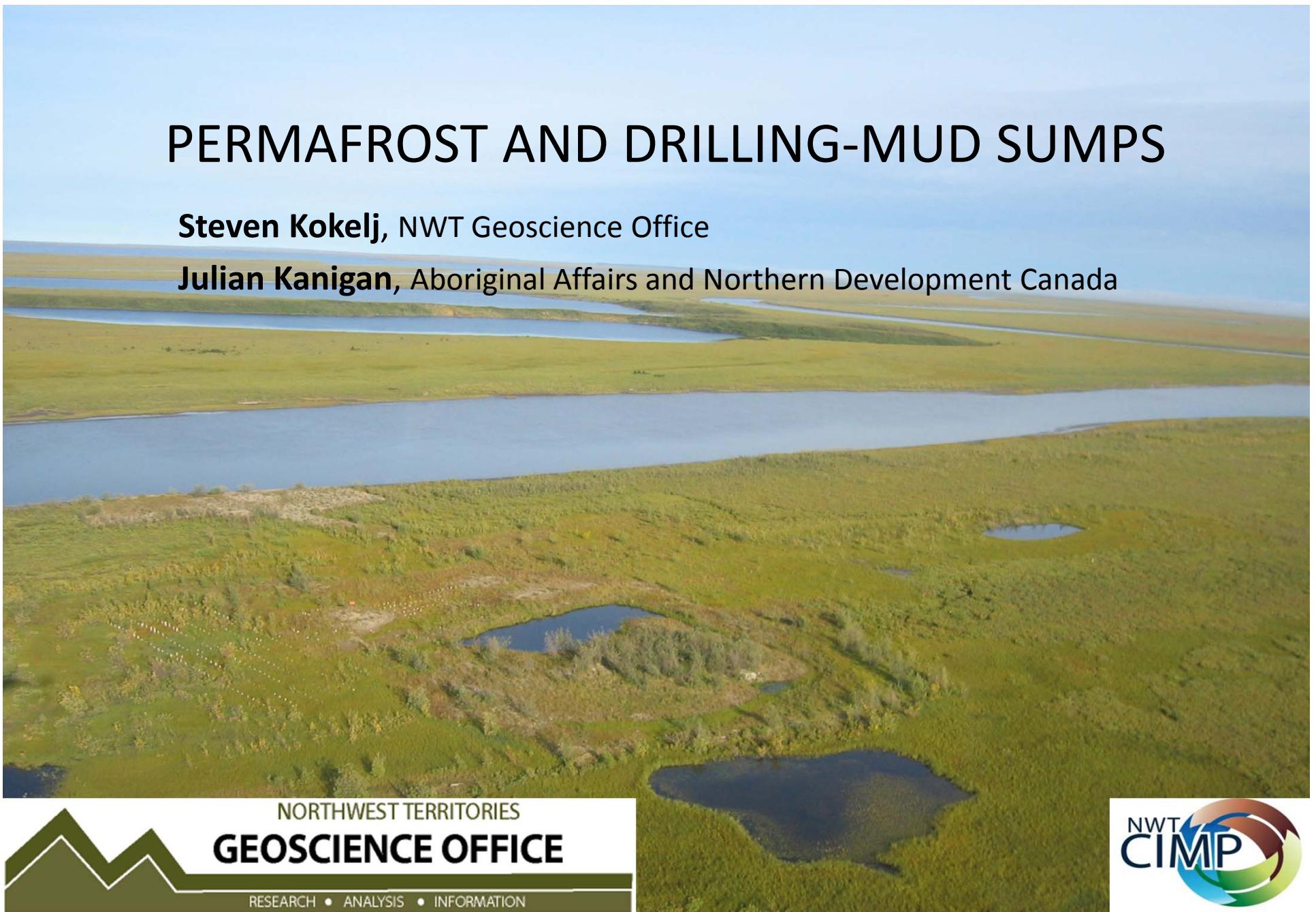


PERMAFROST AND DRILLING-MUD SUMPS

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Julian Kanigan, Aboriginal Affairs and Northern Development Canada



Indian and Northern
Affairs Canada

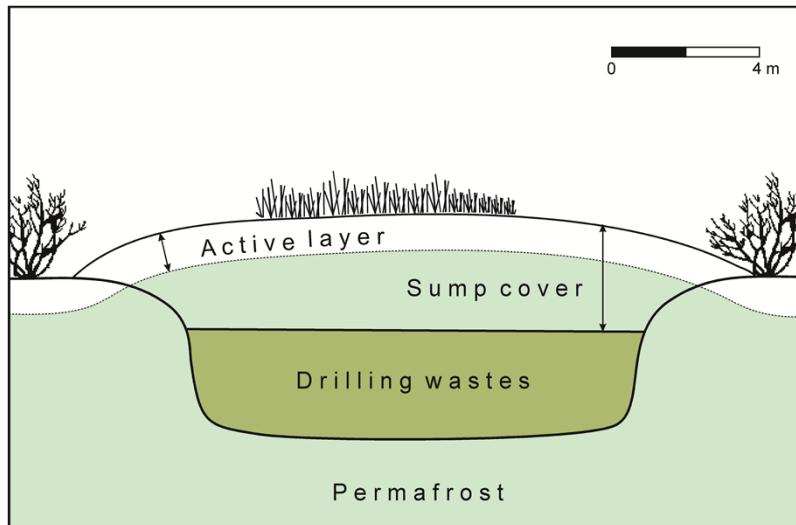
Affaires Indiennes
et du Nord Canada

Overview

- What is a drilling-mud sump?
- Sumps in the Mackenzie Delta region
 - Development context
 - Permafrost context
- Past performance and monitoring
- Disturbance-vegetation-snow feedback
 - Historical infrastructure – hotspots for shrubification
 - Field data and numerical analysis
 - Permafrost cooling
- Summary and conclusions

Drilling-mud sums

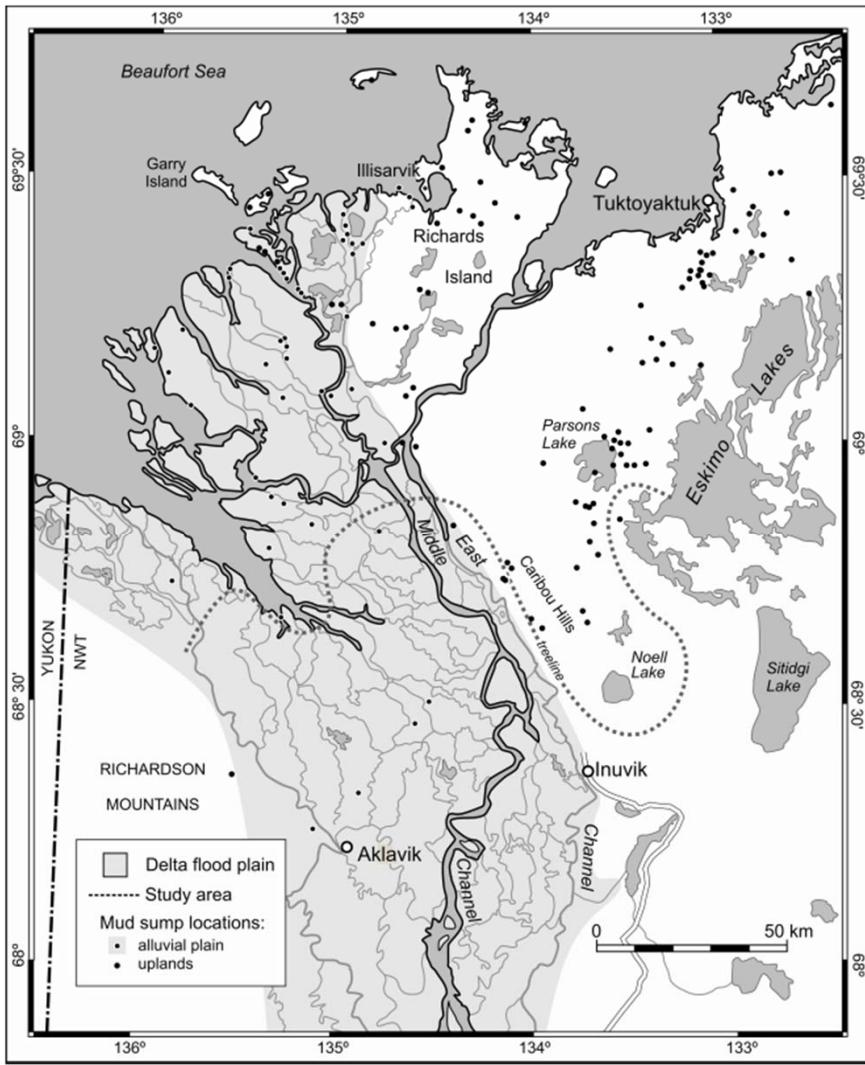
- Sumps are intended to encapsulate drilling wastes in frozen ground
- Subsidence of covers indicates that the permafrost has degraded
- Continues to be an option for waste disposal



