Research Report Qikiqtaruk

Interim Report – April 2025

Project title: Capturing tundra biodiversity and plant phenology above and below ground

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This interim report provides a summary of the research conducted by Prof. Isla Myers-Smith and her research group (Team Shrub) from the University of British Columbia on Qikiqtaruk - Herschel Island in 2024 (for more information see teamshrub.com). This research follows on from fieldwork conducted on Qikiqtaruk – Herschel Island under the Science and Explorers Licences 24-61S&E, 23-58S&E, 22-52S&E, 19-63S&E, 18-62S&E, 17-42S&E, 16-48S&E, 15-50S&E, 14-45S&E. See reports submitted April 2016, April 2017, May 2018 and May 2019, May 2020, April 2022 and May 2023 (https://teamshrub.com/research-reports/).

We also have produced the following reports and leaflets that can be provided:

- Youth Internship Program, Team Shrub Research, Flooding on Qikiqtaruk, Permafrost Thaw on Qikiqtaruk (January 2025)
- Youth Internship Report for Qikiqtaruk – Herschel Island (November 2023)
- Permafrost thaw and the development of active layer detachments on Qikiqtaruk – Herschel Island in August 2023 after an exceptionally warm summer (April 2024)

Figure 1. The 2024 Team Shrub field research crew (credit: Elias Bowman).

Ecological monitoring on Qikiqtaruk

The Qikiqtaruk ecological monitoring program is an ongoing unique collaboration that began in 1999. This program brings together university researchers, government scientists and local park rangers to study tundra vegetation change over time on Qikiqtaruk-Herschel Island, on the Arctic coast of the Yukon Territory, Canada. Qikiqtaruk holds cultural and historical significance to the Inuvialuit people and is located in a unique setting within the Arctic that is particularly relevant to site-specific and global studies of tundra change. Team Shrub has been working on Qikiqtaruk since 2008, and has maintained one of the few long-term research programs in the Arctic. We aim to build upon this long-term research program with the Canada Excellence Research Chair project on the Global Change Ecology of Northern Ecosystems from 2023 to 2032. This new research program will investigate how warming temperatures and shifting seasonality affect Arctic tundra, alpine, and boreal forest ecosystems, including changes in plant growth, habitat composition, wildlife movement and species ranges.

Background

The climate is changing rapidly at the extreme latitudes of our planet[1]. Indigenous people of the Canadian North have well-developed knowledge of how the climate is changing[2,3]. Warming temperatures, melting sea ice, and thawing permafrost are transforming the Arctic[1]. With changes to the environment, Arctic vegetation[4–6] and phenology[7], the timing of life cycle events such as flowering, are shifting[8], altering tundra biodiversity[9]. There remain critical knowledge gaps around the extent of plant phenology changes and their potential implications for future Arctic ecosystem productivity, carbon cycling and wildlife habitats.

Bare ground is becoming vegetated and plants are now growing larger[10] – changes that could alter global-scale climate feedbacks. Qikiqtaruk is experiencing rapid vegetation change including increased cover of shrubs, grasses and sedges and decreased bare ground cover[11]. In the Arctic, the relationship between the timing of above- and below-ground plant growth has been observed to be out of sync, and the below-ground growing season can be up to 50% longer than the above-ground growing season[12]. If plants green up earlier and grow faster in a warmer Arctic, that could influence the habitats for wildlife including potentially influencing migration or other behaviours[13].

Concurrent with vegetation change, permafrost is thawing on the island, and in 2023 permafrost landslides were formed across the island. Summer active layer depths have nearly doubled since 1985 with a nearly doubling of the active layer depth[11], the seasonally unfrozen ground. Up to a third of the world's soil carbon is stored in frozen soils, and if released, this carbon would accelerate climate warming for the entire planet[14]. However, we remain uncertain about how feedbacks might unfold, especially given the diverse landscapes in the Arctic. Increases in plants are thought to be leading to a 'greening' and permafrost thaw and other disturbances to a 'browning' of tundra landscapes, but there is complexity with the interpretation of satellite data[15].

Changes to Arctic vegetation and permafrost thaw could have potentially strong influences on wildlife habitats and the global climate and therefore of interest to both people living in the Arctic and around the world.

Research Activities on Qikiqtaruk in 2024

Over the summer 2024 field season, our field team collected data on: 1) biodiversity monitoring of tundra plant community composition, 2) phenology of tundra plants, 3) wildlife and pollinator abundance and habitat quality, 4) coastal flood monitoring and 5) landscape surveys of permafrost thaw.

1. Biodiversity monitoring of tundra plant community composition

Research question: How does tundra plant biodiversity shift with warming over time?

In 2024, we contributed to the three-decade long ecological monitoring program on Qikiqtaruk to track vegetation change and the drivers of that change (Figure 2). We also carried out drone surveys, measured phenology, plant growth above and below ground, carried out biodiversity protocols and gathered hyperspectral data to help understand vegetation change on Qikiqtaruk.

We continue to track vegetation change on Qikiqtaruk that contribute to site specific studies and international data synthesis. In 2024, we are in the process of publishing a data synthesis of tundra biodiversity change from sites around the Arctic including Qikqitaruk[8]. Around the Arctic, we found no overall increase or decrease in tundra plant biodiversity. However, most plots experienced changes in the amount of plants over time and over half of plots experienced losses and gains of species. The number of species increased most where temperatures had warmed most over time, and shrub expansion led to greater species losses and decreasing number of species in tundra plots over time[9]. Our results show a variety of diversity trends, which could be precursors of future changes in Arctic plant biodiversity.

Figure 2. We collected root ingrowth cores installed in 2024 to measure the timing and biomass of root growth below ground on Qikiqtaruk and continued ecological monitoring to capture vegetation change over time (credit: Ciara Norton and Isla Myers-Smith).

2. Above and below ground phenology of tundra plants

Research question: How does plant phenology above and below ground vary across microclimates among years and with warming over time?

In 2024, we continued monitoring plant phenology – the timing of the growth and flowering of plants – using time-lapse cameras and shrub expansion using repeat photography and drone surveys. We maintained our network of 20 time-lapse cameras across different environments on the island. These data are allowing us to understand how growing seasons are advancing earlier and shifting as the climate warms[8].

