Cover

Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	1928237
Project Title:	NNA Track 1: Landscape evolution and adapting to change in ice-rich permafrost systems
PD/PI Name:	Donald A Walker, Principal Investigator Gary P Kofinas, Co-Principal Investigator Anna Liljedahl, Co-Principal Investigator Vladimir E Romanovsky, Co-Principal Investigator Yuri L Shur, Co-Principal Investigator
Recipient Organization:	University of Alaska Fairbanks Campus
Project/Grant Period:	09/15/2019 - 08/31/2024
Reporting Period:	09/01/2020 - 08/31/2021
Submitting Official (if other than PD\PI):	Donald A Walker Principal Investigator
Submission Date:	08/19/2021
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	Donald A Walker

Accomplishments

*** What are the major goals of the project?**

Overview: ice-rich permafrost (IRP). IRP is at the center of a web of interacting ecosystem components that we call the IRP system (IRPS) *(**Supporting file Figure 1**)*. Our key questions are: How are climate change and infrastructure affecting IRPSs? What roles do ecosystems play in the development and degradation of IRP? and How can people and their infrastructure adapt to changing IRPSs? We are particularly interested in how differences in vegetation, water, and time influence the accumulation and degradation of ground ice in IRP landscapes, and how the loss of ground ice can radically change these landscapes, their components, and the infrastructure built on them. Our ultimate goal is to understand IRPS at local, regional and circumpolar scales.

Goals related to intellectual merit: Our initial focus is at Prudhoe Bay and Point Lay, Alaska, where permafrost temperatures are changing rapidly with large impacts to ecosystems and infrastructure. Both areas provide excellent examples of IRP-related issues relevant to many other areas of Alaska and the Arctic. We are developing three main IRP observatories: (1) Roadside IRP Observatory (RIRPO, including the Colleen Site, Airport Site, and Jorgenson Site In the Prudhoe Bay oilfield; (2) Natural IRP Observatory remote from infrastructure (NIRPO) also in the Prudhoe Bay oilfield*(**Supporting file, Figure 2**)*; and (3) Village IRP Observatory (VIRPO) at Point Lay . The Prudhoe Bay region has the best historical record of geoecological change within the Arctic with key legacy datasets and good collaboration between industry and science. We will revisit permanent plots and remap Prudhoe Bay vegetation and landscapes first studied in the 1970s. We will characterize and compare the permafrost, hydrology, vegetation, and greenhouse gas (GHG) fluxes of IRPS in three main situations: (1) disturbance gradients adjacent to heavily traveled roads in the Prudhoe Bay oilfield (***Supporting file, Figure 3***); (2) undisturbed tundra first mapped in the 1970s in a relatively undisturbed landscape consisting of drained lake basins and residual surfaces unaffected by thaw lake processes; and 3) extremely-ice-rich yedoma soils in the village of Point Lay (***Supporting file, Figure 4***). We will use a multidimensional remote-sensing time-series to measure and monitor changes to microtopography, water, snow cover, vegetation, thermokarst, and thermo-erosional features. We will use the field observations, detailed geoecological maps, and remote-sensing products to provide input for improved permafrost and hydrology models to predict permafrost degradation over the next century under different GHG emission scenarios.

Goals with broader impacts: The project offers a transformative view that places IRP at the center of change to social-ecological systems in many areas of the new Arctic. Much of the response to permafrost-related damage has been incremental actions driven by the necessity to repair and stabilize existing roads and structures. There is an immediate need to develop more strategic approaches to mitigation and adaptation informed by science and engineering in collaboration with local observations, knowledge, and preferences. Point Lay has received less research and agency attention than other climate-impacted communities, yet its thaw-related issues are among the most critical (***Supporting file, Figure 4***). Researchers from the UAF Institute of Northern Engineering, Geophysical Institute, Institute of Arctic Biology, and International Arctic Research Center will combine their expertise to address IRPS-related questions in collaboration with project partners. We will work with the Cold Climate Housing Research Center, Regional Housing Authority, Point Lay community, and North Slope Borough planners to collaboratively produce adaptive housing strategies and actionable knowledge regarding other infrastructure that is relevant to many arctic villages. We will leverage previous and current NSF research, oil-industry resources, and ongoing work by the Alaska Department of Transportation to advance knowledge on IRP-related impacts to roads and industrial infrastructure and contribute to best practice guidelines for road and airport construction. STEAM education and training components will reach K-12, undergraduate, graduate, and post-doctoral students. A permafrost and infrastructure symposium will bring together US-Canadian science and engineering expertise. We will communicate the results to other circumpolar communities through the Rapid Arctic Transitions due to Infrastructure and Climate (RATIC) action group and Terrestrial Multidisciplinary distributed Observatories for the Study of Arctic Connections (T-MOSAiC) project.

*** What was accomplished under these goals and objectives (you must provide information for at least one of the 4 categories below)?**

Major Activities:

Major activities:

Landscape Evolution component:

1. **Summer 2021 field work at Prudhoe Bay:** Field work for the vegetation component of the NNA-IRPS project was conducted 13 July-3 Aug 2021, at the Natural Ice-Rich Permafrost Observatory (NIRPO) and the nearby Jorgenson research site, Prudhoe Bay, AK. Researchers establilshed transects and permanent vegetation plots and thermokarst ponds in different-age lake basins and the residual upland surface. A second Prudhoe Bay field trip, planned from 22 Aug-Sept 5, 2021, will focus will be on obtaining end-of-summer biomass samples from the ponds and terrestrial plots, active-layer measurements from all transects and plots, permafrost temperature and cryostratigraphy boreholes, establish ground control for the aerial Lidar and multispectral image surveys .
2. **Arctic Science Summit Week 2021: Online session; "RATIC meets T-MOSAiC: Sharing best practices in reserach on infrastructure in the Arctic":** Due to the COVID pandemic, the RATIC/T-MOSAiC workshop planned for ASSW 2021 was redesigned as a 3-hour online meeting on 21 March 2021 to share progress and insights on RATIC-related research from around the Arctic. Several early career researchers and indigenous scholars participated in planning and gave presentations. Nine invited speakers from the fields of natural sciences, social sciences and engineering with projects focused on infrastructure and environmental change in the Arctic shared updates on their work. itles of talks, presenters, and slides are online at https://www.geobotany.uaf.edu/ratic/workshop2021.php.
3. **RATIC Science Talk Series**: The Rapid Arctic Transitions due to Infrastructure and Climate initiative (RATIC: https://www.geobotany.uaf.edu/ratic) is a collaborative, multidisciplinary international network to promote research and discussion on the cumulative effects of Arctic infrastructure and climate change. RATIC is also the Infrastructure Action Group of the international RATIC/T-MOSAIC. RATIC project team members launched a monthly science talk series in April 2021 to provide an informal forum for researchers to share knowledge on topics related to Arctic infrastructure and climate change in between major conferences. It provides an especially good opportunity for students and Early Career Researchers to present their work and get diverse, multidisciplinary feedback.

Adaptation component:

1. **Kali School K-12 partnership (Oct 2020-May 2021):** Members of our team collaborated with Kali School principal and teachers in Point Lay and outreach

coordinators at UIC Science on development of 8 hands-on lessons related to permafrost study and cold climate housing, including 4 lessons for Grades 1-2 and 4 for high school students. We also participated in virtual classroom visits by Zoom with students in February and May. NNA IRPS team members created introductory and instructional videos and lesson kits. Equipment and supplies were mailed to the school, including a temperature probe for measuring snow depth and temperature and a thermal imaging camera and iPad. CCHRC interns working on the NNA-IRPS project also completed a library of worksheets and lesson plans for future years.

2. **Literature review**: CCHRC completed the literature review and interviews to compile a list of potential mitigation strategies for infrastructure on thawing permafrost. These were compiled into a spreadsheet categorized into new or retrofit construction, and individual or community efforts. CCHRC staff began a write up of the literature review results.

3. **Kali Advisory Group**: The second meeting of the project's local and regional advisory group met on 20 Nov, 2020 by Zoom. We invited PIs and Co-PIs from other NSF- and federally funded projects working in Point Lay to provide project updates and listen to the comments by local and regional representatives, including the tribal government, the village corporation, the regonal housing authority, and the regional planning department. The role of the advisory body is to meet by phone at least once a year to discuss upcoming research plans and provide input on what research questions and data will be most useful at the local and regional level.
4. **Point Lay Steering Committee:** In 2021, we launched the project's local steering committee, consisting of four Point Lay residents selected by the Tribal Council. The purpose of the group is to help researchers implement the project in the local community and to help identify the best ways to work with the community and to share back the information developed. The steering committee met in July and August to provide input on the best locations to install ground temperature sensors and to discuss the goals, options and logistics for a housing survey and review a draft survey instrument. Steering committee members are compensated for their time.
5. **Interviews with state transportation and oilfield roads supervisors**: In Feb 2021, researchers interviewed road maintenance supervisors with the Alaska Department of Transportation and Public Facilities and the Hilcorp Roads and Pads unit on road maintenance practices that impact dust accumulation and snow off timing.
6. **Permafrost and Infrastructure Symposium**: Due to the coronavirus pandemic, the proposed permafrost and infrastructure symposium was postponed to June 2022. Planning for the symposium began in October 2020 and is ongoing.

7. **Codevelopment networking and professional development**: Project team members attended a variety of NNA seminars, workshops, focus group discussions and presentations during the year on community engagement, data sharing, and approaches for effective collaboration between communities and researchers, especially during COVID.

Data management:

1. Created Arctic Data Center Portal for the project.
2. Participated in an Arctic Data Center focus group on portals in April 2021.
3. Summarized data from the abbreviated 2020 field season that will be included in the 2021 field data report published in fall 2021.

Specific Objectives: Major **objectives:**

Landscape Evolution Field Work in 2021:

1. Baseline transects and permanent vegetation plots on five different-age surfaces with distinct landforms at the NIRPO site:
2. Lidar imagery for the NIRPO site and other nearby areas of interest.
3. Baseline vegetation and soil studies at the permanent plots.
4. Pond studies (vegetation surveys, water and soil temperature, water level surveys) in thermokarst ponds at the Jorgenson and NIRPO sites.
5. Chamber-based trace-gas flux studies on a subset of permanent plots on each surface.
6. Basal peat samples from each surface for C-14 dating.

Adaptation component:

1. Literature review and interviews completed on potential mitigation strategies for infrastructure on thawing permafrost.
2. Successful K-12 outreach with Kali School in Point Lay: Built relationships with students and teachers that we will build on in 2021-22 and created 8 age-appropriate lessons related to permafrost thaw delivered by Kali School teachers, plus additional lessons for future outreach.
3. Launched village steering committee.
4. Drafted housing survey with community input.
5. Selected locations for installing ground temperature sensors in built and natural environment in Point Lay with local input.
6. Planned and facilitated international RATIC workshop at ASSW 2021 and launched monthly RATIC Science Talk series for multidisciplinary collaboration and discussion of infrastructure and climate change research across the Arctic between major conferences.
7. Started planning for 2022 Permafrost and Infrastructure Symposium.

Significant Results:

Landscape Evolution: Comparison of 12 ice wedges between 2014 and 2020 data showed that five ice wedges have not experienced significant changes (or have experienced some minor stabilization) since 2014. Two ice wedges have experienced significant degradation (detected by deeper water-filled ice-wedge troughs; these ice wedges were either degrading or very vulnerable in both 2014 and 2020, but in 2014 the troughs were dry). Five ice wedges have experienced stabilization since 2014. Two of these ice wedges, which are located close to the Spine Road and were actively degrading in 2014, have experienced significant stabilization detected by thicker intermediate and transient layers, which was probably caused by fast accumulation of road dust.

Field Work in 2021:

Descriptions of each of the tasks with figures and preliminary results, tables, lists of plots plots and surveys are in the Supporting file: (NNA-IRPS Field Report 20210811(2).pdf).

Key outcomes or Other achievements:

Cross-NNA and agency collaborative efforts
NNA-IRPS members have been co-authors and many publications and conference presentations that are highly relevant the to the goals of the NNA-IRPS project, but cannot be included in the list of project publications yet because of lack of acknowldegement of the NNA-IRPS award or hard copy pdfs as documentation. These activities demonstrate a high level collaboration of IRPS members across several of NNA projects and other ongoing permafrost research at the state, national, and international levels.

***Publications*:**

Bergstedt, H., Jones, B.M., Farquharson, L.M., Gaglioti, B., Parsekian, A., Kanevskiy, M.Z., Hinkel, K.M., Rangel, R.C., Ohara, N., Breen, A.L., Walker, D.A., Creighton, A., Lantz, T.C., Bartsch, A., Nitze, I., Fuchs, M., Veremeeva, A., Grosse, G., Roy-Léveillée, Forbes, B.C., and Kumpula, T. (2020) Towards panarctic mapping of drained lake

basins in permafrost regions. Abstract C013-0001 presented at AGU 2020 Fall Meeting, 1-17 Dec.

Bristol, E.M., Connolly, C.T., Lorenson, T.D., Richmond, B.M., Ilgen, A.G., Choens, R.C., Bull, D.L., Kanevskiy, M., Iwahana, G., Jones, B.M., McClelland, J.M. (2021). Geochemistry of coastal permafrost and erosion-driven organic matter fluxes to the Beaufort Sea near Drew Point, Alaska. Frontiers in Earth Science 8: 598933. doi:10.3389/feart.2020.598933

Jones , B.M., Grosse, G., Roy-Léveillée, P., Veremeeva A., Kanevskiy, M., Gaglioti, B.V., Breen, A., Farquharson, L., Parsekian, A., Ulrich, M., and Hinkel, K.M. (2021, minor revision) Lake and drained lake basin districts in the Arctic. Submitted to Nature Reviews Earth and Environment.

Oblogov, G.E., Vasiliev, A.A., Streletskaya, I.D., Zadorozhnaya, N.A., Kuznetsova, A.O., Kanevskiy, M.Z., Semenov, P.B. (2020) Methane content and emission in the Permafrost landscapes of Western Yamal, Russian Arctic. Geosciences 10, 412; doi:10.3390/geosciences10100412.