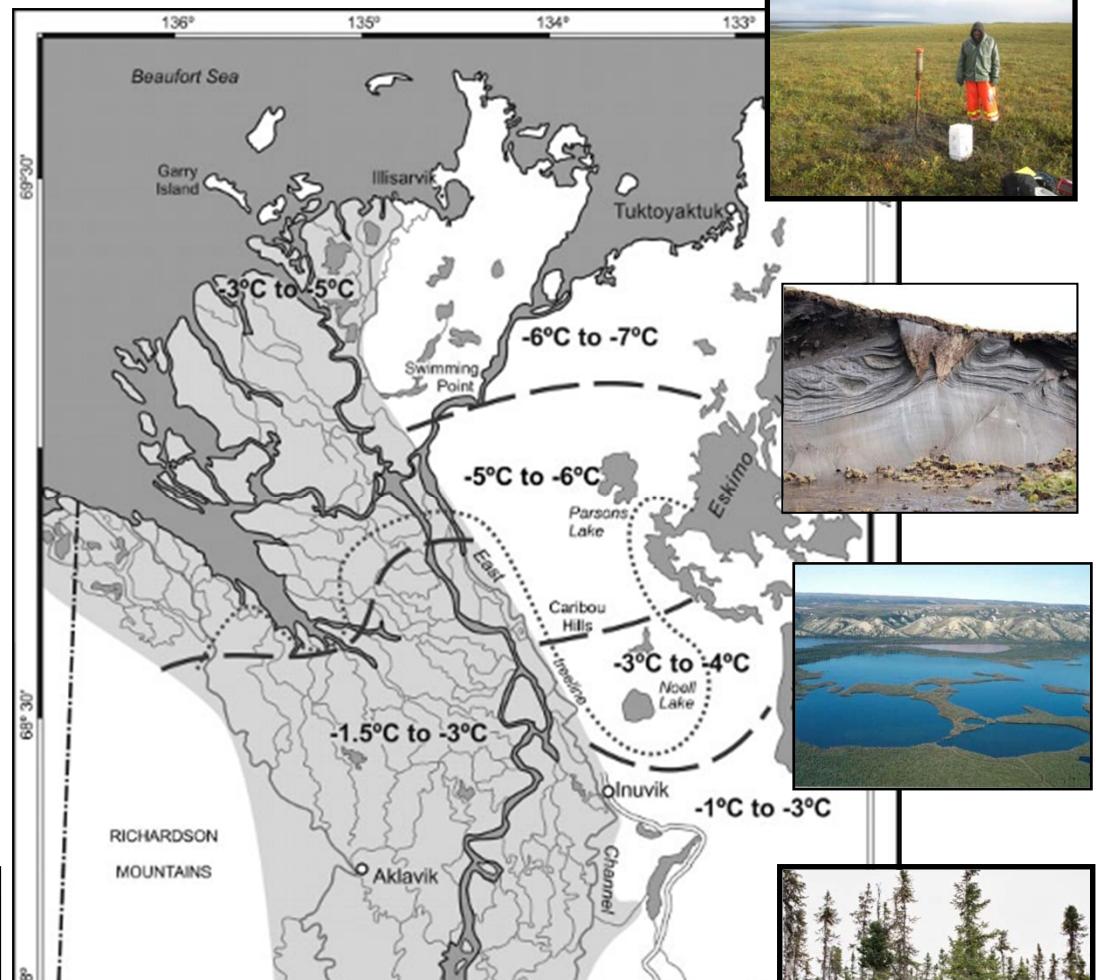
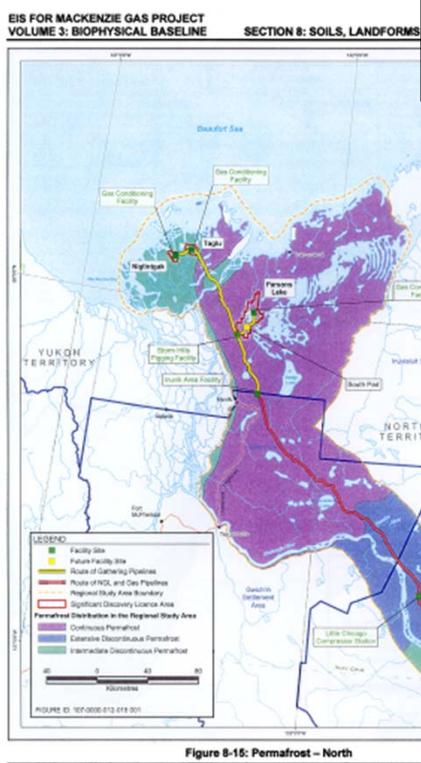
Jenkins et al. 2008



Drilling-mud sums



The context



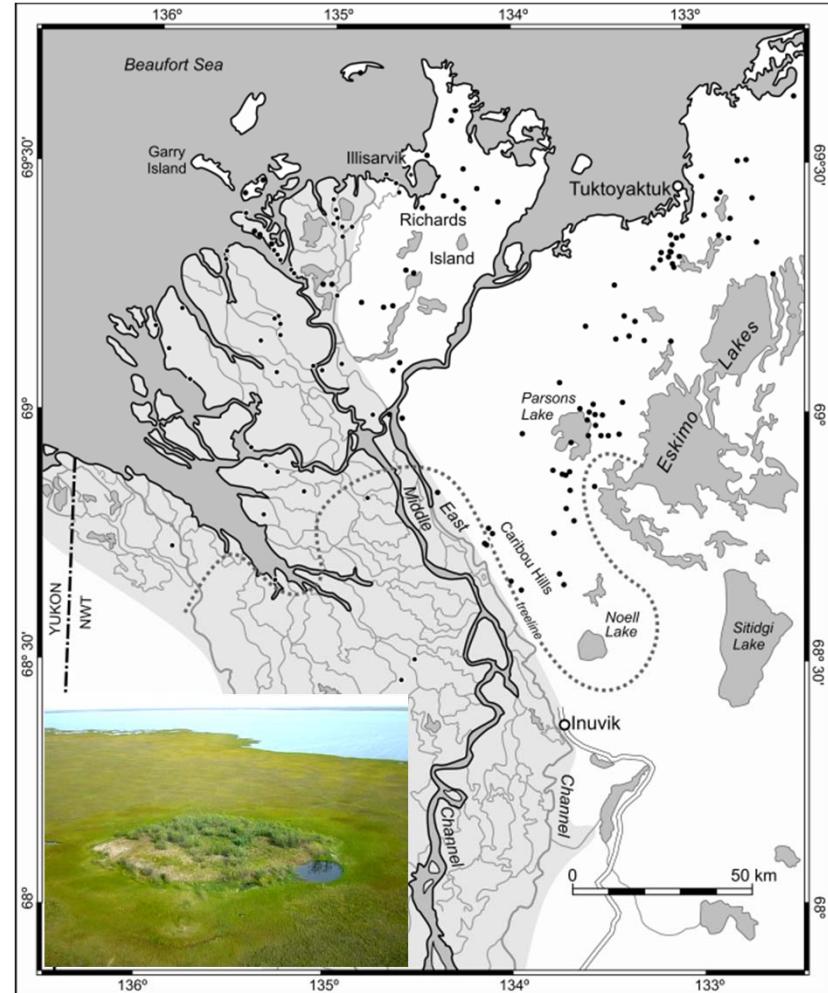
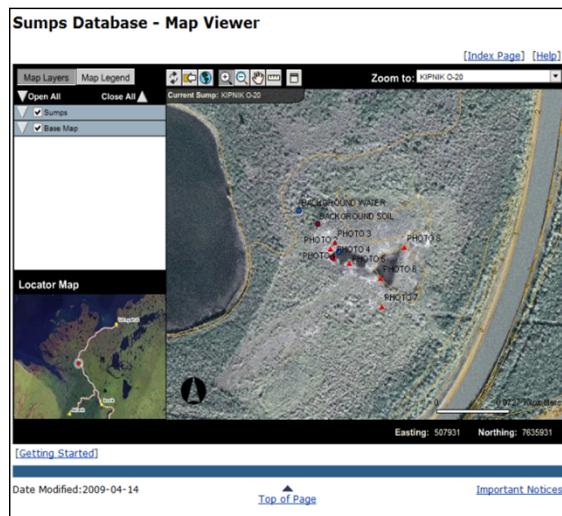
Sump issues