In 2023, we installed clusters of soil cores at 12 of the locations of our time-lapse cameras. As the plants grew and flowered during the summer of 2024, these cores filled with roots from surrounding plants. We harvested the cores throughout summer 2024 to track the phenology of root growth, and compare the timing of root growth to the timing of above-ground phenology. We brought the cores back to our laboratory at UBC in Vancouver to analyze the mass of different root types in the cores.

Findings from all of the sites involved in this research indicate that the above ground phenology of plants is decoupled from the growth of roots below ground (Figure 3). We find that plants begin to senesce above ground in early August, when root growth continues into August. We find that grass and sedge roots have a pulse of root growth at the end of the tundra plant growing season. Taken together, this research demonstrates that plants can continue to grow beyond the summer season above ground in soils that now stay thawed for later altering the timing and amount of plant growth above and below-ground as tundra ecosystems warm.

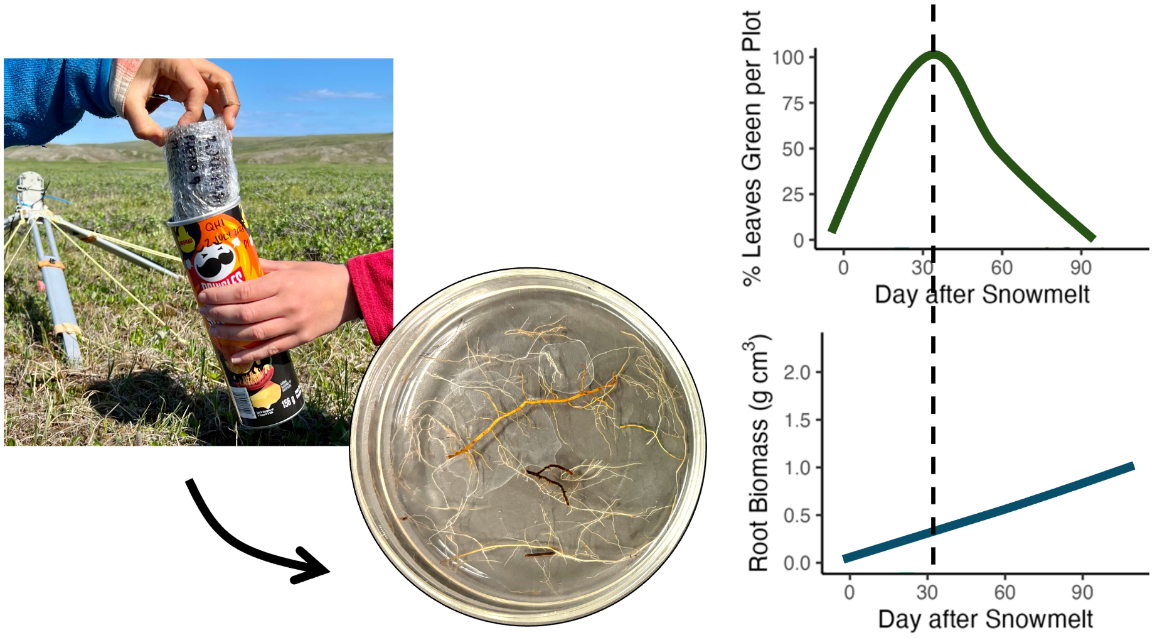

Figure 3. We collected root ingrowth cores installed in 2024 to measure the timing and biomass of root growth below ground on Qikiqtaruk and continued ecological monitoring to capture vegetation change over time[8] (credit: Elise Gallois).

3. Wildlife and pollinator abundance and habitat quality

Research question: How are bird and pollinator communities responding to changes in habitat and local climate?

In 2024, we used audio recorders (ARUs), time-lapse cameras and motion-activated cameras to monitor wildlife, bird, and pollinator activity on Qikiqtaruk. We deployed 20 ARUs, half of which were paired with downward facing cameras (Figure 4). The ARUs allowed us to capture bird and pollinator activity, and the time-lapse cameras recorded the flowering time of surrounding plants. We also installed wildlife cameras on robust tripods at sites selected through discussion with Yukon Parks staff across the island, to monitor the activity and health of animal communities on Qikiqtaruk. ARU deployments were centered in a 25km^2 area around Pauline Cover, whereas trail cameras are spread across the entire island between the Avadlek Delta and Collinson Head.

Following the field season, we processed 7500 hours of audio using custom and existing recognizer algorithms to detect birdsong and pollinator flight activity across the summer (Figure 4). We are in the process of comparing these data to the vegetation traits (such as flowering time recorded by the cameras), as well as climate variables (such as temperature, snowmelt, and sea ice data).

We compared temperature data from each ARU sites with the number of detections of different bird types. Lapland Longspurs (*Calcarius lapponicus*) vocalized more frequently in colder microclimates, while species from other guilds showed no strong response to microclimate (Figure 5).

We compared the timing of flowering across different microclimates to understand how temperature impacts the availability of flower forage for insect pollinators (Figure 6). Flowering seasons were similar across microclimates, but warmer sites tended to have earlier first and last flowering dates and shorter flowering durations (first to last flowering date).

We investigated how temperature changes across microclimates impacted the number of days in which temperatures were warm enough for bumble bees to be active. We also determined the length of time that flowers were open to know how much time bumblebees have in the summer to forage. Warmer microclimates experienced up to seven-day longer bumblebee physiological activity windows (Figure 7).

In summary, we were able to identify pollinators and different bird species from ARU recordings. These data are allowing us to compare the impacts of temperature on these species. Lapland Longspur (*Calcarius lapponicus*) activity increased with colder temperatures. The time of suitable flower foraging conditions for bumblebees varied across microclimates. We are continuing to explore the relationship between vegetation change, temperature and bird and pollinator activity in ongoing analyses.