Rangel, R.C., Parsekian, A.D., Farquharson, L.M., Jones, B.M., Ohara, N., Creighton, A.L., Gaglioti, B.V., Kanevskiy, M., Breen, A.L., Bergstedt, H., Romanovsky, V.E., and Hinkel, K.M. (2021) Geophysical observations of taliks below drained lake basins on the Arctic Coastal Plain of Alaska. Journal of Geophysical Research – Solid Earth 126, e2020JB020889

Shur, Y., Jones, B.M., Kanevskiy, M., Jorgenson, T., Ward Jones, M.K., Fortier, D., Stephani, E., Vasiliev, A. (2021) Fluvio-thermal erosion and thermal denudation in the yedoma region of northern Alaska: revisiting the Itkillik River exposure. Permafrost and Periglacial Processes 32: 277-298. doi: 10.1002/ppp.2105

Strauss , J., Laboor S., Schirrmeister, L., Fedorov, A.N., Fortier, D., Froese, D. Fuchs, M., Günther, F., Grigoriev, M., Harden, J., Hugelius, G., Jongejans, L.L., Kanevskiy, M., Kholodov, A., Kunitsky, V., Kraev, G., Lozhkin, A., Rivkina, E., Shur, Y., Siegert, C., Spektor, V., Streletskaya, I., Ulrich, M., Vartanyan, S., Veremeeva, A., Walter Anthony, K., Wetterich, S., Zimov, N., Grosse, G. (2021, submitted). Circum-Arctic Map of the Yedoma Permafrost Domain. Frontiers in Earth Science.

Wickland, K.P., Jorgenson, M.T., Koch, J.C., Kanevskiy, M., and Striegl, R.G. (2020) Carbon dioxide and methane flux in a dynamic Arctic tundra landscape: Decadal-scale impacts of ice wedge degradation and stabilization. Geophysical Research Letters 47, e2020GL089894. https://doi.org/10.1029/2020GL089894

Witharana, C., Bhuiyan, E.M., Liljedahl, A.K., Kanevskiy, M., Epstein, H.E., Jones, B.M., Daanen, R., Griffin, C.G., Kent, K., and Ward Jones, M.K. (2020) Understanding the synergies of deep learning and data fusion of multispectral and panchromatic high resolution commercial satellite imagery for automated ice-wedge polygon detection. Journal of Photogrammetry and Remote Sensing 170: 174-191.

Witharana, C., Bhuiyan, E.M., Liljedahl, A.K., Kanevskiy, M., Jorgenson, T., Jones, B.M., Daanen, R., Epstein, H.E., Griffin, C.G., Kent, K., and Ward Jones, M.K. (2021) An object-based approach for mapping tundra ice-wedge polygon troughs from very high spatial resolution optical satellite imagery. Remote Sensing 13, 558. https://doi.org/10.3390/rs13040558

• Zhang, X., Bianchi, T.S., Hanna, A.J.M., Shields, M.R., Izon, G., Hutchings, J.A., Ping, C.-L., Kanevskiy, M., Naghipour, N., Eglinton, T.I. (2021) Recent warming fuels increased organic carbon export from Arctic permafrost. AGU Advances 2, e2021AV000396.

Presentations:

Bristol, E., Connolly, C., Lorenson, T., Richmond, B., Ilgen, A., Choens, R. C., Bull, D., Kanevskiy, M., Iwahana, G., Jones, B., Spencer, R., and McClelland, J. (2021) Land-to-ocean fluxes and biolability of organic matter eroding along the Beaufort Sea coast near Drew Point, Alaska, EGU General Assembly 2021, online, 19–30 Apr 2021, EGU21-9260, https://doi.org/10.5194/egusphere-egu21-9260, 2021.

Rangel, R.C., Parsekian, A., Farquharson, L.M., Jones, B.M., Ohara, N., Creighton, A., Gaglioti, B., Kanevskiy, M.Z., Breen, A.L., Bergstedt, H., Romanovsky, V.E., and Hinkel, K.M. (2020) Geophysical Investigations of Drained Lake Basin Taliks, North Slope, Alaska. Abstract NS003-0013 presented at 2020 Fall Meeting, 1-17 Dec.

Witharana, C., Bhuiyan, A.E., Liljedahl, A., Kanevskiy, M., Jorgenson, T., Jones, B.M., Daanen, R., Epstein, H.E., Griffin, C., Kent, K., and Ward Jones, M.K. (2020) Automated Mapping of Ice-wedge Polygon Troughs in the Continuous Permafrost Zone using Commercial Satellite Imagery. Abstract C013-0002 presented at AGU 2020 Fall Meeting, 1-17 Dec.

Griffin, C., Daanen, R., Epstein, H.E., Jorgenson, T., Kanevskiy, M.Z., Kent, K., and Liljedahl, A. (2020) Landscape connectivity and dissolved organic matter in a degrading permafrost polygonal landscape. Abstract B120-14 presented at 2020 AGU Fall Meeting, 1-17 Dec.

Wickland, K., Jorgenson, T., Koch, J., Kanevskiy, M.Z, and Striegl, R.G. (2020) Thermokarst Ponds Drive Landscape-Level Carbon Greenhouse Gas Fluxes in a Dynamic Ice-Rich Arctic Ecosystem Over Decadal Time Scales. Abstract B075-0002 presented at AGU 2020 Fall Meeting, 1-17 Dec. Status = published. Acknowledgement of Federal Support = Yes

Kent, K., Epstein, H.E., Griffin, C., Liljedahl, A.K., Jorgenson, T., Daanen, R.P., and Kanevskiy, M.Z. (2020) Soil Characteristics and Plant Functional Groups across Successional Stages of Ice-wedge Degradation and Re-stabilization in the Tundra of Northern Alaska. Abstract B112-0003 presented at AGU 2020 Fall Meeting, 1-17 Dec. Status = published. Acknowledgement of Federal Support = Yes

Reports:

Kanevskiy, M., and Bjella, K. (2021, under review) A permafrost primer for highway and airport engineers. Report No. 000S927 for the Alaska Department of Transportation and Public Facilities.

Connor, B., Goering, D.J., Kanevskiy, M., Trochim, E., Bjella, K.L., and McHattie, R.L. (2020) Roads and airfields constructed on permafrost. A Synthesis of Practice. INEautc-2020.11/ AKDOT&PF Report No. 000S927 for the Alaska Department of Transportation and Public Facilities.

Bjella, K., Shur, Y., Kanevskiy, M., Duvoy, P., Grunau, B., Best, J., Bourne, S., Affleck, R. (2020) Improving Design Methodologies and Assessment Tools for Building on Permafrost in a Warming Climate. ERDC/CRREL TR-20-13 Final Technical Report (TR), Strategic Environmental Research and Development Program (SERDP).

*** What opportunities for training and professional development has the project provided?**

Landscape Evolution component:

1. Emily Watson-Cook successfully advanced to canidancy for her M.S. degree, and completed most of the field work required for her thesis.
2. Undergraduate student, Josephine Mahoney, was recruited through the AK UNiTE program (NSF Award to UAF ID 2019233) for the summer 2021 NNA field program. Josephine is a highly enthusiastic field researcher and designed an

independent field project to examine the composition of marl in the thermokarst ponds using genomic methods. She will continue with the NNA project in the fall 2021.
3. Post-doc Helena Bergstedt was hired in a joint appointment with the UAF Institute of Northern Engineering (a) completed the remote sensing analysis of dust effects near our Colleen Study site, (b) completed collection of basal peat samples from the major landscapes,(c) submitted an abstract to the 2021 EGU meeting (see Products)

Adaptation component:

1. Two Alaska Native interns to CCHRC who are students at the University of Alaska Fairbanks: Robby Strunk worked on Kali School K-12 outreach and Nastasia Caole who assisted with interviews related to housing foundation mitigation strategies.
2. "JUMP into STEM" (https://jumpintostem.org) summer 2021 intern Zoe Landers worked on the project at CCHRC. Landers is a student at Clark Atlanta University, an HBCU, who hopes to come back to work on the project next year.

*** Have the results been disseminated to communities of interest? If so, please provide details.**

Project Website: https://www.geobotany.uaf.edu/nna/

- **Arctic Data Center portal**: https://arcticdata.io/catalog/portals/nna-irps
- **Workshop**: Rapid Artctic Transitions due to Infrstrcture and Climate (RATIC) https://www.geobotany.uaf.edu/ratic/workshop2021.php
- **Facebook page**: https://www.facebook.com/permafrostpeople
- **You Tube playlist**: https://youtube.com/playlist?list=PL7lKeseyfVF_eNVV6dV4QgzuldDw7o048

*** What do you plan to do during the next reporting period to accomplish the goals?**

LANDSCAPE EVOLUTION COMPONENT

Fieldwork planned for Prudhoe Bay, Aug 2021:

- Familiarize the IRPS team with the NIRPO, Jorgenson, Colleen, and Airport study sites (IRPS Team),
- Conduct thaw-depth surveys of the transects and plots at all sites (IRPS Team),
- Retrieve data loggers from the ponds (Watson-Cook),
- Clip-harvest all terrestrial and pond plots (Walker, Breen, Watson-Cook),
- Place permafrost temperature loggers in representative landscapes,
- Drill permafrost boreholes in representative landscapes to examine the cryostructure of the permafrost (Nikolsky),
- Obtain detailed elevation surveys of the four NIRPO transects (Jones),
- Obtain UAV imagery of the NIRPO transects and plots (Jones), and
- Visit area B and possibly Areas A and C to examine typical areas of dry, moist, wet, and aquatic tundra that have been heavily impacted by climate- and road-related disturbances (IRPS Team).

ADAPTATION COMPONENT

2022 Fieldwork at Point Lay

In the planning phase with village consultation.

CCHRC planned activities

- Housing survey in Point Lay, Alaska, if COVID restrictions allow
- Compilation and review of existing K-12 outreach materials and posted to website
- Write-up of literature review completed, reviewed, and formatted
- Participate in Permafrost Symposium planning efforts
- Completion of a 'Building on Permafrost' short video.

Kali School K-12 Partnership

- Continue collaboration with Kali School principal and interested teachers
- Work with high school students to collect snow depth and temperature data throughout the winter
- Make lesson plans available for use by other teachers and research teams
- Identify existing curriculum related to permafrost and housing that we can share with teachers
- Hopefully meet students in the community and provide in-person, hands-on activities

- Invite NNA-CO Outreach and Education staff to work with our team to enhance our K-12 outreach efforts

Northern Alaska Permafrost and Infrastructure Symposium

- Planned for June 2021, the 7-day symposium is still in the planning phase. A preliminary proposal was developed. A phone call with the NNA program managers indicated that the scope of the plan still needs refinement.

DATA MANAGEMENT

- Hire a new data manager. Lisa Druckenmiller, the data manager who began the project, retired from the university at the end of 2020.
- Archive data from the 2020 and 2021 field seasons on the project's Arctic Data Center portal.
- Publish a data report for the 2020-2021 Prudhoe Bay field trips.

Products

Books

Book Chapters

Inventions

Journals or Juried Conference Papers
View all journal publications currently available in the NSF Public Access Repository for this award.

The results in the NSF Public Access Repository will include a comprehensive listing of all journal publications recorded to date that are associated with this award.

Raynolds, Martha K. and Jorgenson, Janet C. and Jorgenson, M. Torre and Kanevskiy, Mikhail and Liljedahl, Anna K. and Nolan, Matthew and Sturm, Matthew and Walker, Donald A.. (2020). Landscape impacts of 3D-seismic surveys in the Arctic National Wildlife Refuge, Alaska. *Ecological Applications*. 30 (7) . Status = Deposited in NSF-PAR doi:https://doi.org/10.1002/eap.2143 ; Federal Government's License = Acknowledged. (Completed by Walker, null on 08/06/2021) Full text Citation details

Raynolds, Martha K. and Walker, Donald A. and Balser, Andrew and Bay, Christian and Campbell, Mitch and Cherosov, Mikhail M. and Daniëls, Fred J.A. and Eidesen, Pernille Bronken and Ermokhina, Ksenia A. and Frost, Gerald V. and Jedrzejek, Birgit and Jorgenson, M. Torre and Kennedy, Blair E. and Kholod, Sergei S. and Lavrinenko, Igor A. and Lavrinenko, Olga V. and Magnússon, Borgþór and Matveyeva, Nadezhda V. and Metúsalemsson, Sigmar and Nilsen, Lennart and Olthof, Ian and Pospelov, Igor N. and Pospelova, Elena B. and Pouliot, Darren and Razzhivin, Vladimir and Schaepman-Strub, Gabriela and Šibík, Jozef and Telyatnikov, Mikhail Yu. and Troeva, Elena. (2019). A raster version of the Circumpolar Arctic Vegetation Map (CAVM). *Remote Sensing of Environment*. 232 (C) 111297. Status = Deposited in NSF-PAR doi:https://doi.org/10.1016/j.rse.2019.111297 ; Federal Government's License = Acknowledged. (Completed by Walker, null on 08/06/2021) Full text Citation details

Schneider von Deimling, Thomas and Lee, Hanna and Ingeman-Nielsen, Thomas and Westermann, Sebastian and Romanovsky, Vladimir and Lamoureux, Scott and Walker, Donald A. and Chadburn, Sarah and Trochim, Erin and Cai, Lei and Nitzbon, Jan and Jacobi, Stephan and Langer, Moritz. (2021). Consequences of permafrost degradation for Arctic infrastructure – bridging the model gap between regional and engineering scales. *The Cryosphere*. 15 (5) 2451 to 2471. Status = Deposited in NSF-PAR doi:https://doi.org/10.5194/tc-15-2451-2021 ; Federal Government's License = Acknowledged. (Completed by Walker, null on 08/05/2021) Full text Citation details

Bhatt, Uma S and Walker, Donald A and Raynolds, Martha K and Walsh, John E and Bieniek, Peter A and Cai, Lei and Comiso, Josefino C and Epstein, Howard E and Frost, Gerald V and Gersten, Robert and Hendricks, Amy S and Pinzon, Jorge E and Stock, Larry and Tucker, Compton J. (2021). Climate drivers of Arctic tundra variability and change using an indicators framework. *Environmental Research Letters*. 16 (5) 055019. Status = Deposited in NSF-PAR doi:https://doi.org/10.1088/1748-9326/abe676 ; Federal Government's License = Acknowledged. (Completed by Walker, null on 08/05/2021) Full text Citation details

Frost, G. V.. (2020). Tundra greenness. *Bulletin of the American Meteorological Society*. S1–S429. Status = Deposited in NSF-PAR doi:https://doi.org/10.1175/BAMS-D-20-0086. ; Federal Government's License = Acknowledged. (Completed by Walker, null on 08/04/2021) Full text Citation details

Raynolds, M.K., Jorgenson, J.C., Jorgenson, M.T., Kanevskiy, M., Liljedahl, A.K., Nolan, M. Sturm, M., Walker D.A. 2020. Landscape impacts of 3D-seismic surveys in the Arctic National Wildlife Refuge, Alaska. Ecological Applications, https://doi.org/10.1002/eap.2143. Status = PUBLISHED.

Frost, G.V., U. S. Bhatt, H. E. Epstein, L. T. Berner, J. W. Bjerke, B. C. Forbes, S. J. Goetz, M. J. Lara, M. J. Macander, G. K. Phoenix, M. K. Raynolds, H. Tømmervik, and D. A. Walker, 2020. State of the climate in 2019: The Arctic: Tundra greening. Bulletin of the American Meteorological Society, pp. S272–S274. Available at: https://doi.org/10.1175/BAMS-D-20-0086.. Status = PUBLISHED.