- Historical sums
- Contemporary monitoring
- Viability as a future option for disposal of wastes
- Concern regarding environmental impacts



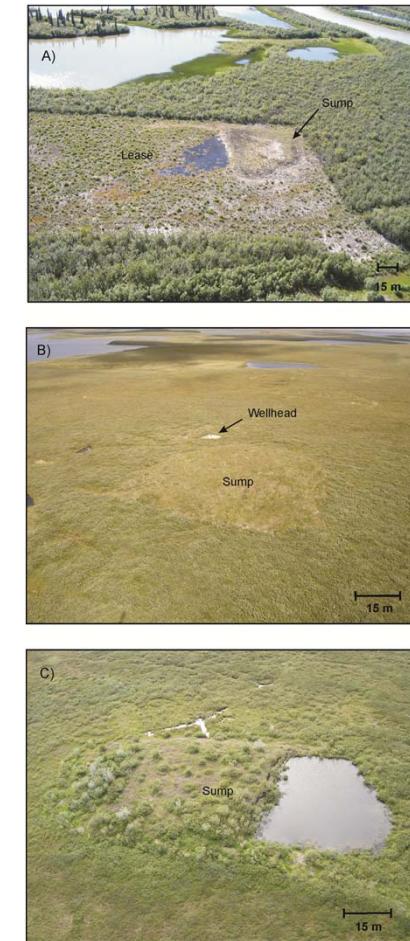
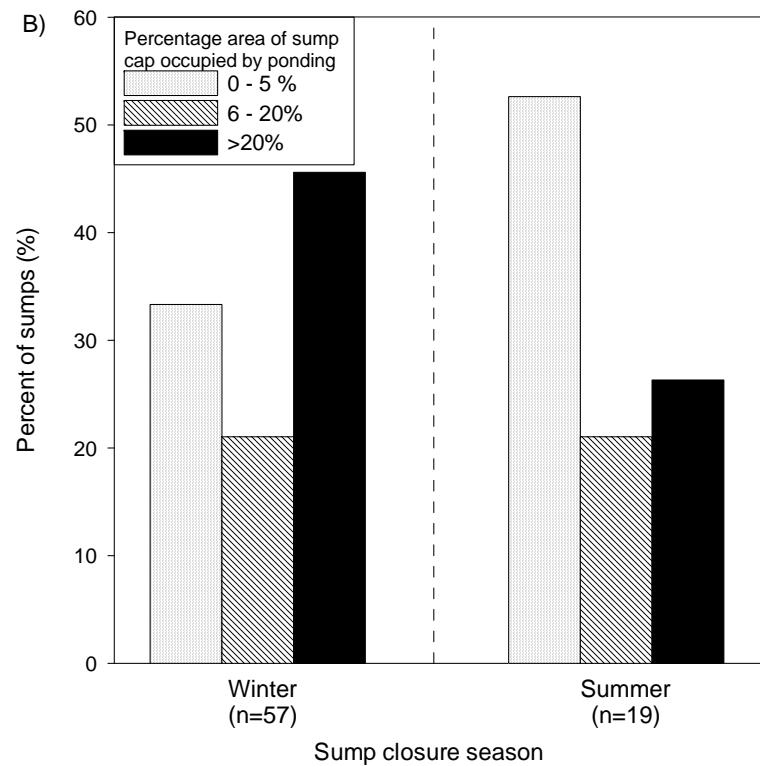
Assessment of historical drilling-mud sumsps

- Environmental Studies Research Fund (ESRF)
- Multi-party technical advisory group
- Desktop inventory & field assessment
- Sumps database: <http://ssc-btc.inac.gc.ca/sumps>



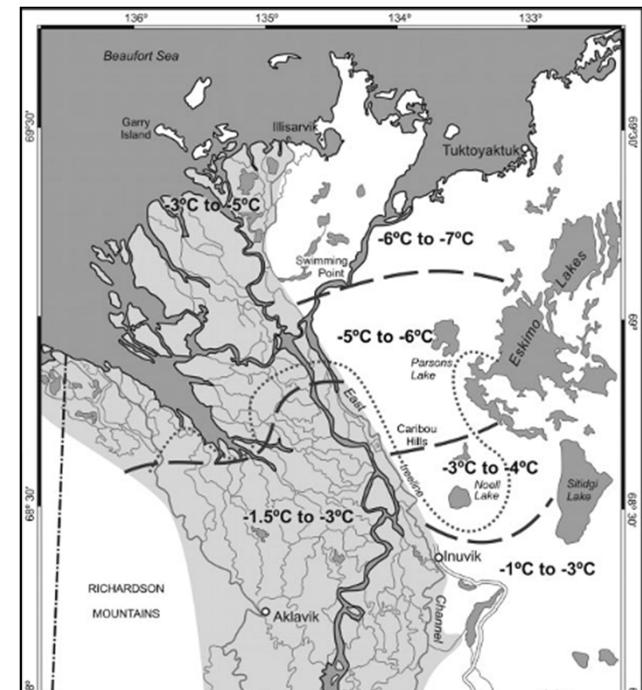
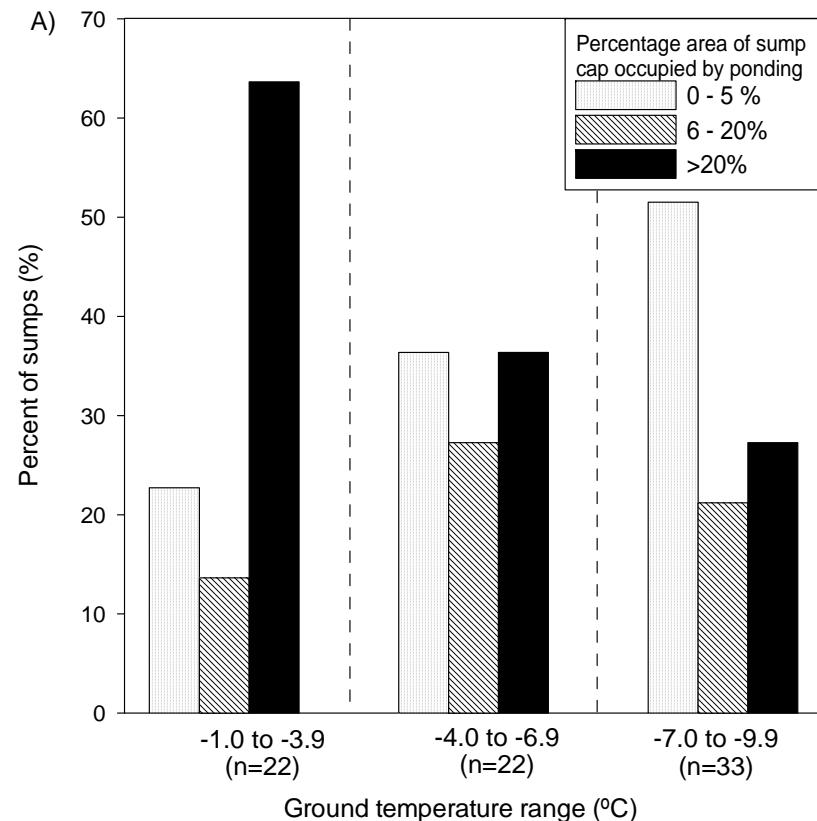
Construction practices

- No significant association between cap ponding and timing of sump closure



Environmental conditions

- Significant association between cap ponding and permafrost temperature



Progressive change over time



Climate warming or vegetation change?