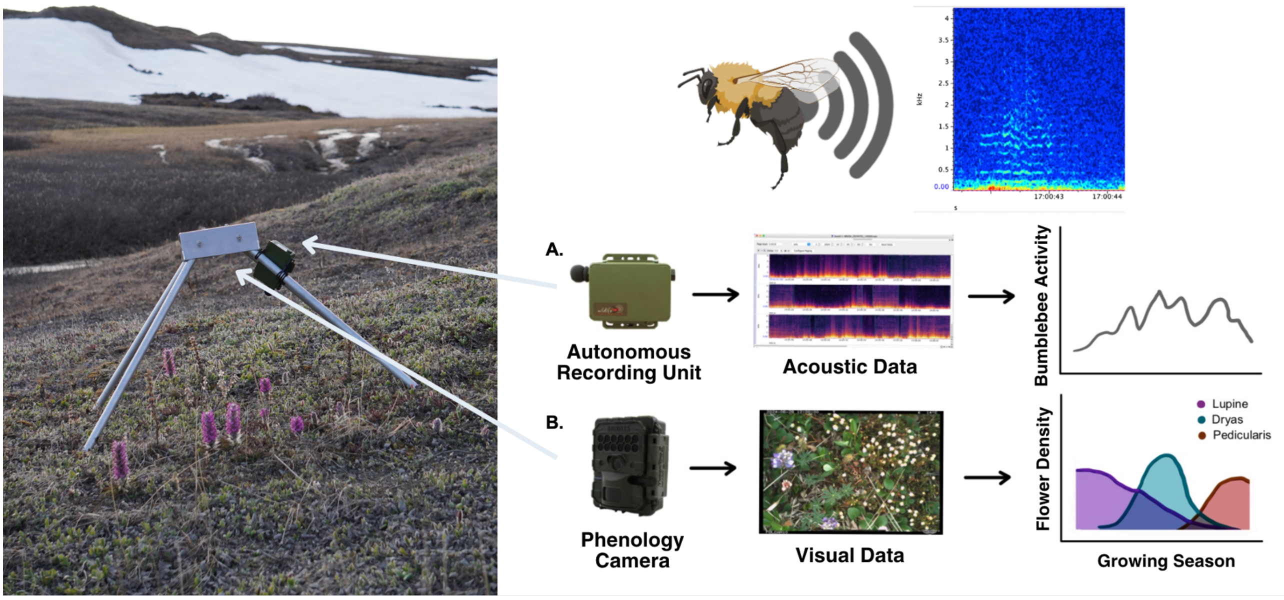

Figure 4. Audio recorders (ARUs, A) record sounds from birds and pollinators. Phenology cameras (B) point downwards to record the timing of vegetation growth (green up, flowering, seed dispersal, yellowing of leaves, etc.). These datasets can be linked to compare when plants, bumblebees and birds are active across the growing season (credit: Alex Beauchemin).

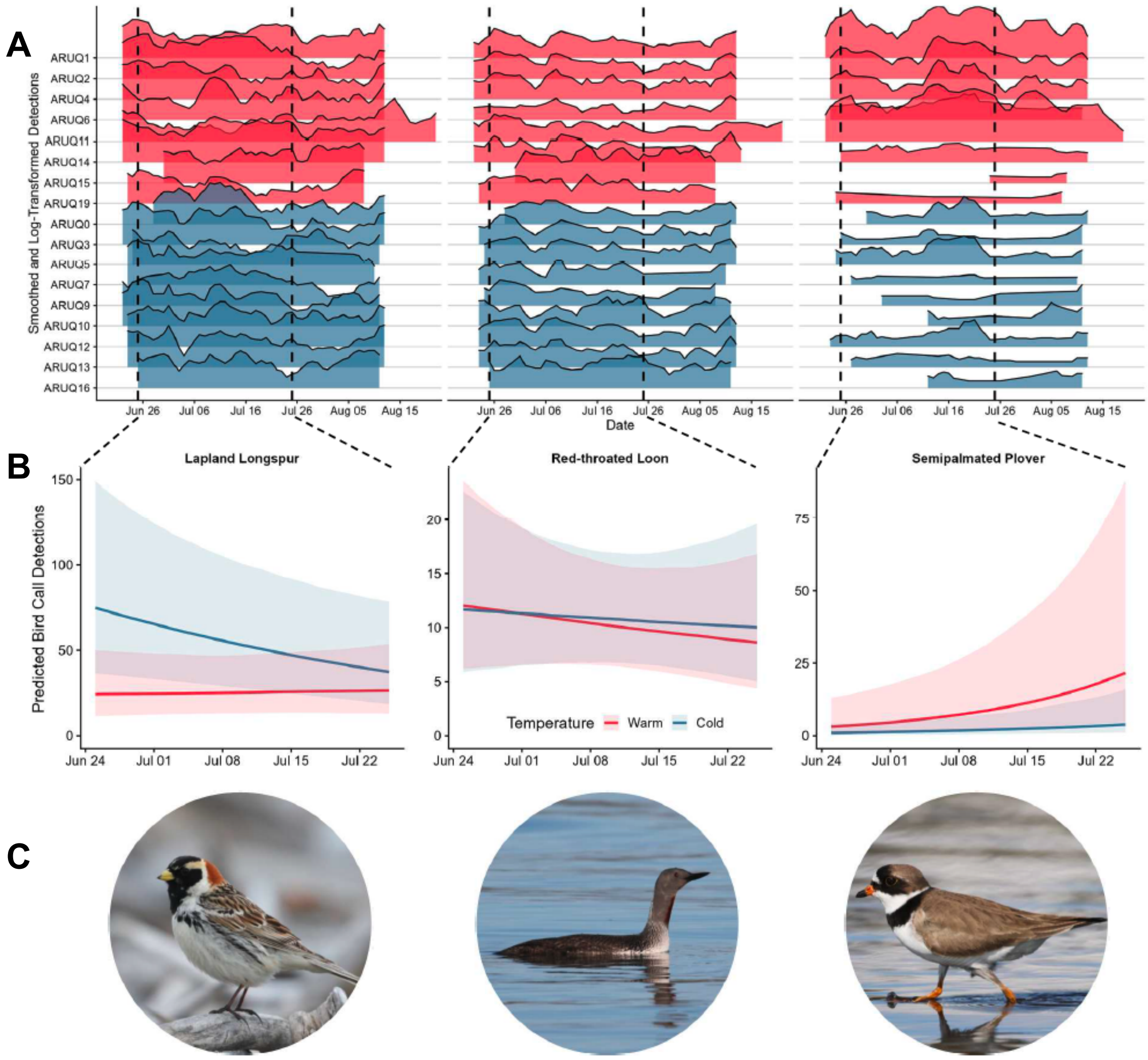

Figure 5. Lapland Longspurs (*Calcarius lapponicus*) vocalized more frequently in colder microclimates following a predicted peak around June 25, suggesting a possible delay in phenology. In contrast, species from other guilds showed no strong response to microclimate. (A) Smoothed, scaled, and log-transformed calling detection plots for Lapland Longspur, Red-throated Loon (*Gavia stellata*), and Semipalmated Plover (*Charadrius semipalmatus*) (left to right). Red indicates warm sites (above 4.25 °C from 4 AM–10 PM, May 15–June 30, 2025), while blue indicates cold sites (below this threshold). (B) Predicted vocalization responses between June 25–July 25, 2025, for the same species (left to right). Colors match panel (A). (C) Photographs of Lapland Longspur, Red-throated Loon and Semipalmated Plover (left to right), courtesy of Cameron Eckert (credit: Elias Bowman).