Kanevskiy, M., Y. Shur, D. A. Walker, M. T. Jorgenson, B. M. Jones, M. Buchhorn, G. Matyshak, H. Bergstedt, A. L. Breen, B. Connor, R. Daanen, A. K. Liljedahl, V. E. Romanovsky, and E. Watson-Cook. 2021 in revision. Risk of ice-wedge thermokarst in relation to road infrastructure, Prudhoe Bay Oilfield, Alaska. Arctic Science.. Status = UNDER_REVIEW.

Walker, D. A., M. K. Raynolds, M. Z. Kanevskiy, Y. Shur, V. E. Romanovsky, B. M. Jones, M. Buchhorn, M. T. Jorgenson, J. Šibík, A. L. Breen, A. Kade, E. Watson-Cook, H. Bergstedt, A. K. Liljedahl, R. Daanen, B. Connor, D. J. Nicolsky, and J. L. Peirce. (2021, in revision). Cumulative impacts of a gravel road and climate change in an ice-wedge polygon landscape, Prudhoe Bay, Alaska. Arctic Science.. Status = UNDER_REVIEW.

Povoroznyuk, O., Vincent, W.F., Schweitzer, P., Laptander, R., Bennett, M., Calmels, F., Sergeev, D. Arp, C., Forbes, B., Roy-Léveillée, P., and Walker, D.A. 2021 submitted. Arctic Roads and Railways: Environmental and Social Consequences of Transport Infrastructure in the Circumpolar North, Arctic Science.. Status = UNDER_REVIEW.

Bergstedt, H., Jones, B, Walker, D.A. Farquharson, L., Breen, A., Hinkel, K. 2020. Mapping lake drainage and drained lake basins around Point Lay, Alaska using multi-source remote sensing data. EGU General Assembly (4–8 May 2020). Session ITS 5.9/EOS 4.14. https://doi.org/10.5194/egusphere-egu2020-11919.. Status = PUBLISHED.

Bergstedt, Helena; Jones, Benjamin; Walker, Donald; Pierce, Jana; Bartsch, Annett; Pointner, Georg; ",Quantifying the spatial and temporal influence of infrastructure on seasonal snow melt timing and its influence on vegetation productivity and early season surface water cover in the Prudhoe Bay Oilfields,EGU General Assembly Conference Abstracts,,,EGU21-10296,2021. Status = PUBLISHED.

Sehmel, Tracy, 2021. Potential Mitigation Strategies for Buildings and Infrastructure on Thawing Permafrost. UAF One Health Conference. Status = OTHER.

Landers, Zoe. 2021. Effects of Ice Rich Permafrost on Infrastructure presented. National Renewable Energy Laboratory Summer Internship Research Poster Session. Status = OTHER.

Ward Jones, M., Jones, B., Walker, S., Kanevskiy, M., Shur, Y., Peirce, J., Zweiback, S., Breen, Liljedahl, A., Natali, S., Miller, C. 2021 submitted. AGU 2021, Session BO74.. Status = SUBMITTED.

Shur, Y., Fortier, D., Jorgenson, T., Kanevskiy, M., Schirrmeister, L., Strauss, J., Vasiliev, A., Ward Jones, M. (2021, submitted) Yedoma Permafrost Genesis: More than 150 Years of Mystery and Controversy. Submitted to Frontiers in Earth Science.. Status = SUBMITTED.

Kanevskiy, M., Shur, Y., Bigelow, N.H., Bjella, K.L., Douglas, T.A., Jones, B.M., Jorgenson, M.T., Fortier, D. (2021, submitted) Yedoma cryostratigraphy of recently excavated sections of the CRREL Permafrost Tunnel near Fairbanks, Alaska. Submitted to Frontiers in Earth Science.. Status = SUBMITTED.

Licenses

Other Conference Presentations / Papers

D.A. Walker, M.K. Raynolds, M.Z. Kanevskiy, Y. Shur, V.E. Romanovsky, B.M. Jones, M. Buchhorn, M.T. Jorgenson, J. Šibík, A.L. Breen, E. Watson-Cook, H. Bergstedt, A. Liljedahl, R. Daanen, D. Nikolsky, B. Connor, J.L. Peirce (2021). *Cumulative impacts of a gravel road and climate change in an ice-wedge polygon landscape, Prudhoe Bay Oilfield, AK*. Oral presentation Arctic Science Summit Week 2021, Session ID 19, Northern Roads and Railways: Social and Environmental Effects of Transport Infrastructure,. Lisbon, Portudal. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

D. A. “Skip” Walker and Jana Peirce (2020). *Navigating the New Arctic with a focus on ground ice: Landscape evolution and adapting to change in ice-rich permafrost systems (NNA-IRPS)*. IARPC Permafrost Collaborations Team Meeting,. Online. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Other Products

Educational aids or Curricula.

Lesson plans created by the NNA-IRPS research team in collaboration with Kali School principal and teachers for the 2021 Spring semester in Point Lay, Alaska. NSF-funded researchers created the unit as part of educational outreach for a Navigating the New Arctic project on Landscape Evolution and Adapting to Change in Ice-rich Permafrost Systems (NNA-IRPS). Research team members provided supplies, videos and instructional worksheets and participated in two virtual classroom visits in Feb and May 2021. Lessons were adapted for local needs and taught by Kali School teachers Dianne Shirrell (grades 1-2) and Daniel Griffis (high school science). Principal Brett Stirling and UIC Science provided collaboration support.

Other Publications

D.A.'Skip' Walker, Jana Peirce, Amy Breen, Anja Kade, Helena Bergstedt, Ronnie Daanen, Emily Watson-Cook (2021). *Navigating the New Arctic: Landscape evolution and adaptation to change in Ice-Rich permafrost systems: Field report of the NNA-IRPS vegetation expedition, Prudhoe Bay, AK, 13 July–3 August 2021*. Field report of the NNA-IRPS vegetation expedition, Prudhoe Bay, AK, 13 July-3 August 2021. Status = OTHER; Acknowledgement of Federal Support = Yes

Patent Applications

Technologies or Techniques

Thesis/Dissertations

Websites or Other Internet Sites

Supporting Files

Filename	Description	Uploaded By	Uploaded On
NNA-IRPS Field Report 20210811(1).pdf	Field report of the NNA-IRPS vegetation expedition, Prudhoe Bay, AK, 13 July-3 August 2021	Donald Walker	08/11/2021
Kali Advisory Group Meeting 2020-11-20 - Notes and Recommendations - Archive.pdf	Local and Regional Advisory Group meeting summary	Donald Walker	08/18/2021
NNA-IRPS Lesson plans for Kali School Spring 2021 - archive.pdf	Multi-age lesson plans created for NNA-IRPS educational outreach in Point Lay, Alaska, in Spring 2021 in collaboration with Kali School principal and teachers.	Donald Walker	08/18/2021
NNA-IRPS Virtual classroom visit - Kali School 2021 - archive.pdf	Select slides from virtual classroom visits with Point Lay, Alaska, students in Spring 2021 showing students engaged in permafrost and housing curricula created by NSF researchers in collaboration with Kali School teachers and principal with support from UIC Science.	Donald Walker	08/18/2021

Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Walker, Donald	PD/PI	6
Kofinas, Gary	Co PD/PI	1
Liljedahl, Anna	Co PD/PI	1
Romanovsky, Vladimir	Co PD/PI	1
Shur, Yuri	Co PD/PI	1
Breen, Amy	Co-Investigator	4
Connor, Billy	Co-Investigator	2
Jones, Ben	Co-Investigator	2
Kade, Anja	Co-Investigator	2
Kanevskiy, Mikhael	Co-Investigator	3
Nicolsky, Dmitry	Co-Investigator	1
Peirce, Jana	Co-Investigator	6
Bergstedt, Helena	Postdoctoral (scholar, fellow or other postdoctoral position)	2
Ward-Jones, Melissa	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Druckenmiller, Lisa	Technician	1
Raynolds, Martha	Technician	1
Watson-Cook, Emily	Graduate Student (research assistant)	6
Meade, Zoe	Non-Student Research Assistant	1
Mahoney, Josephine	Undergraduate Student	1
Daanen, Ronald	Consultant	1

Full details of individuals who have worked on the project:

Donald A Walker
Email: dawalker@alaska.edu

Most Senior Project Role: PD/PI
Nearest Person Month Worked: 6

Contribution to the Project: PI, Organized and directed several online workshops. Wrote and submitted paper to Arctic Science, Contributed to several other papers

Funding Support: This grant and UAF Institute of Arctic Biology

Change in active other support: No

International Collaboration: No
International Travel: No

Gary P Kofinas
Email: gary.kofinas@alaska.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: A few phone calls consulting on activities at Point Lay

Funding Support: this grant

Change in active other support: No

International Collaboration: No
International Travel: No

Anna Liljedahl
Email: aliljedahl@whrc.org
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: Directing hydrology component of the project, contributed to several publications and online meetings

Funding Support: This grant

Change in active other support: No

International Collaboration: No
International Travel: No

Vladimir E Romanovsky
Email: ffver@uaf.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: contributed to several publications and online meetings

Funding Support: This grant and Geophysical Institute, UAF

Change in active other support: No

International Collaboration: No
International Travel: No

Yuri L Shur
Email: yshur@alaska.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: Contributed to several publications and online meetings

Funding Support: This grant and Institute of Northern Engineering, UAF

Change in active other support: No

International Collaboration: No
International Travel: No

Amy Breen
Email: albreen@alaska.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 4

Contribution to the Project: Leader and collaborator on the vegetation component

Funding Support: This grant, and UAF International Arctic Research Center

International Collaboration: No
International Travel: No

Billy Connor
Email: bgconnor@alaska.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2

Contribution to the Project: Co-investigator, permafrost engineering infrastructure components in Point Lay and Prudhoe Bay

Funding Support: This grant and UAF Institute of Northern Engineering

International Collaboration: No
International Travel: No

Ben Jones
Email: bmjones3@alaska.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2

Contribution to the Project: Co investigator, remote sensing component

Funding Support: This award and UAF Institute of Northern Engineering

International Collaboration: No
International Travel: No

Anja Kade
Email: ankade@alaska.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2

Contribution to the Project: Co-investigator, Vegetation component, trace-gas fluxes

Funding Support: This grant

International Collaboration: No
International Travel: No

Mikhael Kanevskiy

Email: Mikhail Kanevskiy
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 3

Contribution to the Project: Co-investigator, permafrost component, ground ice characterization

Funding Support: This award and UAF Institute of Northern Engineering

International Collaboration: No
International Travel: No

Dmitry Nicolsky
Email: djnicolsky@alaska.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: Co-investigator, permafrost modeling

Funding Support: This award

International Collaboration: No
International Travel: No

Jana Peirce
Email: jlpeirce@alaska.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 6

Contribution to the Project: Project coordinator, lead on adaptations portions of the award, and codevelopment with village of Point Lay

Funding Support: This award and UAF Institute of Arctic Biology

International Collaboration: No
International Travel: No

Helena Bergstedt
Email: hbergstedt@alaska.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 2

Contribution to the Project: Post-doc on remote sensing component

Funding Support: This award and UAF Institute of Northern Engineering

International Collaboration: No
International Travel: No

Melissa Ward-Jones
Email: mkwardjones@alaska.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 1

Contribution to the Project: Collaboration: Lead author on manuscript for 2021 AGU meeting Session BO74 using ground temperature data from our Colleen and Airport sites "Preliminary assessment of the micro-topographic impacts of ice-wedge systems using remote sensing and field observations"

Funding Support: INE Post-doctoral support through Ben Jones

International Collaboration: No
International Travel: No

Lisa Druckenmiller
Email: ladruckenmiller@alaska.edu
Most Senior Project Role: Technician
Nearest Person Month Worked: 1

Contribution to the Project: Data manager

Funding Support: This award

International Collaboration: No
International Travel: No

Martha Raynolds
Email: mkraynolds@alaska.edu
Most Senior Project Role: Technician
Nearest Person Month Worked: 1

Contribution to the Project: GIS and remote sensing support

Funding Support: This award

International Collaboration: No
International Travel: No

Emily Watson-Cook
Email: ewatsoncook@alaska.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 6

Contribution to the Project: Began thesis work and accomplished her field season in summer 2020 and 2021

Funding Support: this grant

International Collaboration: No
International Travel: No

Zoe Meade
Email: zemeade@alaska.edu
Most Senior Project Role: Non-Student Research Assistant
Nearest Person Month Worked: 1

Contribution to the Project: Field assistant in 2021

Funding Support: this grant

International Collaboration: No
International Travel: No

Josephine Mahoney
Email: 18jemahoney@gmail.com
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 1

Contribution to the Project: Field assistant for trace-gas flux portion of the grant

Funding Support: This grant and UAF student award

International Collaboration: No
International Travel: No

Ronald Daanen
Email: "Daanen, Ronald P (DNR)"
Most Senior Project Role: Consultant
Nearest Person Month Worked: 1

Contribution to the Project: Consultant, Alaska Department of Geology and Geophysical Surveys (DGGS), consultant on airborne and ground based Lidar

Funding Support: this proposal

International Collaboration: No
International Travel: No

What other organizations have been involved as partners?

Name	Type of Partner Organization	Location
Alaska Division of Geological & Geophysical Surveys	State or Local Government	Fairbanks, AK
Cold Climate Housing Research Center	Other Nonprofits	Fairbanks, AK
Kali School	School or School Systems	Point Lay, AK
Native Village of Point Lay IRA	State or Local Government	Point Lay, AK
North Slope Borough Department of Planning and Community Dev	State or Local Government	Utqiagvik, AK
Tagiuġmiullu Nunamiullu Housing Authority	Other Organizations (foreign or domestic)	Utqiagvik, AK
Woodwell Climate Research Center	Other Organizations (foreign or domestic)	Falmouth, MA

Full details of organizations that have been involved as partners:

Alaska Division of Geological & Geophysical Surveys

Organization Type: State or Local Government
Organization Location: Fairbanks, AK

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: Project researcher Ronald Daanen is a hydrogeololgist with Alaska DGGS. Because of the close coordination and nature of his involvement in the project, his relationship has been changed from a contractor to a subaward with the state agency he works for.

Cold Climate Housing Research Center

Organization Type: Other Nonprofits
Organization Location: Fairbanks, AK

Partner's Contribution to the Project:
Facilities
Personnel Exchanges

More Detail on Partner and Contribution: Partner on the Adaptations to Change component of the research in Point lay

---

Kali School

Organization Type: School or School Systems
Organization Location: Point Lay, AK

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: Kali School principal and interested teachers collaborate with researchers to develop and deliver lessons related to the project and host virtual classroom visits by the science team.