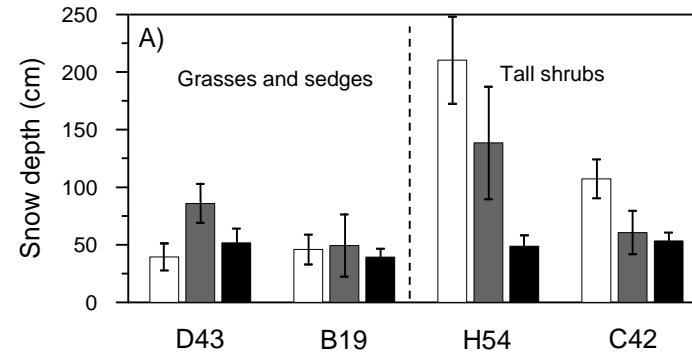


Grasses

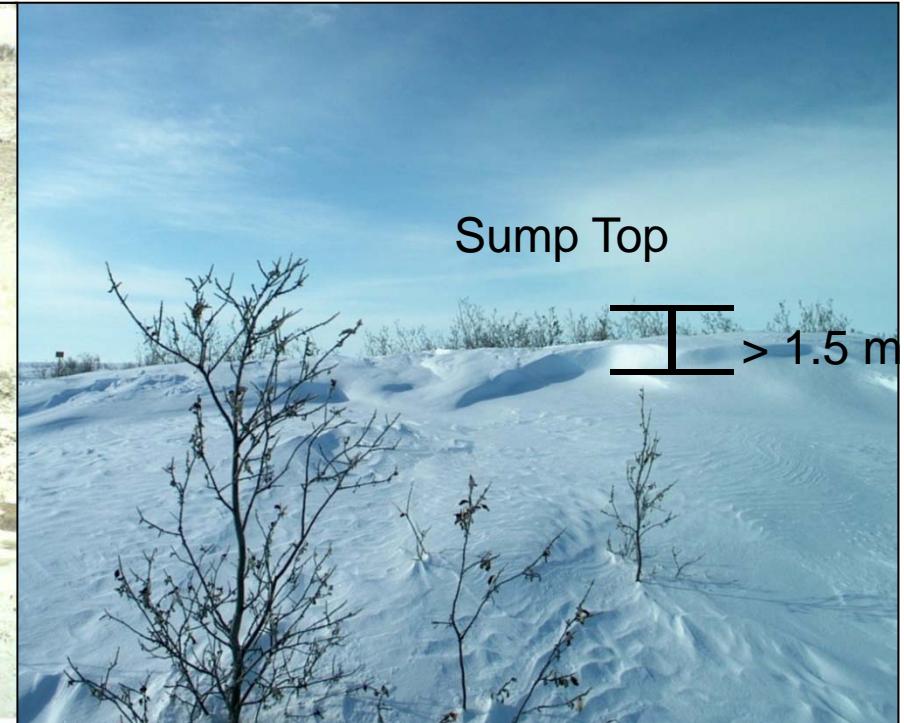


Tall shrubs

Snow accumulation on sums

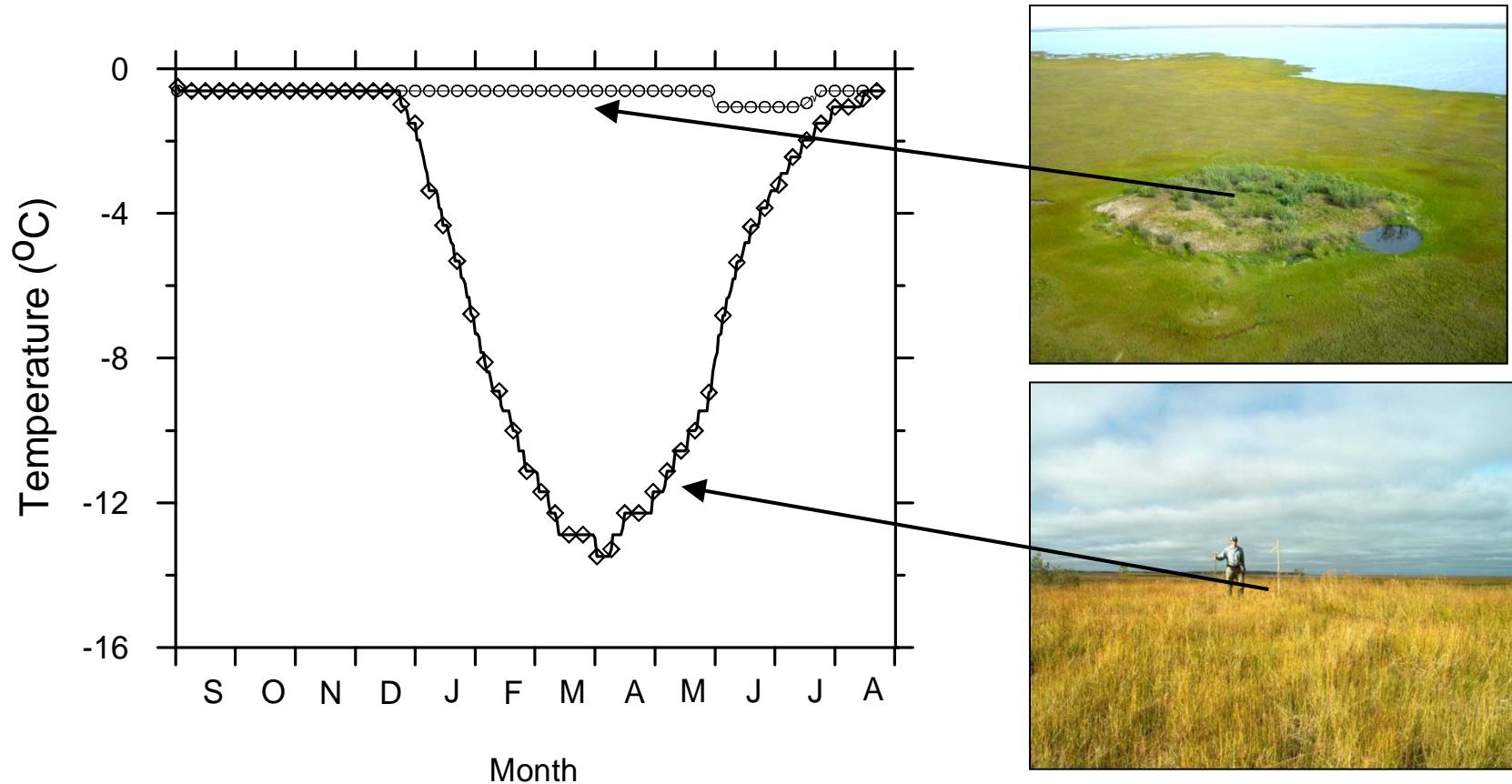


Unvegetated cap



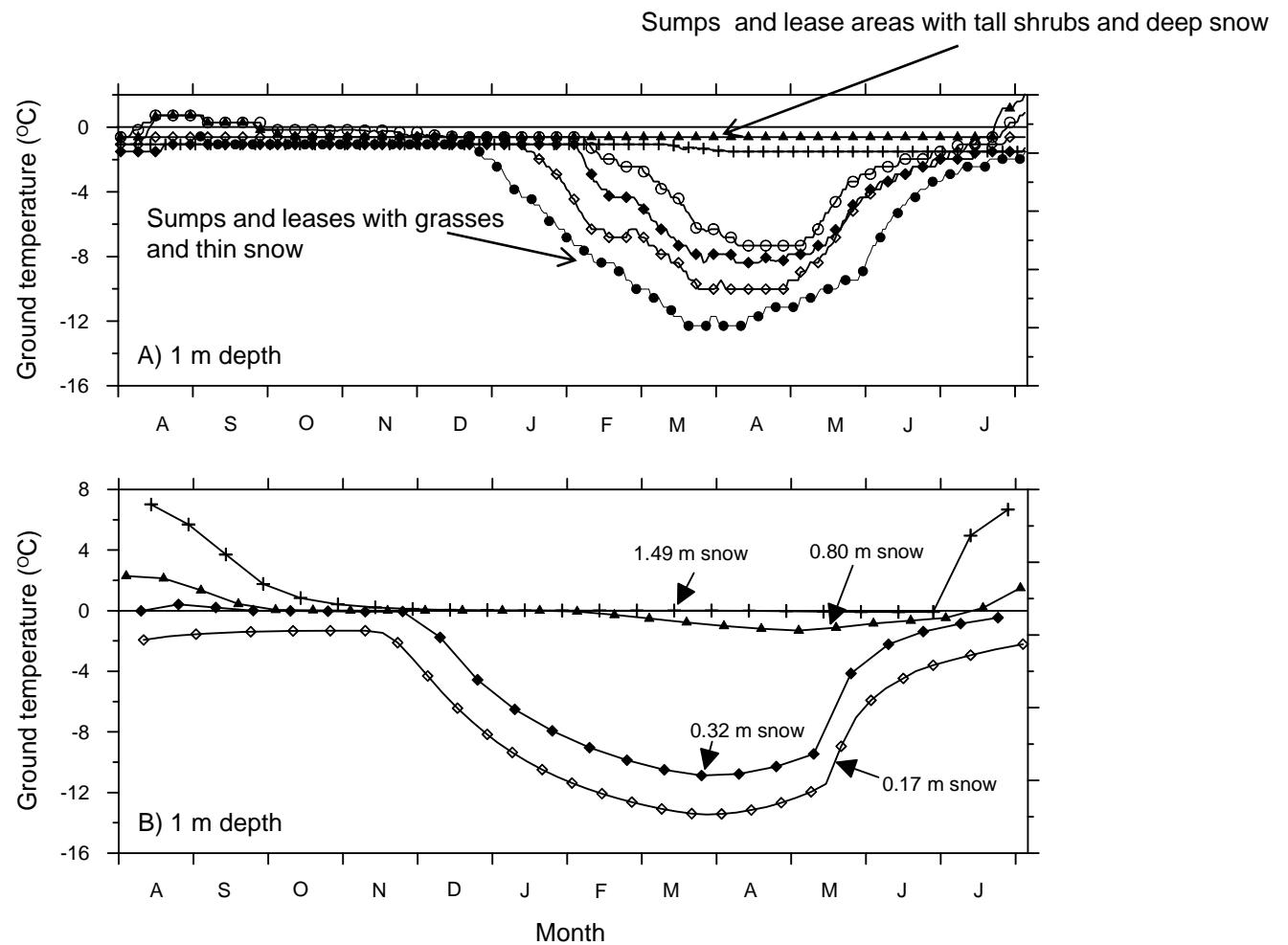
Cap with tall shrubs

Temperature at the top of permafrost in two sumps