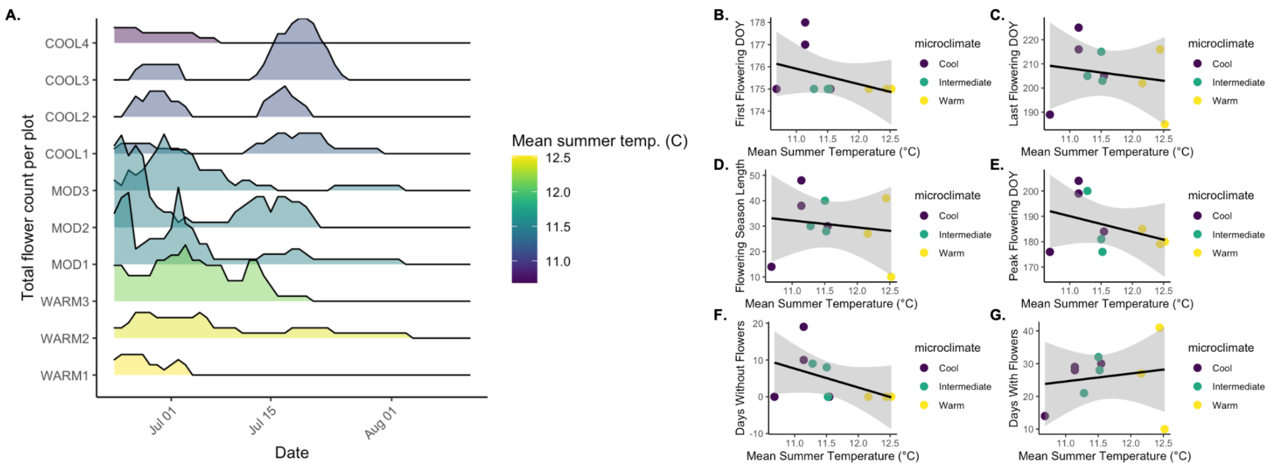

Figure 6. Flowering seasons were similar across microclimates, but warmer sites tended to have earlier first and last flowering dates and shorter flowering durations (first to last flowering date). (A) Flower count per site over time in relation to mean summer temperature. (B–G) Flowering season traits at each site plotted against mean summer temperature (credit: Alex Beauchemin).

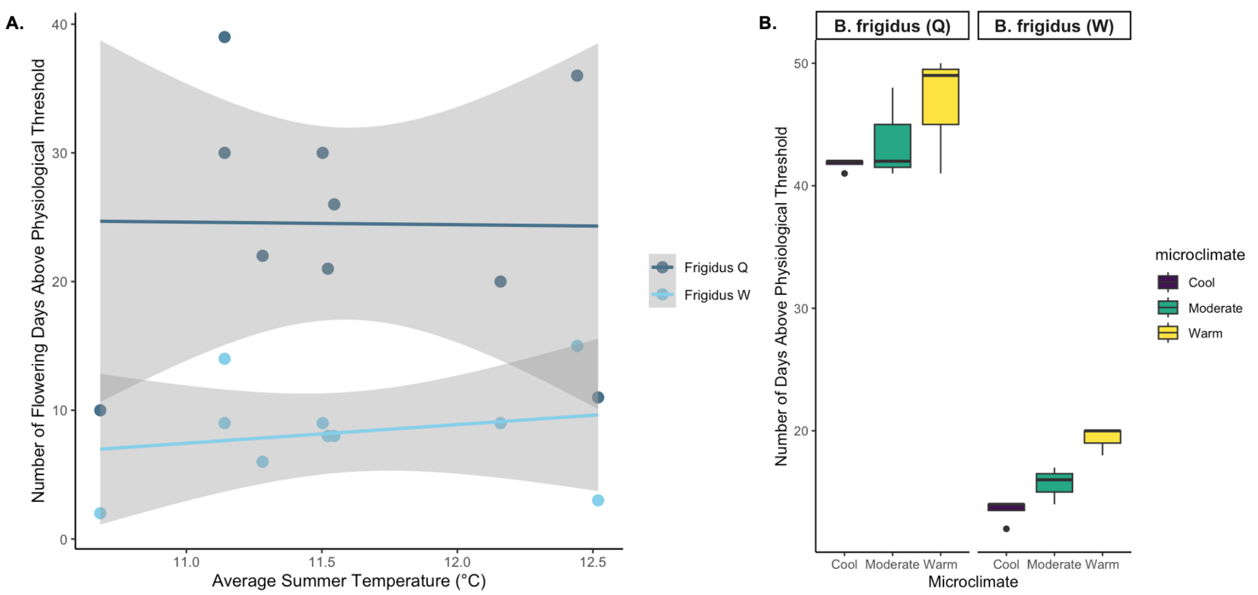

Figure 7. Warmer microclimates experienced up to seven-day longer bumblebee physiological activity windows (B), yet showed no difference in bumblebee foraging window (flowering period at each site with temperatures above physiological thresholds for bumblebee flight) (A). Physiological threshold temperatures for bumblebee flight were T = 6.0°C for *B. frigidus* queens and T = 12.6°C for *B. frigidus* workers[16] (credit: Alex Beauchemin).

4. Coastal floods

Research Question: What are the environmental drivers of flooding and coastal change?