Native Village of Point Lay IRA

Organization Type: State or Local Government
Organization Location: Point Lay, AK

Partner's Contribution to the Project:
In-Kind Support
Collaborative Research

More Detail on Partner and Contribution: The Tribal government of Point Lay provides a project liaison and appoints members to a local steering committee to advise the research team on the best ways to work with and in the community. The Tribal president is on the project Advisory Group.

North Slope Borough Department of Planning and Community Dev

Organization Type: State or Local Government
Organization Location: Utqiagvik, AK

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: The regional planning department advises the research team and helps focus research efforts to ensure the project will have a positive impact. Its director is on the project's Advisory Group and on the Permafrost and Infrastructure Symposium planning committee.

Taġiuġmiullu Nunamiullu Housing Authority

Organization Type: Other Organizations (foreign or domestic)
Organization Location: Utqiagvik, AK

Partner's Contribution to the Project:
Facilities
Collaborative Research

More Detail on Partner and Contribution: TNHA provides lodging for the research team in Point Lay. Its executive director, as a member of the local and regional advisory group for the project and the symposium planning committee, contributes important background information and helps focus research efforts to ensure the project will have a positive impact.

Woodwell Climate Research Center

Organization Type: Other Organizations (foreign or domestic)
Organization Location: Falmouth, MA

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: Project Co-PI Anna Liljedahl is now research staff at Woodwell Climate. Her funding has been moved from UAF to a subaward with Woodwell Climate.

Were other collaborators or contacts involved? If so, please provide details.
Nothing to report

Impacts

What is the impact on the development of the principal discipline(s) of the project?

Environmental impact assessments for new Arctic infrastructure in ice-rich permafrost areas do not adequately consider the likely long-term cumulative effects of climate change and the indirect impacts of proposed infrastructure, due in part to the scarcity of historical case studies that document changes after the infrastructure was built. Our case study in the Prudhoe Bay Oilfield (PBO) examines the long-term changes along a heavily traveled road and in natural areas distant from roads. The combined datasets will provide unique insights into the rate and extent of ecological disturbances associated with infrastructure affected permafrost landscapes under decades of climate warming.

What is the impact on other disciplines?
Nothing to report.

What is the impact on the development of human resources?

How has the project improved the performance, skills, or attitudes of members of underrepresented groups that will improve their access to or retention in research, teaching, or other related professions;

1. The project supported two Alaska Native interns to CCHRC who are students at the University of Alaska Fairbanks: Robby Strunk who worked on Kali School K-12 outreach and Nastasia Caole who assisted with interviews related to housing foundation mitigation strategies.
2. The project supported the mentorship of "JUMP into STEM" (https://jumpintostem.org) intern Zoe Landers at CCHRC. Landers is a student at Clark Atlanta University, an HBCU, who hopes to come back to work on the project next year.

How has the project provided exposure to science and technology for practitioners, teachers, young people, or other members of the public?

1. UAF undergraduate Josephine Mahoney joined our 2021 summer field season through AK UNiTE, an NSF-funded research network to advance undergraduate research opportunities in biology for Alaska students, and will join our team as an undergraduate research assistant this fall. In the field, Josephine assisted with trace gas flux measurements and aquatic vegetation sampling. She also developed her own project analyzing the microbial communities present in gyttja, which she will pursue this fall and winter using samples collected in the field.
2. 1st/2nd grade and high school students at Kali School in Point Lay, Alaska, participated in virtual classroom visits with scientists and an engineer on our team and were introduced to scientific concepts and methods through hands-on lessons in snow measurement, thermal imaging, simulating permafrost thaw from different types of housing foundations. 1st/2nd grade students also completed a vocabulary worksheet and made posters showing elements of a permafrost landscape.
3. Kali School teachers watched a time-lapse video made by co-investigater Ben Jones showing the difference in subsidence related to ground-ice content.
4. A Facebook page (@permafrostpeople) was launched to notify the Point Lay community about project activities and to educate the general public about the study of ice-rich permafrost and the risks to communities from rapid thawing. The

page also helps viewers find the project's You-Tube hosted videos. A post showcasing our 2021 field activities with details about our study has received over 2000 views in just a few weeks.

What was the impact on teaching and educational experiences?

How has the project developed and disseminate new educational materials? How has it developed online resources that will be useful for teachers and students and other school staff?

1. The partnership with Kali School, which started in 2020-2021 and will continue for at least one more year, has resulted in the development of a number of K-12 lesson plans for elementary and middle/high-school students related to permafrost and housing, which will be made available on the project website and the CCHRC website. Several videos produced for the lessons are hosted on You Tube. In the coming year, we hope to take advantage of NNA Community Office Education and Outreach staff to learn about existing permafrost curricula for K-12 teachers and to discuss additional ways to disseminate the lesson plans we've developed.

What is the impact on physical resources that form infrastructure?
Nothing to report.

What is the impact on institutional resources that form infrastructure?
Nothing to report.

What is the impact on information resources that form infrastructure?
Nothing to report.

What is the impact on technology transfer?
Nothing to report.

What is the impact on society beyond science and technology?
Nothing to report.

What percentage of the award's budget was spent in a foreign country?

No funds spent in foreign countries

Changes/Problems

Changes in approach and reason for change

Covid has continued to stress all aspects of the research, including:

1. Field research has been particularly difficult to plan and execute because of changes in national, state, and university Covid mandates and regulations. In 2020, we conducted a very short field season that mainly provided graduate student Emily Watson-Cook with in introduction to the field area, and a brief survey of our NIRPO field site. 2021 was also shortened because of difficulty of several team members to satisfy the Covid policies needed to work at Prudhoe Bay.
2. Daily interactions among team members has at times been nonexistent with everyone working from home.
3. Regular project meetings that were conducted as noon-time "Soup and Science" meetings have been canceled since last year.
4. Progress has been slow with developing the Point Lay component because of impossibility of meeting in person in the village.

We have adapted and moved forward, but with great strain on the team because of the necessity of so many Zoom meetings and much personal interaction and time spent thinking through the details of activities. Much of our planning and thinking occurs "at the whiteboard", and this type of interaction has been very infrequent. The attached partial list of project-related online and Zoom meeting that have occurred the past year gives an idea of the hours spent planning, executing, and summarizing these activities:

Date	Meeting
9/3/2020	NNA-IRPS Team Meeting: Postdoc plan

9/10/2020	RATIC infrastructure classification/monitoring framework
10/2/2020	NNA-IRPS Team Meeting: Observations from Summer Field Work
10/8/2020	RATIC infrastructure classification/monitoring framework: Planning Meeting
10/21/2020	Kali School Educational Outreach: NNA-IRPS team planning meeting
10/23/2020	AAGA ArcGIS Portal: Review of map datasets
10/23/2020	NNA-IRPS Soup and Science: Presentation by B Jones, Pt Lay remote sensing analysis
10/29/2020	Permafrost Symposium: Planning meeting
11/3/2020	AAGA ArcGIS Portal: Progress check-in
11/10/2020	AAGA ArcGIS Portal: Progress check-in
11/11/2020	AAGA ArcGIS Portal: Map previews
11/12/2020	RATIC infrastructure classification/monitoring framework: Planning Meeting
11/13/2020	NNA-IRPS Team Meeting
11/17/2020	RATIC/T-MOSAiC workshop planning: Indigenous/industry focus
11/20/2020	Kali Community/Regional Advisory Group Meeting
11/27/2020	RATIC/T-MOSAiC workshop planning
11/30/2020	AAGA ArcGIS Portal: WebMap App training
12/1/2020	CAVM Map: Team meeting
12/2/2020	Kali School Educational Outreach: Meeting with Kali School teachers
12/4/2020	NNA-IRP Component: Vegetation data analysis
12/7/2020	Kali School Educational Outreach: Review Kali winter packet questions
12/8/2020	NNA Community Networking Meeting
12/17/2020	RATIC infrastructure classification/monitoring framework: Presentations by T Ingeman-Nielsen and P Schweitzer
1/8/2021	NNA-IRPS Team Meeting: 2021 planning
1/11/2021	Postdoc mentoring: Dust paper review
1/20/2021	Permafrost Symposium: Planning meeting
1/21/2021	RATIC infrastructure classification/monitoring framework: Presentations by Epstein and Sergeev
1/22/2021	NNA-IRPS Soup and Science: Presentation by H Bergstedt
1/25/2021	Postdoc mentoring: Dust paper review
2/3/2021	Kali School Educational Outreach: Meeting with Kali School teachers
2/9/2021	Meeting with Alaska DOT&PF Dalton Hwy supervisor

2/17/2021 NNA-IRPS Component: Survey and Mapping Plan

2/18/2021 RATIC/T-MOSAiC: Arctic infrastructure science talks by D Walker and H Bergstedt

2/19/2021 NNA-IRPS Soup and Science presentation: Skip Walker

2/22/2021 Postdoc mentoring: Dust paper review

2/25/2021 Meeting with Hilcorp road and pads supervisors

3/2/2021 Permafrost Symposium: Planning meeting

3/3/2021 RATIC/T-MOSAiC workshop planning

3/3/2021 Kali School Educational Outreach: Meeting with Kali School teachers

3/5/2021 NNA-IRPS Team Meeting

3/18/2021 RATIC/T-MOSAiC workshop planning

3/30/2021 CAVM Map: Team meeting

3/31/2021 Summer field logistics planning

4/2/2021 NNA-IRPS Team Meeting

4/7/2021 Kali School Educational Outreach: Meeting with Kali School teachers

4/15/2021 RATIC/T-MOSAiC Arctic Infrastructure Science Talk: Presentation by O Anisimov

4/15/2021 Permafrost Symposium: Planning meeting

4/28/2021 Kali School Educational Outreach: Meeting with Kali School teachers

5/3/2021 RATIC/T-MOSAiC workshop planning

5/7/2021 NNA-IRPS Team Meeting: Summer field planning

5/20/2021 RATIC/T-MOSAiC Arctic Infrastructure Science Talk: Presentation by M Langer

5/27/2021 Permafrost Symposium: Planning meeting

6/1/2021 Steering Committee planning meeting

6/3/2021 Kali Village Steering Committee Meeting

6/4/2021 NNA-IRPS Team Meeting

6/14/2021 Collaboration with Melissa Ward-Jones

6/18/2021 Permafrost Symposium: Planning meeting

6/23/2021 RATIC/T-MOSAiC workshop planning

6/30/2021 Orientation for undergraduate research assistant

7/6/2021 NNA-IRPS Component: PBO thermistor placement

7/8/2021 NNA-IRPS Component: LiDAR survey discussion

7/9/2021 NNA-IRPS Component: Pt Lay sensor location selection tool

7/9/2021	Permafrost Symposium: Planning meeting
8/6/2021	NNA-IRPS Team Meeting
8/11/2021	Interview student research assistant
8/12/2021	Permafrost Symposium: Planning meeting
8/13/2021	Kali Village Steering Committee Meeting
8/16/2021	Permafrost Symposium: Planning meeting

Actual or Anticipated problems or delays and actions or plans to resolve them

A delay occurred in transferring funds for the subaward to Anna Liljedahl, from UAF to the Woodwell Climate Research Center and is now working from Homer AK. Anna was unable to begin work on the project because of the delay. The transfer of funds was completed in July 2021 and Anna is now able to charge to her subaward.

Changes that have a significant impact on expenditures

Anna was unable to charge her time to the project until the transfer of funds was completed.

Significant changes in use or care of human subjects
Nothing to report.

Significant changes in use or care of vertebrate animals
Nothing to report.

Significant changes in use or care of biohazards
Nothing to report.

Change in primary performance site location

We were unable to visit our Pt. Lay research site as planned in 2021 because of the Covid restrictions.

Special Requirements

Responses to any special reporting requirements specified in the award terms and conditions, as well as any award specific reporting requirements.
Nothing to report.

Navigating the New Arctic: Landscape evolution and adaptation to change in Ice-Rich Permafrost Systems (NNA-IRPS)

Field report of the NNA-IRPS vegetation expedition, Prudhoe Bay, AK, 13 July-3 August 2021

D.A.'Skip' Walker, Jana Peirce, Amy Breen, Anja Kade, Helena Bergstedt, Ronnie Daanen, Emily Watson-Cook

Field work for the vegetation component of the NNA-IRPS project (NSF NNA award 1928237) was conducted 13 July-3 Aug 2021, at the Natural Ice-Rich Permafrost Observatory (NIRPO) and the nearby Jorgenson research site, Prudhoe Bay, AK (Fig. 1). The NIRPO was established to better understand the role that ecosystems play in the development and degradation of ice-rich permafrost. Researchers are studying how differences in vegetation, water, and time influence the accumulation and degradation of ground ice in IRP landscapes, and how the loss of ground ice can radically change these landscapes and the infrastructure built on them. The major goals for the 2021 expedition were to:

- Characterize the vegetation, site factors, and soils on different-age surfaces,
- Characterize the vegetation in the many small thermokarst ponds and determine if aquatic vegetation is affecting pond soil temperatures and the underlying permafrost,
- Characterize the fluxes of trace-gas fluxes on the different surfaces, and
- Date the major surfaces.