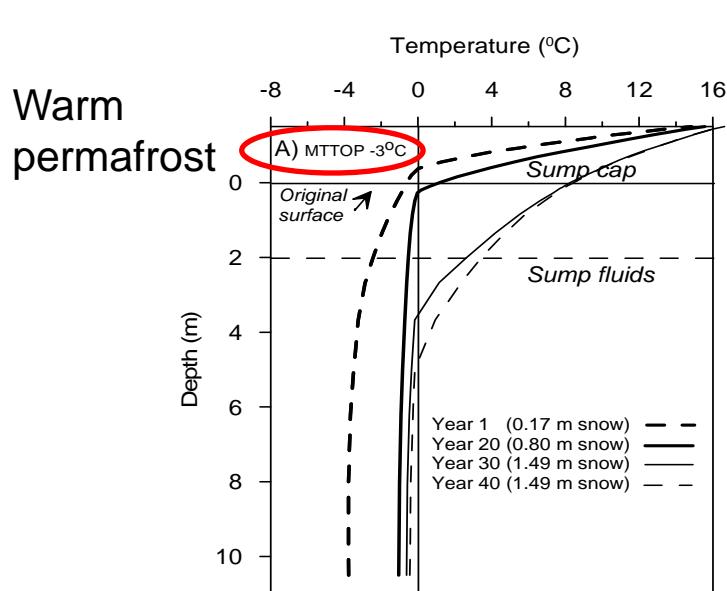
Sump ground temperatures at 1-m depth

Field data

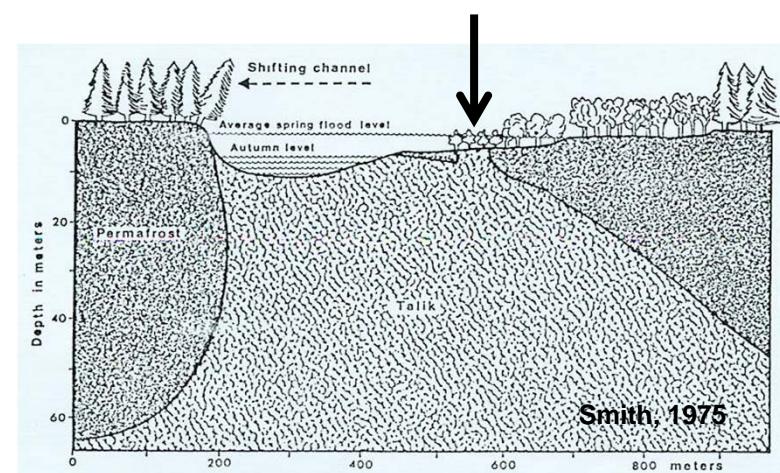
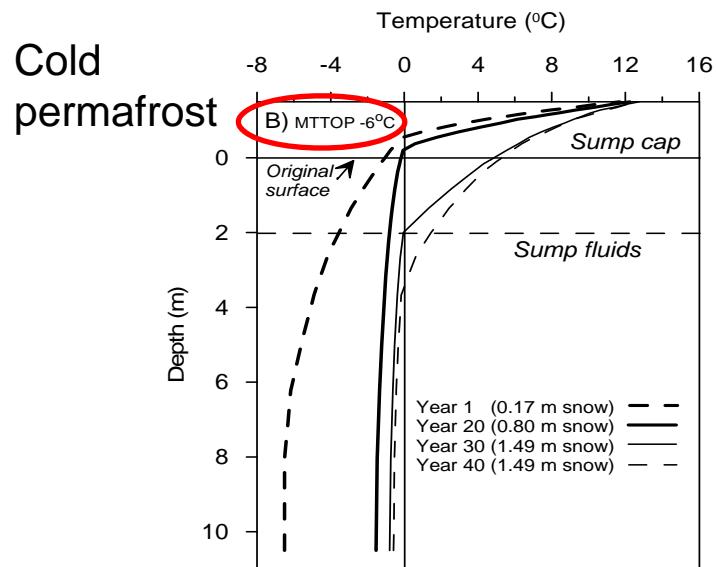


Modeled data

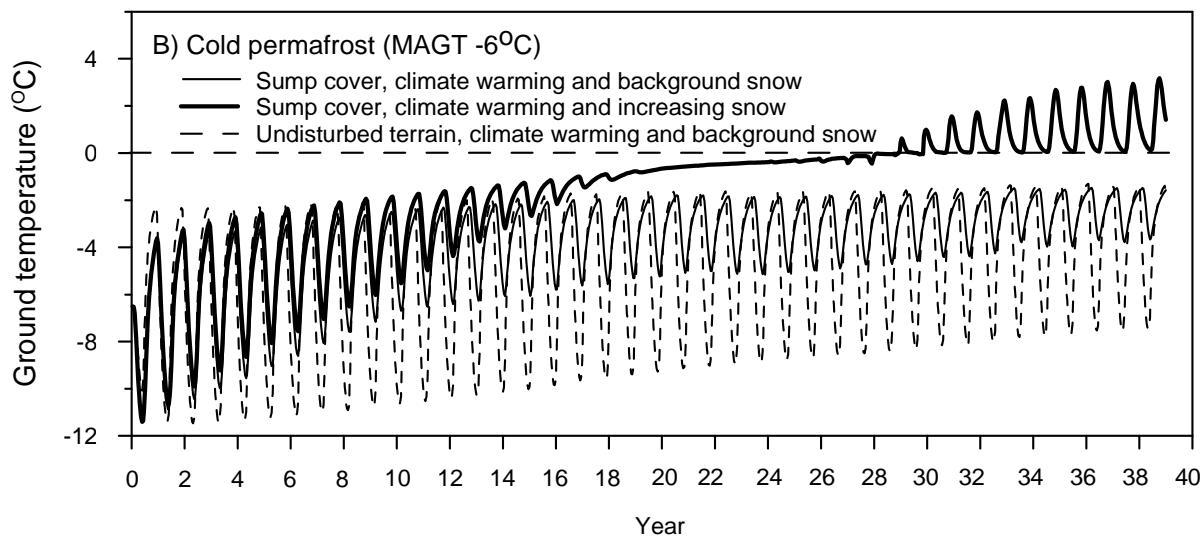
Increasing snow and sump ground temperatures