In 2024, we began a new research project on coastal dynamics to improve our understanding of coastal flooding (Figure 8) and morphological changes and erosion which threaten the settlement on Simpson Point. Flooding has been a persistent issue on Qikiqtaruk with records of floods dating back to the early 20th century[17]. Flooding causes loss of coastal archeological sites, impacts to park and researcher operations (Figure 9) and damage of historic buildings, prompting the movement of buildings to higher ground.

Figure 8. Image of the team walking around camp during high water levels caused by west winds, a storm surge and high tide. (credit: Isla Myers-Smith)

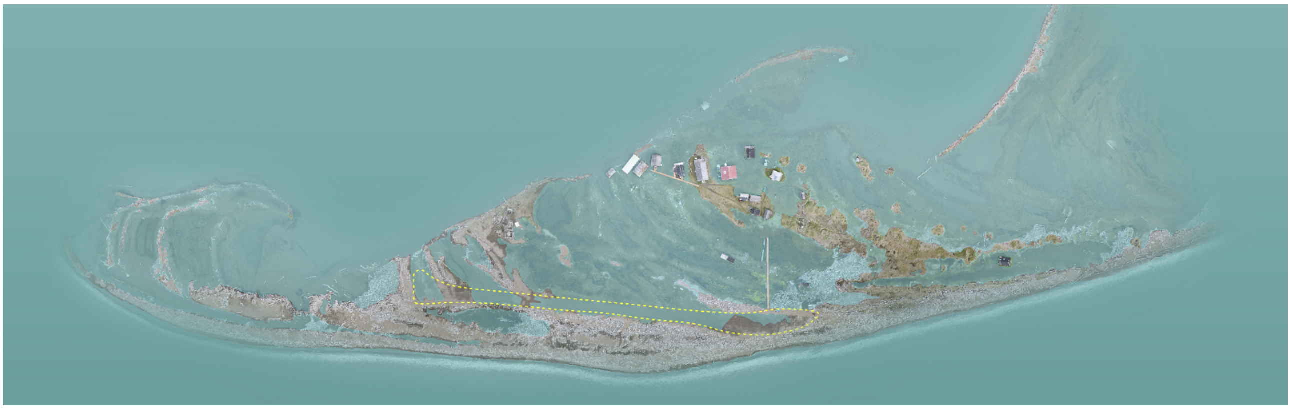

Figure 9. Map of the spit when experiencing flooding in August 2024 indicating high water along the airstrip (yellow dashed line, credit: Ciara Norton).

Our research to date indicates that floods are caused mostly by storm surges which can also align with high tide and strong westerly winds pushing water onto land through the exposed western tip of Simpson Point. In addition, we hypothesize that floods are intensifying through a positive feedback loop with climate change where the extended ice-free season is increasing the rate of sediment redistribution around the spit and subsiding the spit, increasing the vulnerability to future floods (Figure 10).

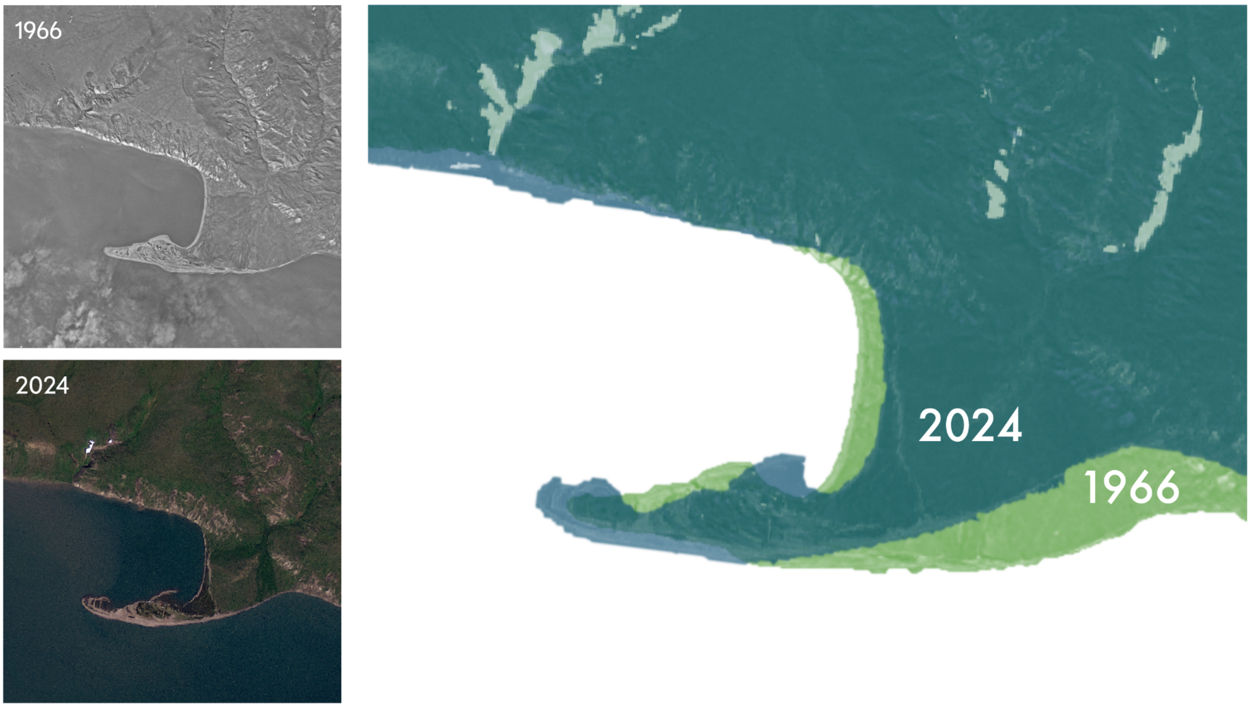

Figure 10. The shape of the spit has changed considerably over the last 60 years. We hypothesise that the extended ice-free season is increasing the rate of sediment redistribution around the spit and subsiding the spit, increasing the vulnerability to future floods.

We are studying the floods using a coastal groundwater monitoring system which was installed in July 2024 by our team. This includes six groundwater wells equipped with Levelogger LTC sensors to monitor the severity (water level), salinity, and temperature of inundation (Figure 11). This provides accurate (cm) estimates of flood severity and occurrence. Paired with a HOBO weather station installed at the same time, we can assess the drivers of flood severity. To study the morphological changes to Simpsons Point and the vulnerability to flooding, we are using aerial, satellite and drone imagery including 3D drone models.