Major tasks:

- Establish baseline transects and permanent vegetation plots on five different-age surfaces with distinct landforms at the NIRPO site:
    - Residual surfaces unaffected by thaw-lake processes, but with extensive thermokarst ponds;
    - Drained thaw-lake bluff with high-centered polygons;
    - Old drained-lake basin surface with well-developed low-centered polygons;
    - Intermediate drained-lake basin surface with irregular and disjunct polygon features; and
    - Recent drained-lake basin with featureless surface, hummocks, and a few bird mounds.
- Collect Lidar imagery for the NIRPO site and other nearby areas of interest.
- Conduct baseline vegetation and soil studies at the permanent plots.
- Conduct pond studies (vegetation surveys, water and soil temperature, water level surveys) in thermokarst ponds at the Jorgenson and NIRPO sites.
- Conduct chamber-based trace-gas flux studies on a subset of permanent plots on each surface.
- Collect basal peat samples from each surface for C-14 dating.
-

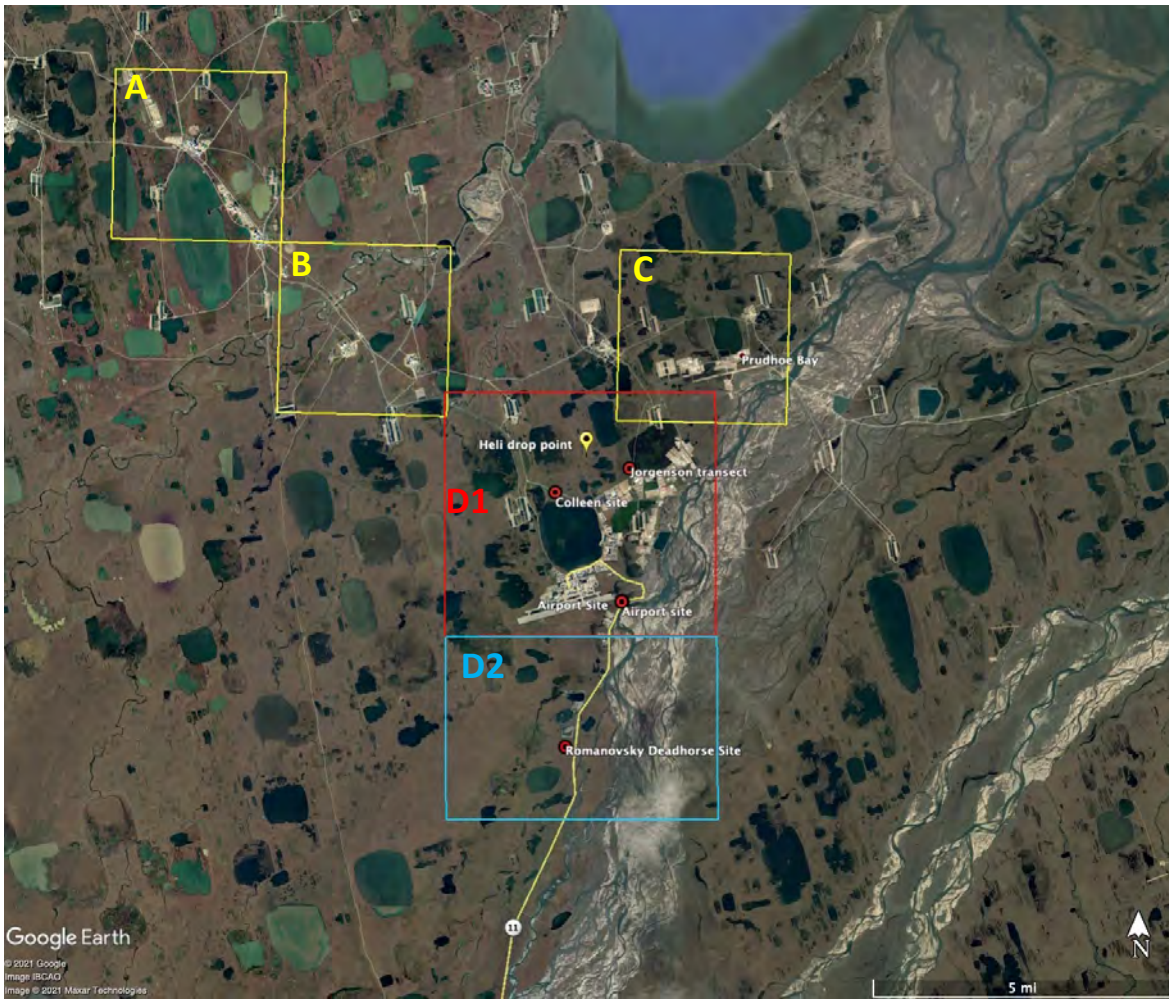


Figure 1. Study areas for the NNA-IRPS project. The studies during the included the area in the vicinity of the helicopter drop point at the NIRPO base camp (yellow dot) and the Jorgenson transect. The red boundary (D1) encloses the NIRPO site, the Colleen site (Walker et al. 2015), and Airport site (Walker et al. 2016). The yellow boxes A, B, and C are geoecological and historical disturbance map areas (Raynolds et al. 2014). The blue boundary (D2) includes the Romanovsky Deadhorse site (Romanovsky and Osterkamp 1995) and areas along the Dalton Highway affected by the 2015 Sagavanirktok flood (Shur 2016).

Expedition members:

Dr. Helena Bergstedt (UAF, Institute of Northern Engineering, Post doc): remote sensing
Dr. Amy Breen (UAF, International Arctic Research Center, Research Assistant Professor): Vegetation surveys
Dr. Ronnie Daanen and Mr. Barrett Salisbury (Alaska Department of Natural Resources, Division of Geological and Geodetic Surveys): Ground topographic control and Lidar acquisition
Dr. Anja Kade (UAF, Dept. of Biology and Wildlife, Assistant Professor): trace-gas fluxes
Ms. Josephine Mahoney (UAF, IAB: research assistant): Trace-gas fluxes
Ms. Zoe Meade (UAF, IAB, research assistant): Pond surveys
Ms. Jana Pierce (UAF, IAB; Project coordinator): Logistics and photographer
Dr. Skip Walker (UAF, IAB; Professor): Project lead and vegetation surveys

Ms. Emily Watson Cook (UAF, IAB and Dept. of Biology and Wildlife; M.S. graduate student): Pond surveys

Most participants were part of the vegetation component of the IRPS project and were divided into four main task groups: terrestrial vegetation surveys (Breen and Walker), trace-gas fluxes (Kade and Mahoney), pond studies (Watson-Cook and Meade), and logistics, communication, and photography (Peirce). Bergstedt joined the group for a few days and collected basal peat samples for C-14 dating. Most of the objectives were completed by August 26. Breen, Kade, Peirce and Walker returned to Fairbanks by truck. Meade returned to Anchorage by plane. Watson-Cook and Mahoney remained to complete the pond studies until Aug 1 and returned to Fairbanks by truck.

Accomplishments and high points:

1. **Logistic support** (Fig. 1): The Batelle ARO provided excellent expedition support, including safety training, two trucks, housing in Wiseman, meals to and from the field site, housing and meals at Prudhoe Bay, and helicopter support for the base camp. The support at the Arctic Oilfield Hotel was excellent and friendly. They allowed us to use of their Conference Room for our daily morning meetings and evening sample preparation and analyses. They also provided freezer space for our samples.

Figure 1. Arctic Oilfield Hotel and conference room during morning meeting. Left to right: Skip Walker, Amy Breen, Emily Watson-Cook, Josephine Mahoney. All photos are by Jana Peirce unless otherwise noted.

2. **Weather:** We had sunny and warm weather 13–21 July. It turned cloudy, cooler and windy for the remaining days with some light rain July 26. Mosquitoes were minimal the entire time.

3. **NIRPO base camp (15 July) (Fig. 2):**

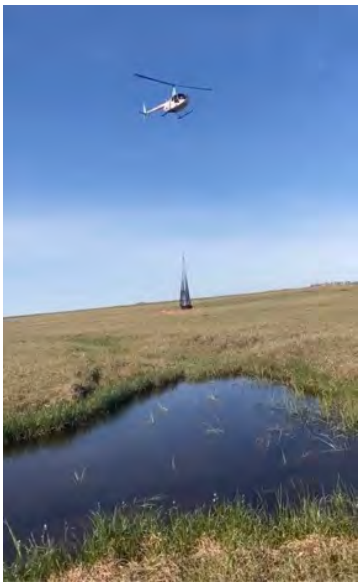


Figure 2. Left: Quicksilver helicopter pilot, Eryk de la Montaña, and Skip Walker preparing sling load. Right: Helicopter dropping the first sling load at the drop point (circle of orange pin flags). Photo by Josephine Mahoney.

The NIRPO base camp was transported from the Deadhorse Airport to the NIRPO in 3 trips (3 trips including 2 sling loads) by a Quicksilver R-44 helicopter stationed at the Teshekpuk Lake Observatory (pilot Eryk de la Montaña). The base camp was used for storing and staging equipment and providing a common area of gathering while in the field. The camp is accessible from the Nabors Drilling Co. pad (1.2 km south of the NIRPO base camp, 25-minute walk).

Figure 3. NIRPO base camp with from left Helena Bergstedt, Amy Breen, Skip Walker.

4. **Lidar acquisition (17-19 July) (Fig. 3):** The Lidar surveys will be used to support the hydrological studies. In addition, the survey will show ground ice degradation in places where the elevation is reduced compared with existing data. Ronnie Daanen surveyed

ground control points in the NIRPO study area, and Barrett Salisbury flew high- and low-resolution LIDAR missions using the Toolik Lake helicopter.

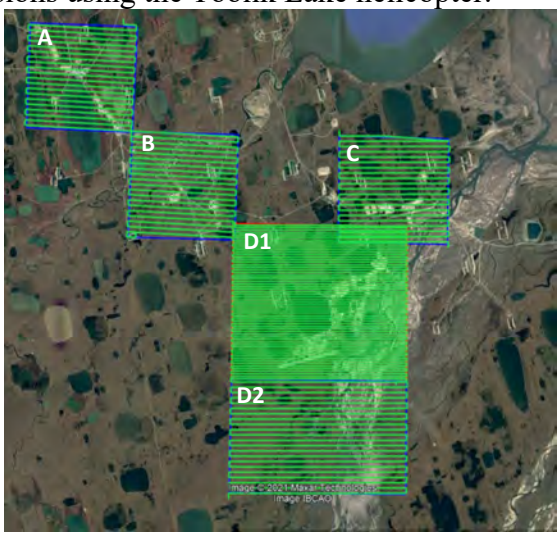


Figure 3. Lidar flight lines for the NNA-IRPS Prudhoe Bay studies. Areas A, B, C, and D2, map areas that are being used for permafrost modeling studies and extrapolation, were surveyed at relatively course resolution (13-18 pts m^{-2}). Area D1contains the IRPS intensive study areas — NIRPO, Jorgeson, Colleen, Airport sites — was surveyed at fine resolution (approximately 110 pts m^{-2}). See Fig. 1 for landscape features. Image by Barret Salisbury. Base image courtesy of Google Maps Maxar Technologies.

5. **Transects and plots (Jul 15–18) (Fig. 4, Table 1):** Four transects were surveyed on surfaces with different ages and geomorphology: Transect T6 (200 m): residual surface with thermokarst ponds; T7 (200 m): older drained lake basin with low-centered polygons; T8 (200 m): newer drained lake basin with featureless and disjunct polygon features; T9 (100 m): margin of drained lake basin and well drained polygons high centered polygons on residual surface). The 0-, 50-, 100-, 150-, and 200-m points of each transect were marked with 1.2-m tall white PVC stakes with the plot number and orange surveyors' tape at the top of the stake. To make the transects easily visible in drone- and aircraft-acquired aerial imagery, the end points of each transect were marked with 1.2-m x 1-2-m white 'X's made of six 13-gallon trash bags nailed to the tundra. The intermediate 50-m points are marked with circular paper plates. The markers will be removed after completion of the aerial surveys.

Thirty-five terrestrial plots (Table 1). and 40 aquatic vegetation plots (Table 2) were marked for vegetation, trace gas, permafrost, basal peat studies, and temperature monitoring. The centers of the 1-m x 1-m plots were marked with rebar stakes with aluminum caps stamped with the plot numbers (21-01 to 21-35 for the terrestrial plots and 21A-1 to 21A-40 for the aquatic plots) and wooden corner stakes. The center stake of each plot pierces a white 25-cm wide circular paper plate to make the plot visible for aerial surveys. The centers were also marked with a white 1.5-m vertical PVC stake with the plot number and blue surveyors' tape at the top of the stake for locating the terrestrial plots in winter and purple surveyors' tape for the aquatic plots.

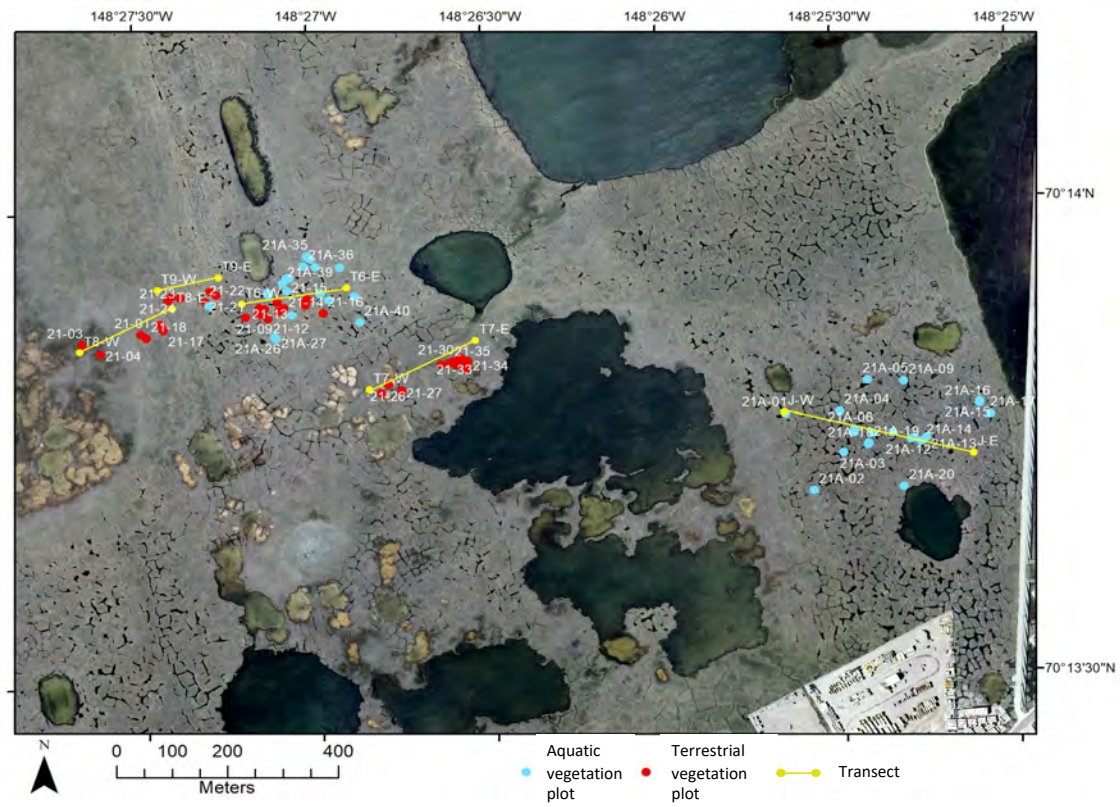


Figure 4. Transects and plots surveyed at the NIRPO site (left group) and Jorgenson sites right group).

6. **Vegetation surveys (18–26 July, Breen and Walker) (Fig. 5):** Surveys were made at 35 permanent plots and included complete lists and estimated cover of vascular plants, lichens and mosses, brief soil descriptions, collection of soils in the upper organic horizon and the mineral horizon, measurement of thaw depth, description of the site factors and vegetation structure. iButton temperature loggers were placed at the ground surface and base of the organic layer of each plot to measure the insulative effect of the vegetation and peat layers. The methods used for the surveys were compatible with previous surveys at the Colleen and Airport sites (Walker et al. 2015, 2016).

Figure 5. Vegetation surveys. Left: Skip Walker and Amy Breen recording plant-community composition in a permanent vegetation plot. Right: Evening moss identification and voucher collections.