Field corroboration

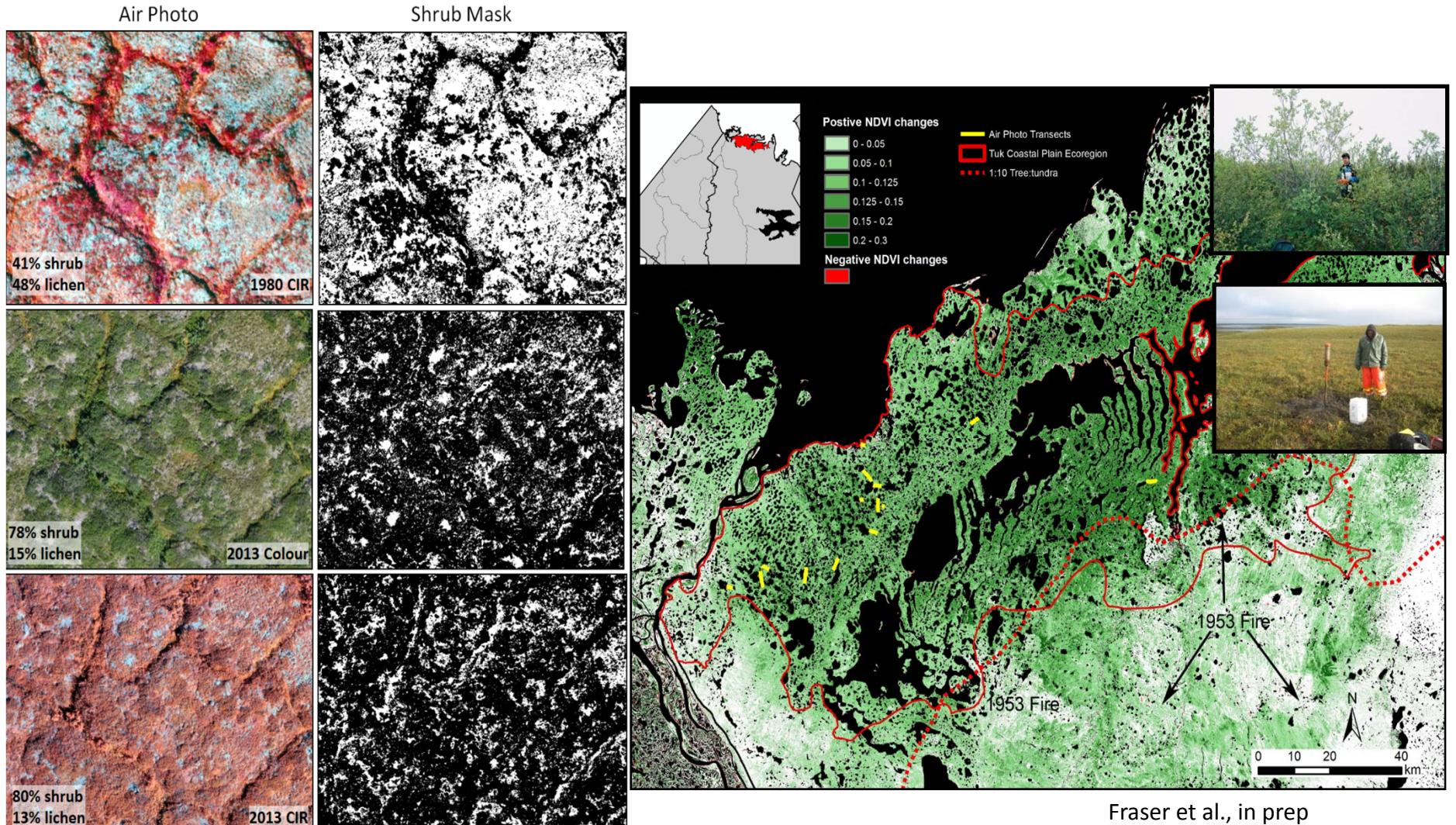


Climate warming effects are less abrupt than changing shrub cover

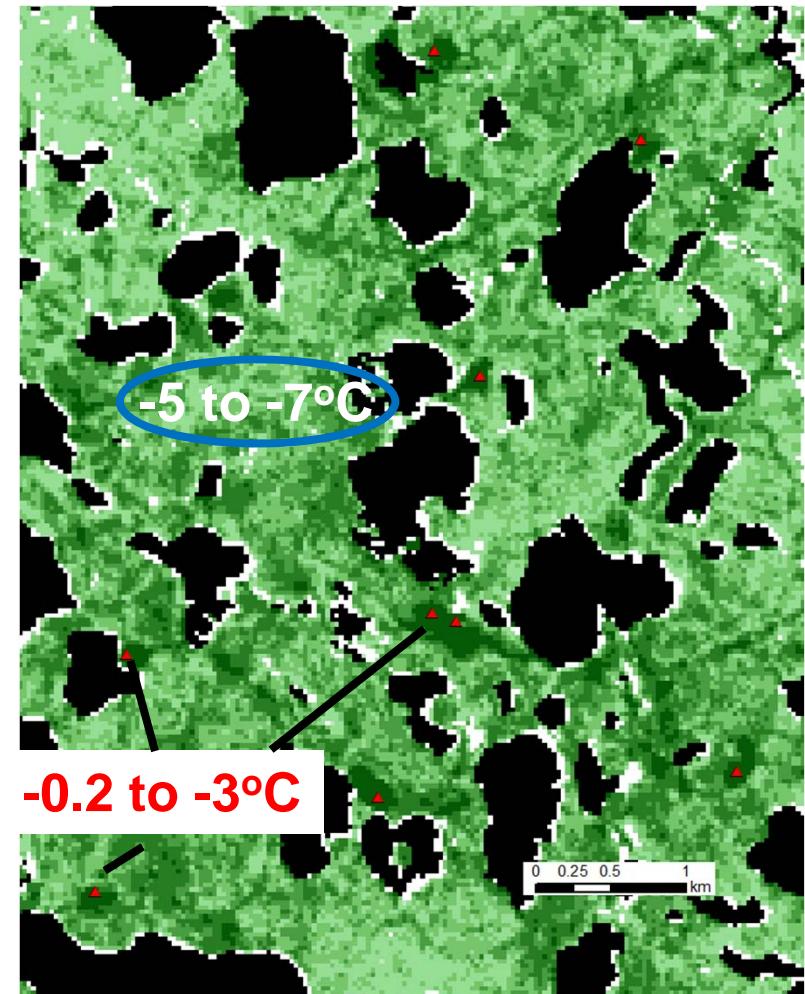


Cold permafrost (-6.0°C)	Undisturbed	Sump – climate warming	Sump - increasing snow	Sump – increasing snow and climate warming
Do sump fluids thaw and when?	No	Not by year 40	Yes – year 30	Yes – year 25