Figure 11. Researchers maintain groundwater wells equipped with Levelogger LTC sensors that monitor the severity (water level), salinity, and temperature of inundation. (credit: Alex Beauchemin)

In 2024, there were 19 days of flooding, 16 of which were recorded by the groundwater monitoring system. This includes 11 days of consecutive flooding in August, which led to a six day delay in our team's departure from Qikiqtaruk. Preliminary analyses show that the spit is elongating over time, increasing the susceptibility to floods through the addition of new inflows from the ocean. Floods appear to be primarily driven by the presence of storm surges and 14 floods coincided with surges. Westerly winds are observed to push water into the western inflow. Floods coincide with an increase in groundwater salinity on the sand spit, or a decrease in salinity in hypersaline bodies on the spit. In the floodplain, salinity rises throughout the month of August, which we hypothesize is from passive tidal intrusion into the fresh water table.

5. **Landscape surveys of permafrost thaw disturbances**

Research question: How much have the active layer detachment (ALD) landslides impacted the landscape of Qikiqtaruk and will they continue to grow??

In 2023, a two-week heatwave triggered the formation of over 750 active layer detachment landslides on Qikiqtaruk (Figure 12). In 2024, we conducted over 30 drone surveys to monitor the landslides that happened in 2023. We are using these data to quantify the extent of the disturbances over time and the rates and magnitudes of further erosion. Landslides removed the top layer of insulating tundra, exposing ground ice below to solar radiation and influencing further thaw. These landslides could develop into retrogressive thaw slumps, larger erosional features that lose large volumes of tundra to thaw and remain active for years to decades. In the 2024 field season, many of these landslides continued to grow, some of which are becoming retrogressive thaw slumps (Figure 13). We deployed nine time-lapse cameras to monitor continued rates of landslide thaw and growth over time.

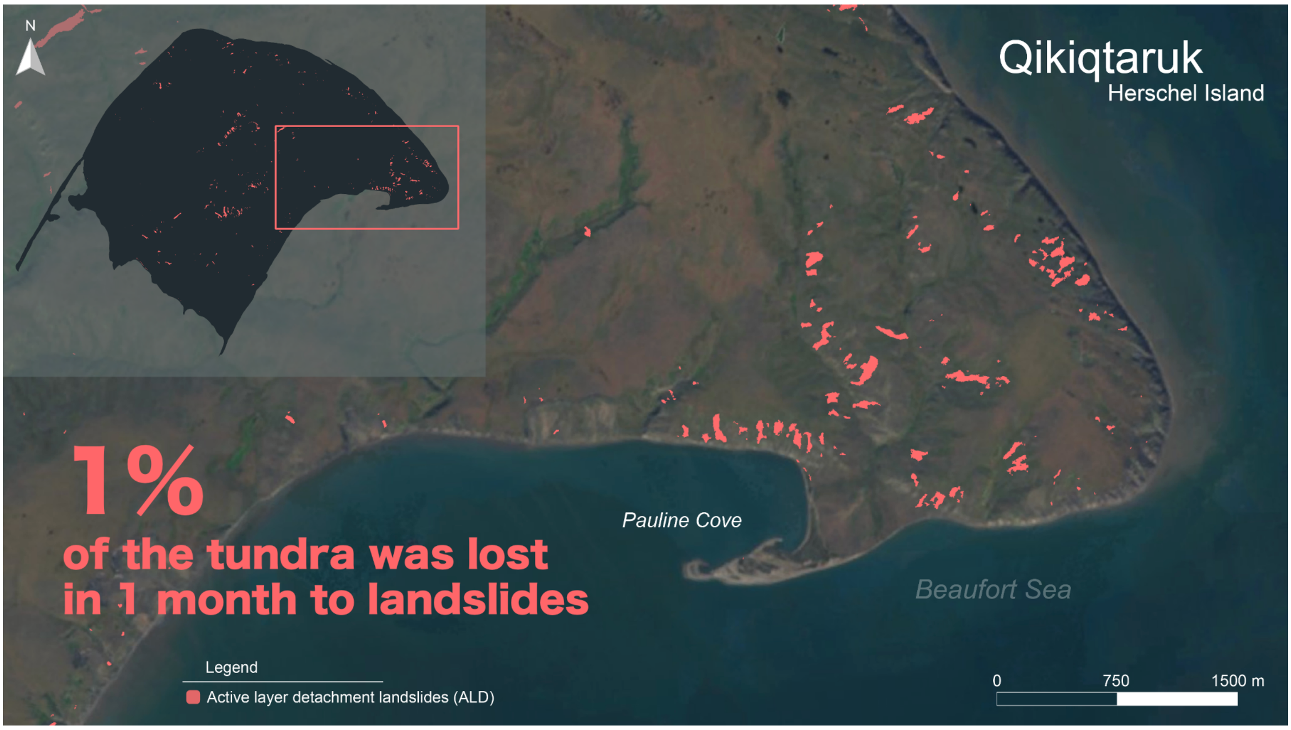

Figure 12. In 2023, over 750 landslides formed after a heatwave across the landscape on Qikiqtaruk (pink) disturbing 1% of the island's tundra as shown in this map made from analysing satellite imagery over time (credit: Ciara Norton).

Figure 13. The headwall of an active layer detachment that has evolved into a retrogressive thaw slump after one year. Exposed ice at the headwall continues to thaw in the hot summer temperatures (credit: Isla Myers-Smith).

Slump D, spanning over 650 metres wide, is a megaslump on Qikiqtaruk and one of the largest megaslumps in the world[18]. In 2024, we conducted a drone survey of Slump D, a data collection protocol that has been conducted annually since 2015 (with the exception of 2020 and 2021 due to the COVID19 pandemic). These data are being used to inform the volume of tundra that has thawed and eroded from the slump, and ongoing rates of erosion. Our preliminary results report that Slump D has lost over 1,000,000 cubic metres of ground in the past 5 years (2019-2024), a volume that could fill more than 400 olympic swimming pools (Figure 14).