Table 1. Terrestrial vegetation plot summary, including coordinates, transect, landform, surface age, and preliminary vegetation type names, basal peat sampled, and iButtons.

PLOT_ID	DATE_SAMPLED (YYYYMMDD)	LATITUDE (North, decimal degrees)	LONGITUDE (West, decimal degrees)	TRANSECT	LANDFORM	SURFACE_AGE	MICROSITE	VEG_CODE	VEG_TYPE_BROAD	VEG_TYPE_SPECIFIC	BASAL_PEAT_SAMPLED	IBUTTONS
21-01	20210722	70.231207	148.458254	T8	Drained lake basin	Young	Flark, interstrang, or interhummock	M2	Wet tundra	Wet Carex aquatilis-Drepanocladus brevifolius graminoid moss tundra	N	Y
21-02	20210722	70.231378	148.457325	T8	Drained lake basin	Young	Flark, interstrang, or interhummock	M2	Wet tundra	Wet Carex aquatilis-Drepanocladus brevifolius graminoid moss tundra	Y	Y
21-03	20210722	70.231047	148.461073	T8	Drained lake basin	Young	Flark, interstrang, or interhummock	M4	Wet to aquatic tundra	Wet to aquatic Carex aquatilis-Scorpidium scorpoides graminoid tundra	Y	Y
21-04	20210722	70.230879	148.460215	T8	Drained lake basin	Young	Flark, interstrang, or interhummock	M4	Wet to aquatic tundra	Wet to aquatic Carex aquatilis-Scorpidium scorpoides graminoid tundra	Y	Y
21-05	20210719	70.231717	148.450367	T6	Plain - residual surface	Primary	High center polygon	U3	Moist lichen-rich tundra	Moist Eriophorum angustifolium-Dryas integrifolia-Tomenhypnum nitens-Thamnolia subuliformis graminoid dwarf shrub tundra	Y	Y
21-06	20210719	70.231660	148.450367	T6	Plain - residual surface	Primary	High center polygon	U3	Moist lichen-rich tundra	Moist Eriophorum angustifolium-Dryas integrifolia-Tomenhypnum nitens-Thamnolia subuliformis graminoid dwarf shrub tundra	Y	Y
21-07	20210719	70.231568	148.451636	T6	Plain - residual surface	Primary	High center polygon	U4	Moist tundra	Moist Carex aquatilis-Dryas integrifolia-Salix arctica-Tomentypnum nitens graminoid dwarf shrub tundra	N	Y
21-08	20210719	70.231509	148.452599	T6	Plain - residual surface	Primary	High center polygon	U4	Moist tundra	Moist Carex aquatilis-Dryas integrifolia-Salix arctica-Tomentypnum nitens graminoid dwarf shrub tundra	Y	Y
21-09	20210719	70.231474	148.453238	T6	Plain - residual surface	Primary	High center polygon	U4	Moist tundra	Moist Carex aquatilis-Dryas integrifolia-Salix arctica-Tomentypnum nitens graminoid dwarf shrub tundra	N	Y
21-10	20210719	70.231632	148.452558	T6	Plain - residual surface	Primary	High center polygon	U3	Moist lichen-rich tundra	Moist Eriophorum angustifolium-Dryas integrifolia-Tomenhypnum nitens-Thamnolia subuliformis graminoid dwarf shrub tundra	N	Y
21-11	20210721	70.231615	148.452332	T6	Plain - residual surface	Primary	Polygon Trough	M2	Wet tundra	Wet Carex aquatilis-Drepanocladus brevifolius graminoid moss tundra	N	Y
21-12	20210721	70.231437	148.452164	T6	Plain - residual surface	Primary	Polygon Trough	U4	Moist tundra	Moist Carex aquatilis-Dryas integrifolia-Salix arctica-Tomentypnum nitens graminoid dwarf shrub tundra	N	Y
21-13	20210721	70.231723	148.451711	T6	Plain - residual surface	Primary	Polygon Trough	U4	Moist tundra	Moist Carex aquatilis-Dryas integrifolia-Salix arctica-Tomentypnum nitens graminoid dwarf shrub tundra	N	Y
21-14	20210721	70.231617	148.451407	T6	Plain - residual surface	Primary	Polygon Trough	M2	Wet tundra	Wet Carex aquatilis-Drepanocladus brevifolius graminoid moss tundra	N	Y
21-15	20210721	70.231766	148.450267	T6	Plain - residual surface	Primary	Polygon Trough	U4	Moist tundra	Moist Carex aquatilis-Dryas integrifolia-Salix arctica-Tomentypnum nitens graminoid dwarf shrub tundra	N	Y
21-16	20210721	70.231516	148.449526	T6	Plain - residual surface	Primary	Polygon Trough	M2	Wet tundra	Wet Carex aquatilis-Drepanocladus brevifolius graminoid moss tundra	N	Y
21-17	20210722	70.231273	148.457175	T8	Drained lake basin	Young	Strang, hummock, or disjunt polygon rim	U4	Moist tundra	Moist Carex aquatilis-Dryas integrifolia-Salix arctica-Tomentypnum nitens graminoid dwarf shrub tundra	N	Y
21-18	20210722	70.231143	148.458003	T8	Drained lake basin	Young	Strang, hummock, or disjunt polygon rim	U4	Moist tundra	Moist Carex aquatilis-Dryas integrifolia-Salix arctica-Tomentypnum nitens graminoid dwarf shrub tundra	N	Y
21-19	20210723	70.231784	148.456931	T9	Drained lake basin	Intermediate	Flat center polygon	M2	Wet tundra	Wet Carex aquatilis-Drepanocladus brevifolius graminoid moss tundra	Y	Y
21-20	20210723	70.231940	148.454904	T9	Plain - residual surface	Primary	High center polygon	U3	Moist lichen-rich tundra	Moist Eriophorum angustifolium-Dryas integrifolia-Tomenhypnum nitens-Thamnolia subuliformis graminoid dwarf shrub tundra	N	Y
21-21	20210723	70.231873	148.454629	T9	Plain - residual surface	Primary	High center polygon	U3	Moist lichen-rich tundra	Moist Eriophorum angustifolium-Dryas integrifolia-Tomenhypnum nitens-Thamnolia subuliformis graminoid dwarf shrub tundra	N	Y
21-22	20210723	70.231759	148.455148	T9	Plain - residual surface	Primary	High center polygon	U3	Moist lichen-rich tundra	Moist Eriophorum angustifolium-Dryas integrifolia-Tomenhypnum nitens-Thamnolia subuliformis graminoid dwarf shrub tundra	N	Y
21-23	20210723	70.231835	148.456326	T9	Drained lake basin	Intermediate	Flat center polygon	M2	Wet tundra	Wet Carex aquatilis-Drepanocladus brevifolius graminoid moss tundra	N	Y
21-24	20210724	70.231859	148.456760	T9	Drained lake basin	Intermediate	Strang, hummock, or disjunt polygon rim	U3	Moist lichen-rich tundra	Moist Eriophorum angustifolium-Dryas integrifolia-Tomenhypnum nitens-Thamnolia subuliformis graminoid dwarf shrub tundra	N	Y
21-25	20210724	70.230085	148.446855	T7	Lake margin	Intermediate	Ephemeral pond	W-Gyttj	Aquatic tundra	Wet to aquatic Carex aquatilis, gyttja-rich tundra	N	Y
21-26	20210724	70.230235	148.446488	T7	Lake margin	Intermediate	Ephemeral pond	W-Gyttj	Aquatic tundra	Wet to aquatic Carex aquatilis, gyttja-rich tundra	N	Y
21-27	20210724	70.230130	148.445879	T7	Drained lake basin	Intermediate	Low center polygon	M2	Wet tundra	Wet Carex aquatilis-Drepanocladus brevifolius graminoid moss tundra	Y	Y
21-28	20210724	70.230564	148.443961	T7	Drained lake basin	Intermediate	Polygon Trough	M4	Wet to aquatic tundra	Wet to aquatic Carex aquatilis-Scorpidium scorpoides graminoid tundra	N	Y
21-29	20210724	70.230549	148.443240	T7	Drained lake basin	Intermediate	Low center polygon	M2	Wet tundra	Wet Carex aquatilis-Drepanocladus brevifolius graminoid moss tundra	N	N
21-30	20210725	70.230614	148.443354	T7	Drained lake basin	Intermediate	Polygon rim	U4	Moist tundra	Moist Carex aquatilis-Dryas integrifolia-Salix arctica-Tomentypnum nitens graminoid dwarf shrub tundra	N	N
21-31		70.230481	148.442761	T7	Drained lake basin	Intermediate	Polygon Trough	M4/E1	Aquatic tundra	Aquatic Carex aquatilis graminoid tundra	N	Y
21-32	20210725	70.230606	148.442825	T7	Drained lake basin	Intermediate	Low center polygon	M4	Wet to aquatic tundra	Wet to aquatic Carex aquatilis-Scorpidium scorpoides graminoid tundra	N	Y
21-33	20210726	70.230670	148.443007	T7	Drained lake basin	Intermediate	Low center polygon	M4	Wet to aquatic tundra	Wet to aquatic Carex aquatilis-Scorpidium scorpoides graminoid tundra	Y	N
21-34	20210726	70.270617	148.442873	T7	Drained lake basin	Intermediate	Polygon rim	U4	Moist tundra	Moist Carex aquatilis-Dryas integrifolia-Salix arctica-Tomentypnum nitens graminoid dwarf shrub tundra	N	N
21-35	20210726	70.230593	148.443552	T7	Drained lake basin	Intermediate	Polygon Trough	M4/E1	Aquatic tundra	Aquatic Carex aquatilis graminoid tundra	N	Y

7. **Pond surveys (July 16–Aug 1, Watson-Cook, Meade, and Mahoney) (Fig. 6, Table 2):** 40 pond vegetation plots were surveyed (20 at the Jorgenson site and 20 at the NIRPO Transect 6). These transects are on older primary (residual) surfaces with abundant thermokarst ponds. Short-term temperature sensors were placed in three positions in the water column of each pond. Long-term temperature sensors were placed in 20 ponds. Water depth sensors were placed in 20 ponds at the Jorgenson site.

Figure 6. Pond surveys. Left: Emily Watson-Cook and Zoe Meade monitoring pond temperature, pH, and conductivity in thermokarst pond. Right: Recording plant community composition and site factors in a Sparganium hyperboreum *aquatic plant community.*

Table 2. Aquatic vegetation plot summary.

PLOT ID	DATE SAMPLED (YYYYMMDD)	LATITUDE (decimal degrees)	LONGITUDE (decimal degrees)	TRANSECT	LANDFORM	SURFACE_AGE	VEG_TYPE_BROAD	VEG_TYPE_NAME	IBUTTONS	WATER DEPTH SENSOR	SOIL SAMPLES
21A-01	20210723	70.2296	-148.42756	JS	Pond	Primary	Aquatic forb	*Hippuris vulgaris, Calliergon giganteum*	Y	Y	Y
21A-02	20210724	70.2282	-148.42631	JS	Pond	Primary	Moss mat	*Scorpidium scorpioides*	Y	Y	Y
21A-03	20210724	70.2289	-148.42485	JS	Pond	Primary	Aquatic forb	*Hippuris vulgaris, Utricularia vulgaris*	Y	Y	Y
21A-04	20210723	70.2296	-148.42499	JS	Pond	Primary	Shallow moss	*Scorpidium scorpiodes*	Y	Y	Y
21A-05	20210724	70.2301	-148.42363	JS	Pond	Primary	Moss mat	*Calliergon giganteum, Hippuris vulgaris*	Y	Y	Y
21A-06	20210724	70.2293	-148.42429	JS	Pond	Primary	Moss mat	*Calliergon giganteum, Hippuris vulgaris*	Y	Y	Y
21A-07	20210729	70.2292	-148.42432	JS	Pond	Primary	Bare	N/A	Y	Y	Y
21A-08	20210724	70.2292	-148.42342	JS	Pond	Primary	Shallow moss	*Scorpidium scorpioides*	Y	Y	Y
21A-09	20210724	70.2301	-148.42189	JS	Pond	Primary	Shallow moss	*Drepanocladus* sp., *Calliergon giganteum*	Y	Y	Y
21A-10	20210725	70.2292	-148.42247	JS	Pond	Primary	Moss mat	*Calliergon giganteum*	Y	Y	Y
21A-11	20210725	70.2291	-148.42160	JS	Pond	Primary	Shallow moss	*Scorpidium scorpioides*	Y	Y	Y
21A-12	20210729	70.2291	-148.42145	JS	Pond	Primary	Bare	N/A	Y	Y	Y
21A-13	20210725	70.2291	-148.42088	JS	Pond	Primary	Aquatic forb	*Hippuris vulgaris*	Y	Y	Y
21A-14	20210729	70.229	-148.42111	JS	Pond	Primary	Bare	N/A	Y	Y	Y
21A-15	20210725	70.2297	-148.41828	JS	Pond	Primary	Moss mat	*Calliergon giganteum*	Y	Y	Y
21A-16	20210716	70.2297	-148.41829	JS	Pond	Primary	Bare	N/A	Y	Y	Y
21A-17	20210725	70.2295	-148.41779	JS	Pond	Primary	Aquatic forb	*Utricularia vulgaris, Ranunculus aquatilis*	Y	Y	Y
21A-18	20210724	70.229	-148.42367	JS	Pond	Primary	Moss mat	*Scorpidium scorpioides*	Y	Y	Y
21A-19	20210729	70.229	-148.42364	JS	Pond	Primary	Bare	N/A	Y	Y	Y
21A-20	N/A	70.22826	-148.42200	JS	Lake	Primary	N/A	N/A	Y	Y	Y
21A-21	20210720	70.2318	-148.44802	T6	Pond	Primary	Moss mat	Unknown moss, *Drepanocladus* sp.	Y	N	Y
21A-22	20210722	70.2317	-148.44923	T6	Pond	Primary	Aquatic forb	*Hippuris vulgaris, Ranunculus aquatilis*	Y	N	Y
21A-23	20210722	70.2319	-148.44967	T6	Pond	Primary	Shallow moss	*Calliergon giganteum*	Y	N	Y
21A-24	20210727	70.2319	-148.44965	T6	Pond	Primary	Bare	N/A	Y	N	Y
21A-25	20210722	70.2315	-148.45101	T6	Pond	Primary	Aquatic forb	*Hippuris vulgaris, Calliergon giganteum*	Y	N	Y
21A-26	20210723	70.2311	-148.45188	T6	Pond	Primary	Moss mat	*Calliergon giganteum*	Y	N	Y
21A-27	20210727	70.2311	-148.45180	T6	Pond	Primary	Bare	N/A	Y	N	Y
21A-28	20210723	70.2317	-148.45499	T6	Pond	Primary	Aquatic forb	*Hippuris vulgaris*	Y	N	Y
21A-29	20210722	70.2319	-148.45213	T6	Pond	Primary	Shallow moss	*Calliergon giganteum, Drepanocladus* sp.	Y	N	Y
21A-30	20210727	70.2319	-148.45215	T6	Pond	Primary	Bare	N/A	Y	N	Y
21A-31	20210722	70.2319	-148.45123	T6	Pond	Primary	Aquatic forb	*Ranunculus aquatilis*	Y	N	Y
21A-32	20210720	70.2323	-148.44869	T6	Pond	Primary	Moss mat	Unknown moss, *Drepanocladus* sp.	Y	N	Y
21A-33	20210721	70.2323	-148.44986	T6	Pond	Primary	Shallow moss	*Calliergon giganteum*	Y	N	Y
21A-34	20210720	70.2325	-148.45009	T6	Pond	Primary	Moss mat	*Calliergon giganteum, Hippurus vulgaris*	Y	N	Y
21A-35	20210727	70.2325	-148.45025	T6	Pond	Primary	Bare	N/A	Y	N	Y
21A-36	20210721	70.2324	-148.45041	T6	Pond	Primary	Moss mat	*Calliergon giganteum*	Y	N	Y
21A-37	20210721	70.2322	-148.45123	T6	Pond	Primary	Shallow moss	*Calliergon giganteum*	Y	N	Y
21A-38	20210727	70.2321	-148.45113	T6	Pond	Primary	Bare	N/A	Y	N	Y
21A-39	20210722	70.2321	-148.45144	T6	Pond	Primary	Shallow moss	*Calliergon giganteum, Drepanocladus* sp.	Y	N	Y
21A-40	20210720	70.2313	-148.44779	T6	Pond	Primary	Aquatic forb	*Hippuris vulgaris, Sparganium* sp.	Y	N	Y

8. **Trace-gas flux plots (Kade and Mahony) (Fig. 7, Table 3): Trace-gas flux measurements (A. Kade)**

Figure 7. Trace-gas flux measurements. Left: Anja Kade and Josephine Mahoney preparing to make flux measurements using a 0.7-m x 0.7-m chamber. Right: Anja Kade recording trace-gas flux and respiration in a wet-tundra plant community.