Climate warming and vegetation - Tundra greening

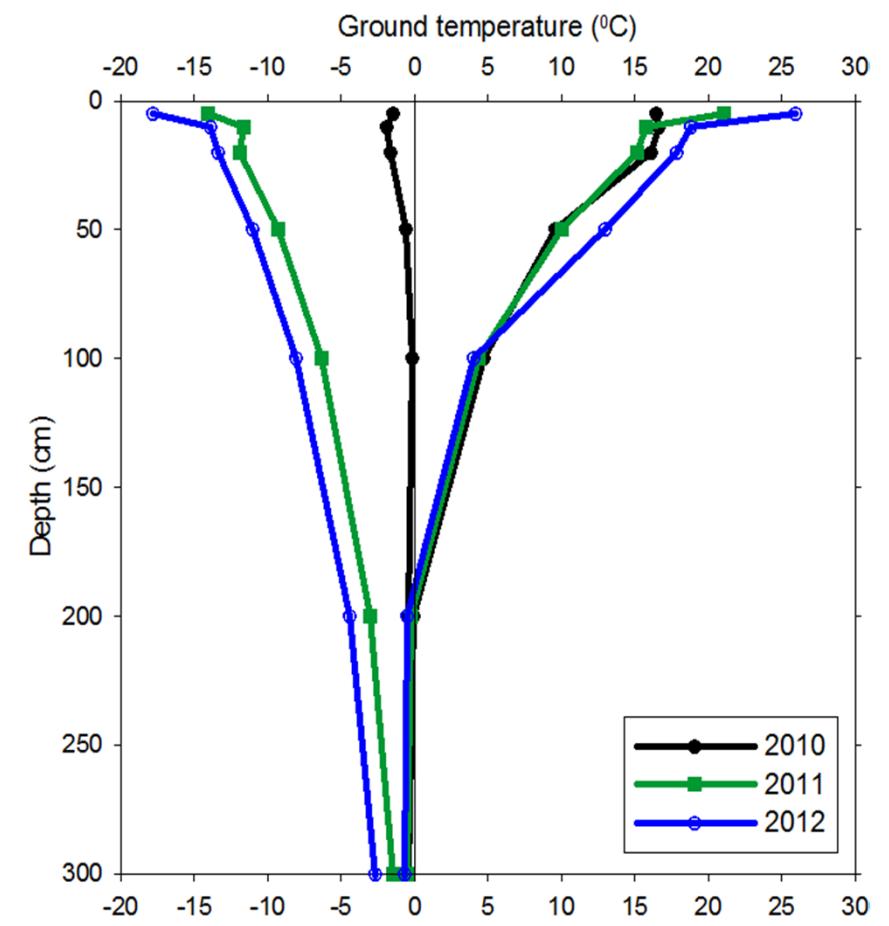


Human disturbance – ↑shrub - ↑snow -
permafrost warming



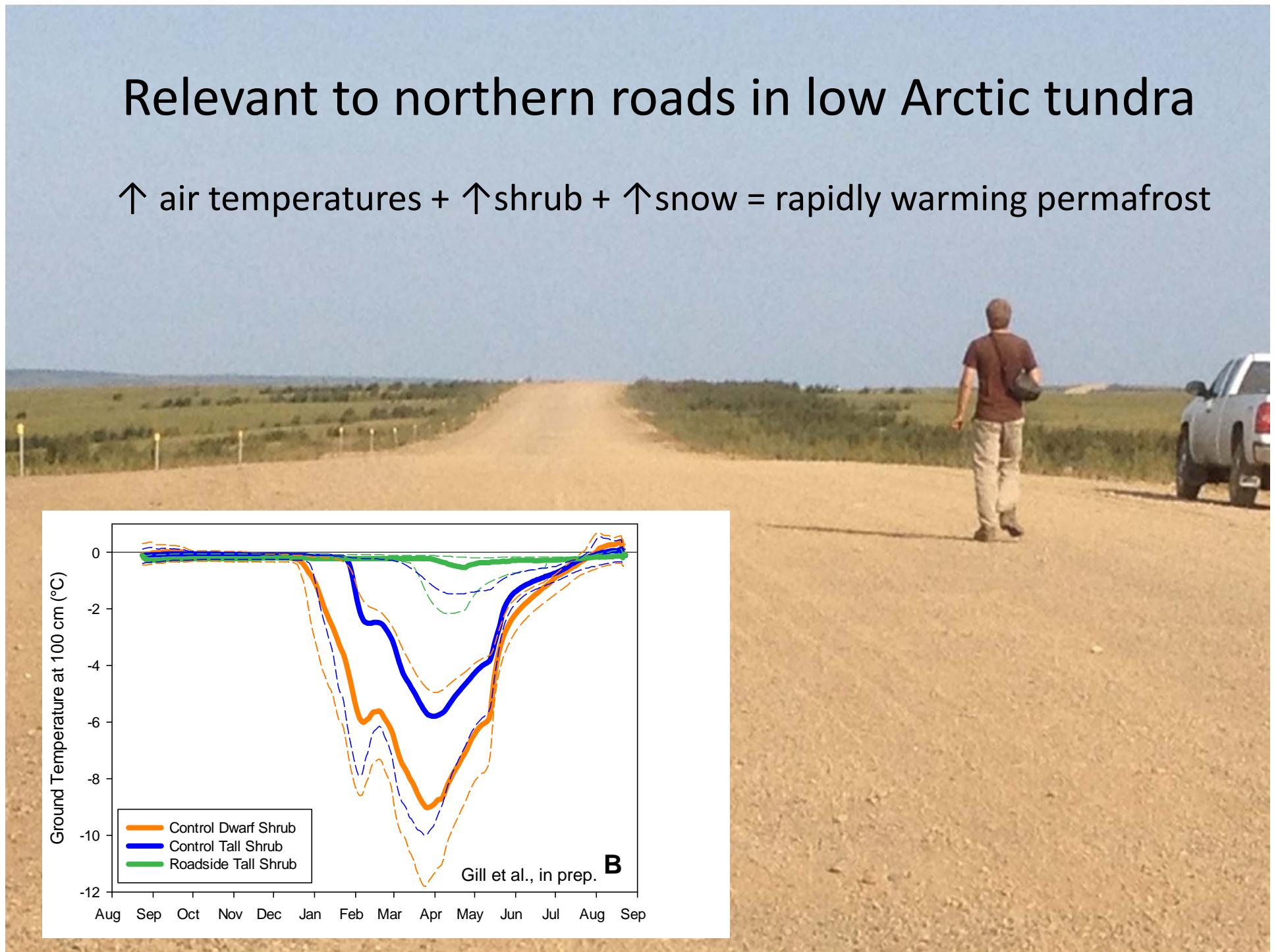
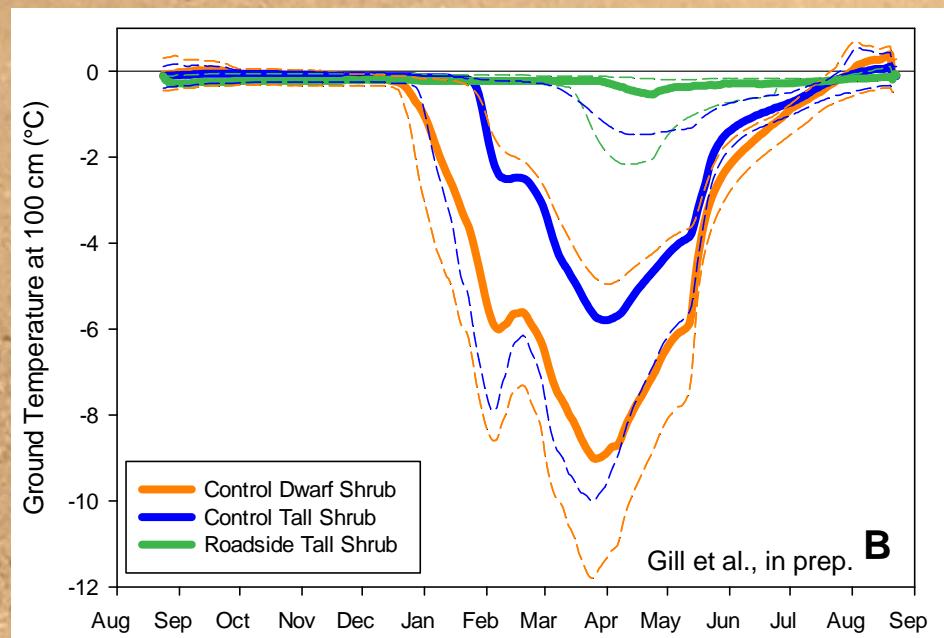
From R. Fraser, CCRS

Remove shrubs and cool the permafrost



Relevant to northern roads in low Arctic tundra

↑ air temperatures + ↑shrub + ↑snow = rapidly warming permafrost



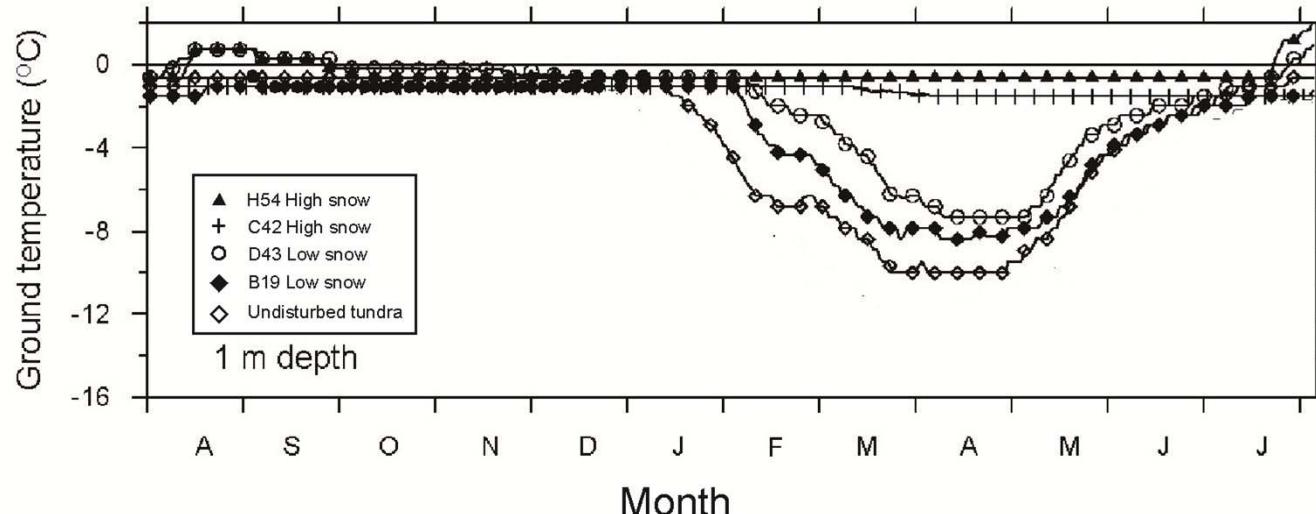
Conclusions

- Regarding long-term sump performance – local permafrost conditions matter



Conclusions

- Shrub growth and thick snow accumulation on sump covers causes permafrost to warm, and eventually to thaw at decadal time scales
- Climate warming takes us to the same end point, but not as rapidly as ecological change