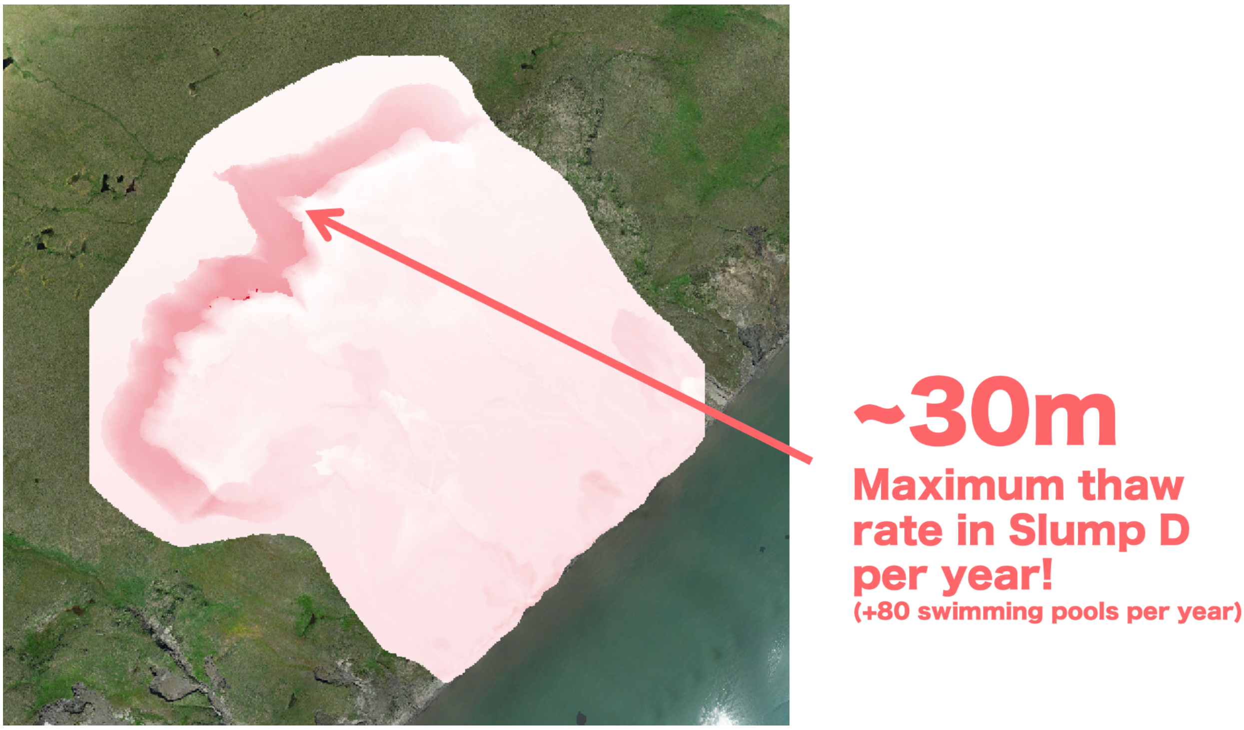

Figure 14. Drone surveys are allowing us to capture permafrost thaw, coastal erosion and vegetation change in high resolution on the island. This map shows erosion of Slump D from 2019 to 2024. Across these five years, Slump D lost over 1 million cubic metres of permafrost, a volume equivalent to over 400 Olympic-sized swimming pools (credit: Ciara Norton).

To assess the state of permafrost on Qikiqtaruk, we deployed a new data logger at a borehole at Collinson Head to revive permafrost temperature monitoring that was previously conducted by Chris Burn from Carlton University[19]. We also continued data collection of active layer depths, data collection that has been ongoing as a part of the Ecological Monitoring program since 1999[11]. Active layer depths on the island have been increasing over time from ~40 cm in the 1980s to up to ~80 cm in 2024 in the same locations[14], reaching depths of 1 m in 2023 in areas where active layer detachments formed.

6. Microclimate data

In 2024, we maintained a network of microclimate loggers to record surface temperature, soil temperature, and soil moisture at different locations around the island[20]. In total, there are 40 temperature loggers (TOMST) to record continuous soil temperature and soil moisture content and two weather stations (HOBO, at the phenology transects and on Collison Head). In addition, we have used digital elevation models to produce modelled maps of microclimate across the island. These measurements will help us determine how phenology and root growth differs across different microclimates across Qikiqtaruk.

We have also found that growing season lengths remain fairly static across microclimates with both green up and yellowing of leaves being advanced on warmer south-facing slopes and delayed on colder north-facing slopes[13] (Figure 15).

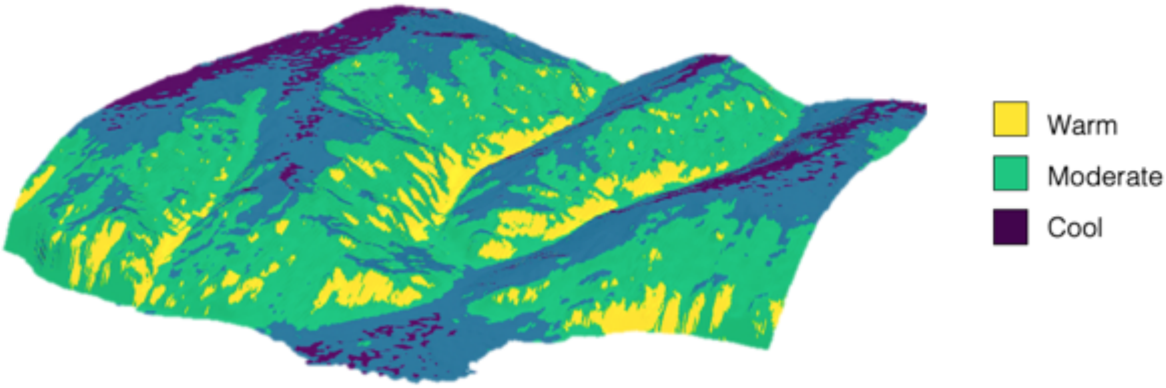

Figure 15. We are using temperature sensors and drone imagery to build maps of microclimates across the landscape on Qikiqtaruk to compare to plant growth and phenology (credit: Elise Gallois).

7. Tundra monoliths

In 2024, we collected 21 blocks of live tundra from active layer detachment landslides on Qikiqtaruk (Figure 16). These plants were collected only from tundra turf that was already disconnected from the mainland and no longer able to grow *in situ* due to permafrost thaw disturbance. We transported the tundra monoliths to the University of British Columbia where they are currently growing in a controlled growth chamber environment. Using the growth chambers, we are simulating different future climate scenarios such as heatwaves and increased growing season length. We are collecting data on greenness, flowering and senescence timing, plant species survival and plant size. We will use these data to assess the impacts of climate change on Arctic plants, with more results to come in the Fall of 2025.