We measured trace-gas fluxes during our peak-season measurement campaign (16-24 July 2021) at 27 terrestrial and 6 aquatic plots that were co-located with the plots selected for the vegetation and pond surveys. We selected 3 representative plots for each common vegetation on various patterned-ground locations such as polygon centers, rims and troughs. We used chamber-based methods to measure ecosystem respiration (ER) and the light response of net ecosystem exchange (NEE), and we calculated gross ecosystem exchange (GEE) at each study plot. We measured midday carbon dioxide, humidity and methane concentrations by connecting a clear Plexiglas chamber (0.7x0.7x0.25 m) to a LI-7810 portable infrared gas analyzer in closed-path configuration (Li-Cor Inc., Lincoln, Nebraska) and fitting the chamber to a portable rectangular base with an airtight polyethylene skirt. Two small fans mixed the air within the chamber. The LI-7810 recorded internal trace-gas concentrations, while temperature, barometric pressure and photosynthetic active radiation (PAR) were logged simultaneously to a Campbell CR-6 data logger every second over a 40-second period.
At each study plot, we took two to three measurements each under full sunlight, three levels of successive shading and complete darkness. Shading was provided with layers of fiberglass window screen material (approximately 1.5 mm mesh), and each successive layer of shading reduced the ambient light intensity by approximately 50%. To obtain complete darkness for the ER measurements, we covered the chamber with an opaque tarp. The chamber was ventilated between measurements.
For each data set, only periods with stable PAR values were used to calculate net CO_2 flux. From these data, we constructed a light-response curve for each plot by interpolating between

measured light intensities. We calculated net CO_2 flux as NEE = (r*V/A)*(dC/dt), where r is air density (mol/m^3), V is the chamber volume (m^3), dC/dt is the rate of change in CO_2 concentration (μmol/mol/s) and A is the surface area of the chamber (m^2). GEE was calculated as the difference between NEE and ER. In our preliminary analysis of CO_2 fluxes, we report NEE values at 600 μmol photons/m^2/s, because we achieved this light level consistently in the field and did not wish to extrapolate beyond the measured values of PAR. GEE was calculated as the difference between NEE and ER. We used negative GEE and NEE values to indicate carbon uptake by the vegetation, according to the micrometeorological sign convention.

Our preliminary analysis of peak-season CO_2 fluxes shows that NEE was generally greater in troughs than polygon centers or rims, with the highest CO_2 uptake occurring in the very wet M4 troughs(F ig. NEE). For example, when comparing results within the same vegetation type such as moist tundra U4 or wet tundra M4, troughs took up significantly more CO_2 than polygon centers or rims. Presumably, nutrient dynamics in the troughs are more favorable. The CO_2 flux data showed no consistent pattern when considering the chronosequence from old residual surfaces to more recently drained lake basins. Unfortunately, the data from the pond plots were erratic without clear trends, possibly due to methodological errors. We will investigate how we can better transfer our measurement methodology from a terrestrial to an aquatic setting and hopefully get meaningful results for the pond plots during our next measurement campaign in July 2022.

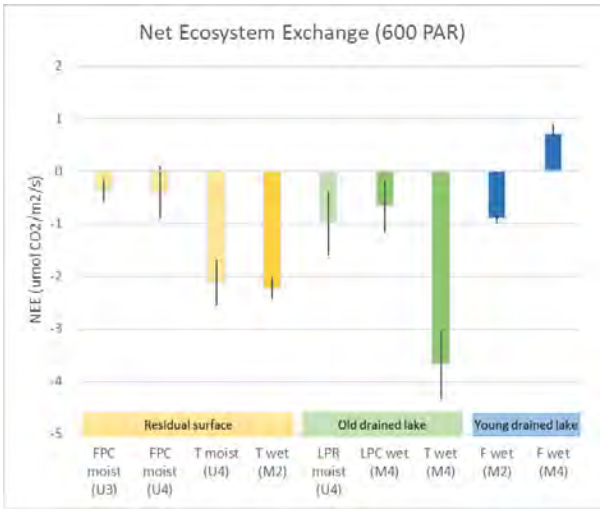


Fig. 8. Mean net ecosystem exchange and standard error at 600 μmol photons/m^2/s. FPC = flat center polygon; T = trough; LPC = low center polygon; F = featureless.

Table 3. Summary of flux measurements

Transect	Landform	Surface form element	Vegetation type	Number of samples
T6	Residual surface	Polygon flat center	U3	3
T6	Residual surface	polygon flat center	U4	3
T6	Residual surface	polygon trough	U4	3
T6	Residual surface	polygon trough	M2	3
T6	Residual surface	pond, moss mat	?	3
T6	Residual surface	pond, bare	?	3
T7	Older drained lake basin	Low-centered polygon rim	U4	3
T7	Older drained lake basin	Low-centered polygon center	M2	3
T7	Older drained lake basin	Low-centered polygon trough	M4	3
T8	Younger drained-lake basin	Featureless	M2	3
T8	Younger drained-lake basin	Featureless	M4	3
Total				33

9. **Basal peat collections (Bergstedt and Peirce) (Fig. 8, Table 4):** Eleven basal peat samples were collected 19 Aug 2021 from three lake-basin sites with different drainage histories and the residual surface for C-14 dating.

Figure 8. Helena Bergstedt and Skip Walker examining soil plug from a vegetation plot for possible C-14 dating.

Table 4. Summary of basal peat samples collected for C-14 dating samples.

Sample ID	21-02 FL M2 RC	21-03 FL M4 RC	21-04 FL M4	21-05 C U3	21-06 C U3 RC	31-08 C U4 RC	21-19 C M2 RC	21-27 C M2 RC	21-33 C M4 RC	21-X (rogue) C RC
Transect	T8	T8	T8	T6	T6	T6	T9	T7	T7	T7
GPS Coordinates	70.231378; -148.457424	70.231056; -148.461261	70.230895; -148.460234	70.231693; -148.450438	70.231685; -148.451058	70.231547; -148.452610	70.231796; -148.456901	70.230145; -148.445852	70.230647; -148.442998	70.230320; -148.443046
Thaw depth (cm)	24	33	32	33	30	27	36	39	43	35
Total depth (cm)	25	33	32	34	33	27	35	37	39	37
Cumulative organic (cm)	24	25	22	Unclear (1st 8 cm fibric to hemic then almost mineral soil)	10	13	32	25	32	29
Surface org thickness (cm)	18	21	24	10	13	19	21	20	22	16
Dominant mineral	sandy silt	silt	silt	sandy silty clay	silt	silty clay	silt	sandy silt	sandy silt	sandy silt
Dominant texture	organic	organic	organic	mineral	mineral	organic	organic with a lot of mineral in organic horizon	organic	organic	organic
State of the organic horizon	hemic/fibric	hemic/fibric	hemic (a lot of silt in organic horizon)	very sapric/hemic (Nicely aged soil; stones)	sapric	sapric	sapric/hemic	sapric/hemic (1st 5 cm fibric)	sapric (a lot of mineral deposits in organic)	sapric/hemic
Water depth (cm)	17	33	32	0	0	0	10	14	20	1
Water above/below	below	above 4 cm	below (rapidly rising)	No	No	No	below	below	below	below
Sample depth	23-24	24-25	21-22	2 samples: 1) 8 cm; 2) 28 cm (buried organic layer?)	No sample	13-14	31-32	24-25	32-33	28-29
Notes	Fibric part is 18-25 cm	Pit immediately filled with water		Buried organic horizon (cryoturbation). No drained lake history	Org boundary no longer visible	Saprc layer well-developed, decomposed				Some rocks in mineral layer. Site is south of T7 closer to lake than transect plots.
Date sampled	19-Jul-20	19-Jul-20	19-Jul-20	19-Jul-20	19-Jul-20	19-Jul-20	19-Jul-20	19-Jul-20	19-Jul-20	19-Jul-20
Image numbers										
Image credit	H Bergstedt	H Bergstedt	H Bergstedt	H Bergstedt	H Bergstedt	H Bergstedt	H Bergstedt	H Bergstedt	H Bergstedt	H Bergstedt

Plans for August 2021

We are planning a second trip 18 Aug–3 Sep 2021 with members of the permafrost, hydrology, and remote-sensing groups. The goals are:

- Familiarize the IRPS team with the NIRPO, Jorgenson, Colleen, and Airport study sites (IRPS Team),
- Conduct thaw-depth surveys of the transects and plots at all sites (IRPS Team),
- Retrieve data loggers from the ponds (Watson-Cook),
- Clip-harvest all terrestrial and pond plots (Walker, Breen, Watson-Cook),
- Place permafrost temperature loggers in representative landscapes,
- Drill permafrost boreholes in representative landscapes to examine the cryostructure of the permafrost (Nikolsky),
- Obtain detailed elevation surveys of the four NIRPO transects (Jones),
- Obtain UAV imagery of the NIRPO transects and plots (Jones), and
- Visit area B and possibly Areas A and C (Fig. 1) to examine typical areas of dry, moist, wet, and aquatic tundra that have been heavily impacted by climate- and road-related disturbances (IRPS Team).

References

Raynolds, M. K., D. A. Walker, K. J. Ambrosius, J. Brown, K. R. Everett, M. Kanevskiy, G. P. Kofinas, V. E. Romanovsky, Y. Shur, and P. J. Webber. 2014. Cumulative geoecological effects of 62 years of infrastructure and climate change in ice-rich permafrost landscapes, Prudhoe Bay Oilfield, Alaska. Global Change Biology 20:1211–1224. http://doi.wiley.com/10.1111/gcb.12500.

Romanovsky, V. E., and T. E. Osterkamp. 1995. Interannual variations of the thermal regime of the active layer and near-surface permafrost in Northern Alaska. Permafrost and Periglacial Processes 6:313–335. https://doi.org/10.1002/ppp.3430060404.

Shur, Y., M. Kanevskiy, D. A. Walker, M. T. Jorgenson, M. Buchhorn, and M. K. Raynolds. 2016. Permafrost-related causes and consequences of Sagavanirktok River flooding in Spring 2015, Abstract 1065. Pages 1014–1016 *in* F. Gunther and A. Morgenstern, editors. 11th International Conference on Permafrost, Potsdam, Germany.

Walker, D. A., M. Buchhorn, M. Kanevskiy, G. V. Matyshak, M. K. Raynolds, Y. L. Shur, and J. L. Peirce. 2015. Infrastructure-Thermokarst-Soil-Vegetation Interactions at Lake Colleen Site A, Prudhoe Bay, Alaska. AGC Data Report. Fairbanks. https://www.geobotany.uaf.edu/library/pubs/WalkerDA2015_agc15-01_datarpt.pdf.

Walker, D. A., M. Kanevskiy, Y. L. Shur, M. K. Raynolds, M. Buchhorn, and L. M. Wirth. 2016. Airport study site, Prudhoe Bay, Alaska, Summer 2015: Road effects data report. Pages 1–74. Alaska Geobotany Center, Fairbanks, AK. https://cn.dataone.org/cn/v2/resolve/urn:uuid:614dcab5-9be8-472e-a13f-6883ae963ba1.

Kali Community/Regional Advisory Group

MEETING NOTES | NOVEMBER 20, 2020

Overview

Local and regional advisors met by teleconference in November 2020 with scientists and engineers from five federally funded research projects studying permafrost and coastal erosion issues in Point Lay, Alaska. The advisory group was organized by the National Science Foundation (NSF) project *Navigating the New Arctic: Landscape evolution and adapting to change in ice-rich permafrost systems* (NSF Award 1928237).

Contents

Summary of Questions and Recommendations

From Advisory Group Members

NATIVE VILLAGE OF POINT LAY

- **Village relocation**: Are we going to stay here with our community, or are we going to consider relocating? That is the biggest question on everyone's mind.
- **Validate piling solutions:** A previous study recommended bigger and deeper pilings (20-25 feet?), more top cover, and a slurry backfill that is more silt than gravel. This study needs to find out if that's a viable option for new construction foundations.
- **Ocean currents, marine ecosystem**: Have the currents changed? Are there changes in where animals are feeding and what they're eating?
- **Suggestions for test sites to install sensors**:
    - East of the village on the north end of town (the most favorable area to expand village)
    - Around the 600 block behind the Episcopal church where all the ice wedges are
    - Along proposed trail to potential water source six miles from town (1-2 sites)
    - Gravel pads, including pad under failed water tank (suggested by Ming Xiao)
    - Kuchiak coal mine (more or less on *bedrock)* about 40 miles south of Point Lay
    - Sensors to test ice conditions: On lagoon system, near river, and in ocean
- **Involve Kali students** & tap into what kids learned in *A World Bridge* curriculum a few years ago.
- **More frequent meetings**: Make this a monthly or quarterly meeting now that we're all connected and starting to come up with a plan.
- **Website for data sharing**: A website that presents data in layman's form with comparisons to the past would allow the community to follow studies and stay in touch between meetings.
- **Weather station**: Re-establish Kali weather station.
- **Drained thaw lake + gravel and silt source:** If it's possible to repair the fresh water lake, we could also extract gravel and silt to deepen it and make it a more viable water source.
- **Work together and get people talking** about climate change issues, young and old together.
- **Local monitoring**: Expand and invest in local capacity to do ground studies and monitor changes on a daily, weekly or monthly basis using local labor and knowledge.
- **Plan for growth and address overcrowding.** Kali is growing.
- **NSBSD district-wide educational outreach**: Would like to see the district partner and coordinate to create an outreach program for children across the slope, because Point Lay is not the only community facing climate change.
- **Coordinate with the Borough, ASRC, Cully Corporation and others** to fund multiple studies and address all the issues mentioned (e.g., subsidence on intervillage trails, ice quality, public safety, changes affecting wildlife, etc.).