Conclusions

- If permanent freezing of drilling wastes is a primary disposal objective then alternatives must be considered for subarctic and low Arctic regions



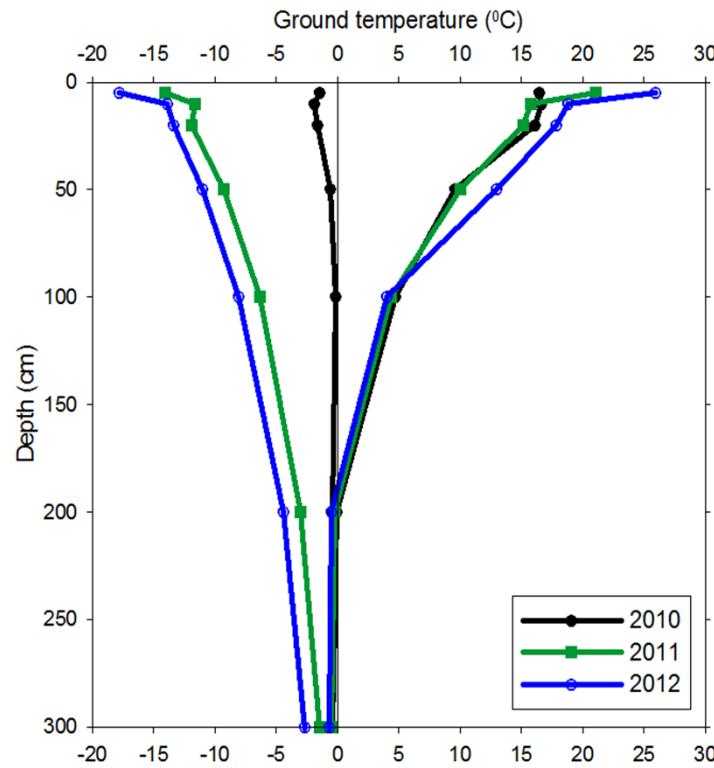
Conclusions

- Human disturbances in the low Arctic are permafrost warming hotspots due to the “shrub – snow – ground warming feedback”



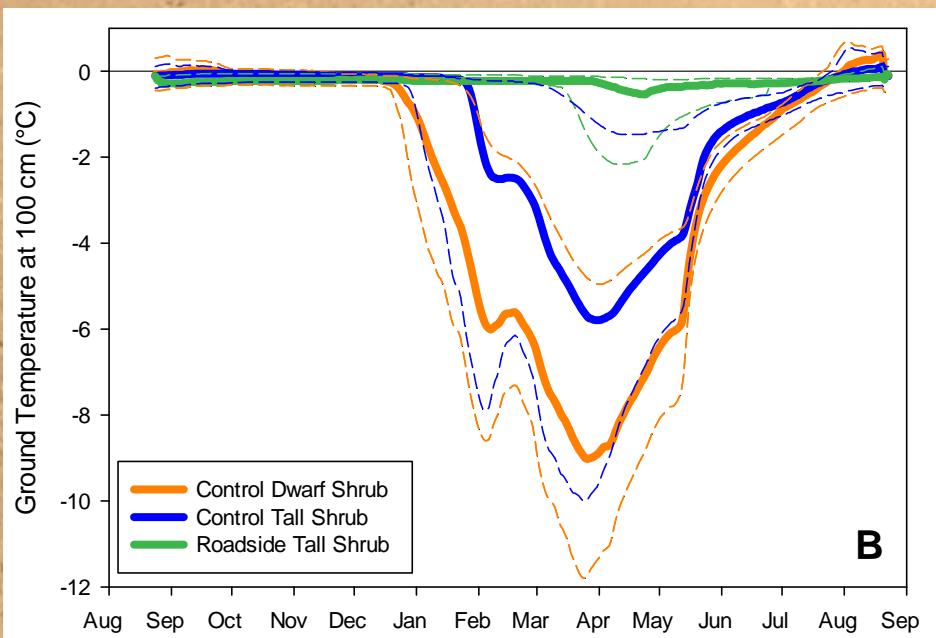
Conclusions

- In the low Arctic, shrub removal can decrease snow accumulation, promote ground heat loss and cause permafrost temperatures to decrease

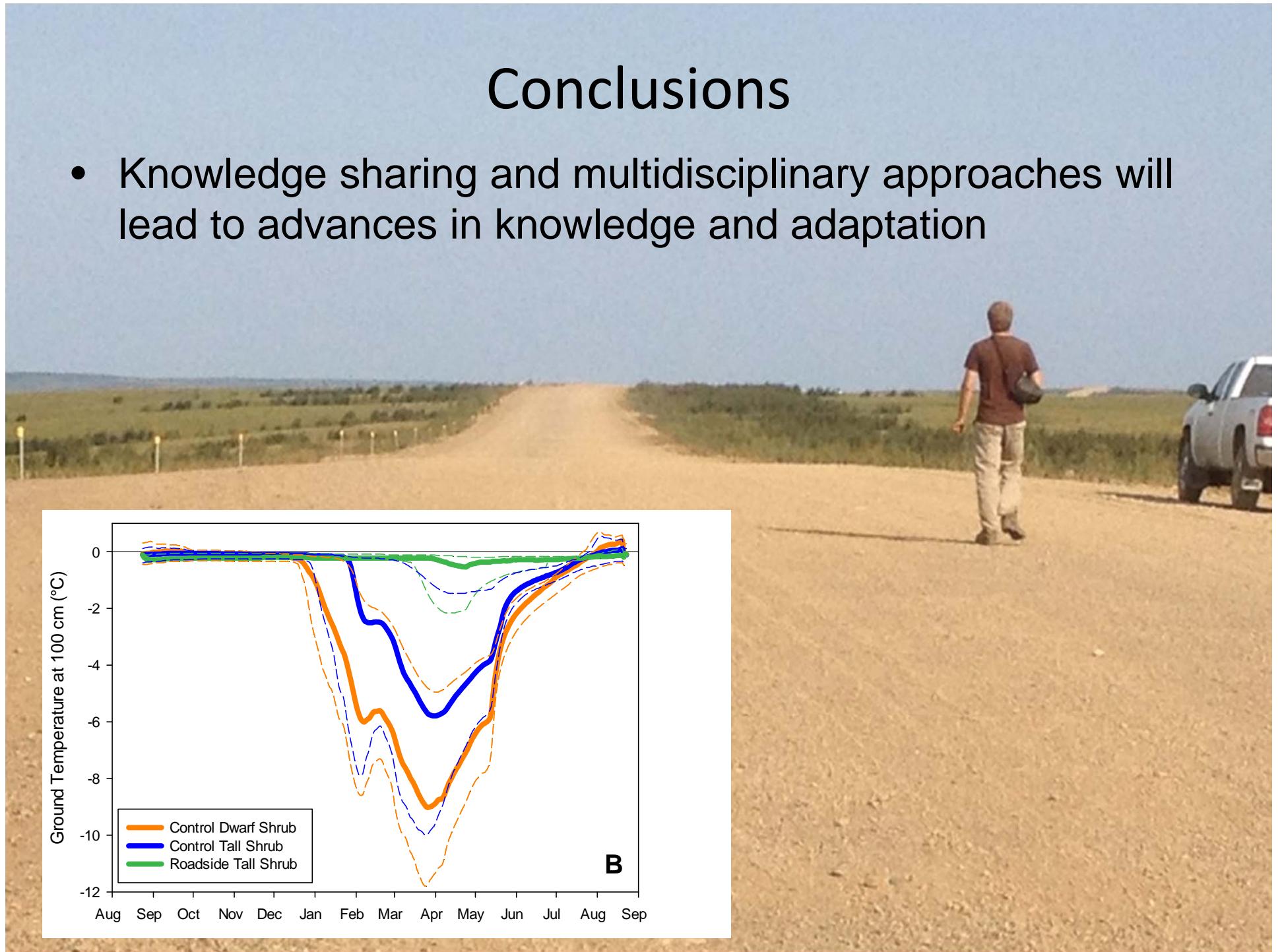


Conclusions

- Knowledge sharing and multidisciplinary approaches will lead to advances in knowledge and adaptation



B



Thank you



- Aboriginal Affairs and Northern Development Canada; Cumulative Impact Monitoring Program and Northern Energy Development Initiative
- Inuvialuit Joint Secretariat and Game Council
- NSERC Northern Chair Program (CR Burn)
- Environmental Studies Research Fund
- Geological Survey of Canada
- Canadian Centre for Remote Sensing
- University of Victoria
- NWT Land and Water Board
- Ardent Innovation Inc.
- Mackenzie Gas Project Proponents