Figure 16. Collecting the tundra monoliths and those same samples growing in the growth chamber at the University of British Columbia. (credit: Isla Myers-Smith)

Recent publications from the research on Qikiqtaruk (2019 to 2025):

García Criado M (PostDoc), IH Myers-Smith et al. 2025. Plant diversity dynamics over space and time in a warming Arctic. EcoEvoRxiv. Accepted at Nature. doi: https://doi.org/10.32942/X2MS4N

Gallois E (PhD), IH Myers-Smith* et al. Tundra vegetation community, not microclimate, controls asynchrony of above and below-ground phenology. EcoEvoRxiv. Accepted at Global Change Biology. doi: https://doi.org/10.32942/X2332B

Anderson MJ (PhD), IH Myers-Smith*, E Zaja, HJD Thomas, MG Criado, GN Daskalova, E Gallois, JJ Šubrt, M Vellend. Earlier and increased growth of tundra willows after a decade of growth in a warmer common garden environment. EcoEvoRxiv Submitted to Journal of Ecology. doi: https://doi.org/10.32942/X2132Q

Schwieger et al. IH Myers-Smith… 2024 Macro-environment strongly interacts with warming in a global analysis of decomposition. Ecology Letters. doi: https://doi.org/10.1111/ele.70026

Sarneel et al. IH Myers-Smith… 2024. Reading tea leaves worldwide: Decoupled drivers of initial litter decomposition mass-loss rate and stabilization. Ecology Letters. doi: https://doi.org/10.1111/ele.14415

Elphinstone C, et al. IH Myers-Smith… 2024. Multiple Pleistocene refugia for Arctic White Heather (Cassiope tetragona) supported by population genomics analyses of contemporary and Little-Ice-Age samples. Journal of Biogeography. doi: https://doi.org/10.1111/jbi.14961

Gallois E *et al.* 2023. Summer litter decomposition is moderated by scale-dependent microenvironmental variation in tundra ecosystems. Oikos e10261. doi: https://doi.org/10.32942/osf.io/crup3

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Vuorinen K *et al.* 2022. Growth rings show limited evidence for ungulates' potential to suppress shrubs across the Arctic. Environmental Research Letters 17(3): 034013. doi: https://doi.org/10.1088/1748-9326/ac5207

Lindén E *et al.* 2022. Circum-Arctic distribution of chemical anti-herbivore compounds suggests biome-wide trade-off in defence strategies in Arctic shrubs. Ecography, p.e06166. doi: https://doi.org/10.1111/ecog.06166

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Rixen C *et al.* 2022. Winters are changing: snow effects on Arctic and alpine tundra ecosystems. Arctic Science 8(3). doi: https://doi.org/10.1139/AS-2020-0058

Stanski K, IH Myers-Smith, CG Lucas. 2021. Flower detection using object analysis: New ways to quantify plant phenology in a warming tundra biome. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 14: 9287-9296. doi: https://doi.org/10.1109/JSTARS.2021.3110365

Cunliffe AM *et al.* 2021. Global application of an unoccupied aerial vehicle photogrammetry protocol for predicting aboveground biomass in non-forest ecosystems. Remote Sensing for Biodiversity & Conservation 8(1): 57-71. doi: https://doi.org/10.1002/rse2.228

Prevéy J *et al.* 2021. The tundra phenology database: More than two decades of tundra phenology responses to climate change. Arctic Science 1-14. doi: https://doi.org/10.1139/AS-2020-0041

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Cunliffe AM *et al.* 2020. Aboveground biomass corresponds strongly with drone-derived canopy height but weakly with greenness (NDVI) in a shrub tundra landscape. Environmental Research Letters 15:125004. doi: https://doi.org/10.1088/1748-9326/aba470
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Prevéy J *et al.* 2019. Warming shortens flowering seasons of tundra plant communities. Nature Ecology and Evolution 3:45-52. doi: http://doi.org/10.1038/s41559-018-0745-6

Databases

We contributed data from Qikiqtaruk to the following databases:

- **The Below-ground Tundra Phenology database**
  In progress

- **The Tundra Phenocam database**
  In progress

- **The ITEX+ Plant Composition database**
  Data paper to be published in 2025

- **The ITEX Phenology database**
  Prevéy J, *et al.* IH Myers-Smith… 2021. The tundra phenology database: More than two decades of tundra phenology responses to climate change. *Arctic Science* 8(3): 1026-1039. doi: https://doi.org/10.1139/AS-2020-0041

- **The TRY plant database**
  Kattge J, *et al.* IH Myers-Smith... 2020. TRY plant trait database–enhanced coverage and open access. Global Change Biology. 26(1): 119-188. doi: https://doi.org/10.1111/gcb.14904

- **The Soil Temp database**

Lembrechts JJ *et al.* IH Myers-Smith... 2020. SoilTemp: a global database of near-surface temperature. Global Change Biology 28(9): 3110-3144. doi: https://doi.org/10.1111/gcb.15123

- **The Tundra Trait Team database**
  Bjorkman AD, IH Myers-Smith, SC Elmendorf, S Normand, Thomas HJD, *et al.* 2018. Tundra Trait Team: A database of plant traits spanning the tundra biome. Global Ecology and Biogeography 27(12): 1402-1411. doi: http://dx.doi.org/10.1111/geb.12821

Additional information

Team Shrub at the University of Edinburgh https://teamshrub.com/
The High Latitude Drone Ecology Network https://arcticdrones.org/
International Tundra Experiment https://www.gvsu.edu/itex/
Canadian Airborne Biodiversity Observatory: https://www.caboscience.org/
Herbivory Network https://herbivory.lbhi.is/
Team Shrub on Twitter https://twitter.com/TeamShrub/
Team Shrub on Instagram https://www.instagram.com/teamshrub/
Photography websites: http://vanishingislandphoto.com/, https://arcticabove.com/
Media coverage: https://teamshrub.com/media/
Team Shrub Blog Posts: https://teamshrub.com/lab-blog/

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