affected soils and lichens: A case-study in Yamal Peninsula, Russia. *Arctic, Human and Ecological Risk Assessment: An International Journal*, 25(8), 2142–2159. doi: 10.1080/10807039.2018.1490887
- [7] Lamb, David Michael. (2017, Apr 17). 'It scares me': Permafrost thaw in Canadian Arctic sign of global trend. *CBC News*. Retrieved from <https://www.cbc.ca/news>
- [8] Lara, M. J., Lin, D. H., Andresen, C., Lougheed, V. L., & Tweedie, C. E. (2019). Nutrient Release From Permafrost Thaw Enhances CH4 Emissions From Arctic Tundra Wetlands. *Journal of Geophysical Research: Biogeosciences*, 124(6), 1560–1573. doi: 10.1029/2018jg004641
- [9] Macdonald, J. P., Willox, A. C., Ford, J. D., Shiwak, I., & Wood, M. (2015). Protective factors for mental health and well-being in a changing climate: Perspectives from Inuit youth in Nunatsiavut, Labrador. *Social Science & Medicine*, 141, 133–141. doi: 10.1016/j.socscimed.2015.07.017
- [10] Murray, W. (2019, Nov 4). This Arctic Community Is Literally Falling Into the Ocean. *Vice*. Retrieved from <https://www.vice.com>
- [11] Overland, J., Dunlea, E. Box, J.E., Corell R., Forsius, M., Kattsov, V... Wang, M. (2019). The urgency of Arctic change. *Polar Science*, 21, 6–13. <https://doi.org/10.1016/j.polar.2018.11.008>
- [12] Schuster, P.F., Schaefer, K. M., Aiken, G.R., Antweiler, R.C., Dewild, J.F., Gryziec, J.D... Zhang, T. (2018). Permafrost Stores a Globally Significant Amount of Mercury. *Geophysical Research Letters*, 45(3), 1463–1471. <https://doi.org/myaccess.library.utoronto.ca/10.1002/2017GL075571>
- [13] Thomson, J. (2019, June 20). Meet the scientists embracing traditional Indigenous knowledge. *The Narwhal*. Retrieved from <https://thenarwhal.ca/>
- [14] Turetsky M.R., Abbott B.W., Jones M.C., Anthony K.W., Olefeldt D., Schuur E.A.G... Sannel, A.B.K. (2019). Permafrost collapse is accelerating carbon release. *Nature*, 569, 32–34. doi: 10.1038/d41586-019-01313-4
- [15] Warren, J.A., Berner, J. E. & Curtis, T. (2005) Climate change and human health: infrastructure impacts to small remote communities in the north. *International Journal of Circumpolar Health*, 64(5), 487–497. <https://doi.org/10.3402/ijch.v64i5.18030>
- [16] Zhang, Y., Chen, W., & Riseborough, D. W. (2008). Transient projections of permafrost distribution in Canada during the 21st century under scenarios of climate change. *Global and Planetary Change*, 60(3–4), 443–456. <https://doi.org/10.1016/j.gloplacha.2007.05.003>
- [17] Diagram: Reprinted from: "Trends in permafrost conditions and ecology in northern Canada," by S. Smith, *Canadian Councils of Resource Ministers*, 2010, Retrieved from <https://biodycanada.chm-cbd.net/ecosystem-status-trends-2010/technical-report-9>