NORTH SLOPE BOROUGH

- **We need real recommendations** and then we need to identify synergies, leverage outside resources, and adopt methodical approaches to solving the problems.
- **Short- and long-term solutions**: We need both short-term fixes to make the community habitable and longer-term solutions to guide investment and decision making.

- **Study other cold climate regions around the world**: How are they dealing with same issues? Is their infrastructure developed in ways that are different than our direct bury system?
- **Oil and gas industry solutions**: Are there industry solutions for stabilizing subsidence issues that can be adapted to village use?

CULLY CORPORATION

- **New fresh water source + emergency road out**: Look at finding another water source outside of Point Lay towards the mountains, if possible. A road to the new water sources could double as an emergency road out, fulfilling another community goal from its comprehensive plan.
- **Air force facilities in Point Lay**: Has anyone ever looked at how these facilities built since 1957 have remained so stable and upright? Have there been any studies on that?

From Research Teams

NSF NNA RESILIENCE AND ADAPTATION TO THE EFFECTS OF PERMAFROST DEGRADATION-INDUCED COASTAL EROSION: PEOPLE-INFRASTRUCTURE-PERMAFROST-RESILIENCE (PIPER)

- **Community survey help**: Once the community questionnaire is finalized, we'll work with the community to help get the survey done.
- **Location of sensors**: We would like input from community members on where to install ground temperature sensors in the natural environment (open tundra, undisturbed sites where construction might occur, or any other undisturbed sites) as well at sites where the disturbance occurs (typical buildings, gravel pads, road prisms, etc.).
- **Possible help installing sensors**: If we can't travel this summer, there's potential for local communities to install the sensors themselves. They are easy to install, and we can ship everything so it's ready to go. It requires auguring 1-2" holes in the ground to around a one-meter depth, and you can initiate the sensors using a laptop computer.
- **Measuring snow depth**: We're interested in working with high school students to measure snow depth distribution using iButtons at locations around the community next winter (Sept-Apr).

NSF NNA-IRPS: LANDSCAPE EVOLUTION COMPONENT

- **Big questions**: What are the big questions you hope we can help answer in our research?
- **Most useful data**: What kinds of data will be useful to you?
- **Local research assistants**: Are there students or other residents interested in:
    - Measuring snow depth
    - Taking photos of vegetation and infrastructure
    - Installing or monitoring sensors
    - Other research tasks to be identified
- **Educational outreach**
    - How can we work with Kali School on remote lessons and activities during COVID?
    - Are there a few elders who would like to share their observations and insights with students to help kick-off our Kali School project?
- **Review of Past studies**: Various people have mentioned specific studies done in the past. I think a thorough review of past studies is needed.

- **Weather station**: We may be able to help get a weather station set up in the community. These stations are now completely automated. It will require finding some funding and determining the best way to transfer data, possibly over a cell phone connection. There is a National Weather Service weather station at the Point Lay airport.

NSF NNA-IRPS: HOUSING ADAPTATION COMPONENT

- **Mitigation strategies**: We're really hoping to get input on which mitigation strategies we should be looking at to help us narrow down the ones we found through interviews and the literature review, and what makes a strategy feasible on the North Slope of Alaska.
- **Housing survey**: What data can help you moving forward?

NSF DRAINED THAW LAKE BASIN

- **Lake drainage observations**: We would like to work with community members to discuss their observations of lakes that have drained in the past and look at maps to determine the most relevant areas to study.

CRREL: COMBINING REMOTE SENSING WITH LOCAL KNOWLEDGE TO INFORM MEASURES PROTECTING ALASKAN COASTAL COMMUNITIES FROM EROSION AND PERMAFROST THAW

- **Collaboration**: The Department of Defense has a lot of interest in infrastructure and environmental change work across the North Slope. We have seed funds to work at Point Lay and Kaktovik to identify needs, establish a research and collaboration team that includes the community, and, as a group, develop a much larger 4- to 5-year research and engineering effort. If you have ideas or are interested in more info or collaborating, email *Tom.Douglas@erdc.dren.mil*.

NSF NNA PERMAFROST DISCOVERY GATEWAY

- **Data preferences**: Any advice on how you would like to interact with permafrost data? There is a mock-up of the visualization tool to give people an idea how it can look like.
- **Beta program for better Internet**: For improving future internet connectivity, sign up as beta testers for the SpaceX new project: *https://www.starlink.com*. The more people you sign up the better. Early beta testers are reporting amazing results, sustained 150Mbps over the LEO satellites with very reasonable prices. More info: *https://en.wikipedia.org/wiki/Starlink*.

Meeting Materials

- Agenda: *Advisory Group Meeting 2020 11-20 - Agenda.pdf*
- Recording: *Audio only (126 MB)* | *Video + Audio (657 MB)*
- Meeting Chat: *Text (5 KB)*
- Presentation Slides: *Project updates (4 MB)*

Updates from Community and Regional Advisors

Text in *italics* are direct quotes from the meeting transcript. Non-italic text has been lightly edited for clarity and to reduce repetition. Times in brackets correspond to audio and video recordings of the meeting (links to recordings are on page 4.)

Observations:

- Since we met last winter, what changes have you observed in coastal erosion, permafrost thaw, ponds and lakes?
- Have you observed new or accelerating impacts on village housing and other infrastructure?

Questions for Research Teams:

- What are the main questions you hope research projects can answer or provide insight on?

Upcoming Projects:

- What Point Lay housing or other infrastructure projects are planned or underway for 2021-2022 (or beyond)?

Frederick Tukrook, Native Village of Point Lay [1:12 / 1:41:21]

Fred Tukrook is an Iñupiaq Elder in Point Lay. Fred was one of three people representing the Kali community at the November Advisory Group meeting. (Kali is the Iñupiaq name for the village. The Native Village of Point Lay is the name of the tribal government, the only local government in Kali since the village is unincorporated.)

OBSERVATIONS

- **Climate***: Our ocean is taking forever to freeze up. And also, our wind change. [Within this] 50 years, and it changed. We don't have that real cold weather coming in we usually have before Halloween. Nowadays, you still can go boating. If you want to go boating, you can take your boat down to the beach and go boating. But 50 years ago it used to be different, you know. Nowadays everything is changed. Erosion. You know, even our bird migration.*
- **Subsistence**: *Our walruses, when they come back in the 70s when we moved back here, they were just right out here - floating towards the North, toward [placename?]. But nowadays, you got to go 50, 40 miles down to just to catch a walrus, a good fresh walrus. Springtime. And now they are starting to come back after 50 years, they are right down here on our spit. Fall time. Creating a problem for us or for the animals too maybe. Maybe they got a lot of food out there. I don't know. But that's a big change. And when they are here fall time, they are not that fat. You don't hunt them when they are skinny. When they're fat. Springtime, when you catch your animals like walrus and seals... That was our food to keep us warm. They got that oil, walrus. All the animals that live here. Even our caribou migration changed. That's pretty hard. Our winds make it very difficult for hunters to go out and hunt.*
- **Houses**: *Started to get crooked… some of these places are like 45 degrees…. you wonder how [people] sleep.*
- **Food security**: Need to order more food from outside, because the village is growing.

- **Security, self-governance**: *All the hunters that are out there, when they come back, they let us know what's going on with our national security people. They find tracks. They find other snow machines that doesn't belong to the village. They wonder why.*
- **Water and sewer:** *I was born and raised in Point Lay. I've watched this village grow since I was small. And I've watched the houses being built here. When we moved into these homes, they were made with running water with pipes going from one room into this room to that room to keep the houses warm, with the pipes under […] And I live here in Point Lay and I know water is not the answer to keep your house warm. Not even in the bath tub, you know. You have 1/2-inch copper wire underneath your tub and you want to go take a shower. That tub is frozen until you get your water hot enough to make that tub warm. You have to think about…. And now we got these houses with… septic tanks and water tanks, holding tanks, like that. Our pump on our water system… keeps breaking down. Mine is leaking. It's been leaking like that for over, I don't know, half a year now? So, I need a new pump, but I don't know where to get it from. I need to order a new one. But it's still leaking water from my holding tank….*
- **Growth, overcrowding:** *Our village is growing. Babies are coming, and we don't have that much time right now to talk about climate change. We need to move our people. And into secured homes. Safe. It's not only for this village. It's also for the outlying villages that are going to be going through what we are…. Use and occupancy need some attention, because we got to keep [people] clean also and healthy…. [People are] moving from one house to another… staying here, moving to another place, and you [end up with] problems.*

RECOMMENDATIONS

- *What can we do? We have to sit down and talk…. Climate change is REAL bad. We need to get that talked about. Our subsistence is the most important part for Iñupiat way of life. We're trying to keep that. Our language, everything.*
- *Everything is important to our land up here. Whatever we leave, whatever is left out there, is left just like ghost town. We don't want that. We need to keep it clean.*
- *Human beings aren't products. We have our minds. We can feel. We can see. We can hear. In our families, when our elders tell us what to do, we have to have respect for that. The only way to do it is to communicate. Iñupiaq people have to work together. From the young to the old, together.*
- *Let's work together and get these movements going. We're talking. While we're talking people are being born. And land and water system, weather system, is changing because the world moves a little bit. And when it does that, boy look at us… everybody in the world. That's a big change for a little 1 or 2 or 3 degrees change from the world…. I'm talking to you as a human being and the newborns are going to be taking over pretty soon. We were here, and now my daughter is here talking with you folks, and in charge of […] in the village here also. Trying to get things straightened out. But the problem is right in the village itself, and we face it, see? We live with it. We have to take care of our system and our kids here.*

Bill Tracey, Sr., Native Village of Point Lay [10:52 / 35:35]

Long-time resident of Kali. Bill Tracey, Sr., moved to Point Lay in the early 70s when Point Lay was being resettled. In 1975, Bill built the first house in the village's current location. He is a member of the NSB Mayor's proposed task force on climate change issues in Point Lay.

OBSERVATIONS

- **Kali relocation history**: The community relocated from the barrier island (the original Point Lay site) to a river site, and then eventually to the current location, because the river village was too wet and too small for runways: *You had to cross the river to get to the airport, which was an all-day affair. So, we moved next to the Air Force Base, the DEW line, and we had one main road that cut right through this present community to what we call our boat dock.*
- **Contamination from military sites**: The current village's location next to the old Air Force Base and DEW line was littered with thousands of Air Force fuel oil barrels, mainly 55-gallon drums, that have been blown into the lagoon (causing hardships with our outboard motors) and were buried along the coastline and up and down the hill the village now sits on. It's been an ongoing effort to clean it up. Bill believes the disturbance to the tundra from the burial of fuel oil barrels, as well as towers, pipes, cables, cat tracks, vehicles, and scrap metal is accelerating some of what the community is experiencing today where they've built homes.
- **Fresh water supply**: *We are now getting water from the river which is semi-saline at its base root, so we have to go through an osmosis kind of system to have fresh water. And by the way, one of our three water tanks -- a million-gallon water tank -- just lost its bottom and it drained out completely, so we're going to be experiencing water shortage this coming spring. And we believe that is because of the ground shifting and the bottom of this million-gallon water tank became unstable and broke loose.*
- **Subsidence**: *Back to 1975, I built… a two-story home, and I wanted to start with that because… of the subsidence, I was able to box in what normally is called skirting the house, is now a full-size wall. So, I have a three-story house now, and I can drive vehicles under the house. Pilings are only 10-12 feet deep. And if I now have only an 8-ft. space under my house, that doesn't leave much in the ground. And what is in the ground is thawed by August…. The porch is built on stilts. The house is on pilings. The stilts just sit on the surface. That has failed. The porch is falling off the house, which is ripping my conduit -- electrical conduit from the walls -- exposing wires.*
- **Water and sewer**: *We have water-sewer service cans outside the house -- direct bury system. Those service cans in every location are sinking and causing leaks and causing a ripple effect in the… Arctic pipe. It's buried, and sewage doesn't flow uphill in a gravity flow system, so it's backing up. It's breaking underground. It's costing the North Slope Borough millions of dollars to come in here several times a year to dig it up, repair it, and bury it again. And then there's a domino effect because every time they dig it up, they dig up blue board Styrofoam, and that just blows in the wind. It's filling the lagoon shorelines. So, we got to get smart with our construction. If they got to keep digging something up, something is wrong there. We need to work on that.*
- **Landscape changes and public safety**: *I live on the 200 block… I have photographs when I was building the house and the tundra was completely level. Very flat. We could play baseball in my yard. Now you need mountain climbing gear, and I'm not exaggerating, some of them trenches we are afraid we're going to lose our kids in. Not all of them are filling with water because it's such an extensive trench that it migrates right out of that hole. But some are filling and they are staying wet, and we're constantly keeping vigilance on making sure our kids don't fall in there. And they have. Especially when there's thin ice conditions.*
- **Power poles**: Our recent batch of power poles for new block in town, the 900 block and down to the boat dock, they buried these power poles with a backhoe rather than a drill rig. Those poles

are now leaning really bad. Being the newest poles in town, they're leaning. So, backhoe trenching doesn't work for power poles. I think anyone really knows that.

- **Coastal Winter Trail System (CWAT)**: *Our traditional routes, they were all tundra, except river crossings. The tundra is so bad now with subsidence and trenching and it's just the old trails really aren't going to work anymore, so they're looking at a coastal trail that includes 85% of lagoon travel…. That brings up concerns about vehicles being on lagoons. But nowadays, the lagoon is wet throughout the winter, so the lagoon travel may not be a viable solution. So not only are we looking at problems right here in the town site, but to get to and from other communities is a big concern now too. We have to change our trails.*
- **Invasive fish species**: *We're noticing with our ice fishing that we've gone from grayling to tom cod, a species of trout is starting to show up, and we're just waiting for the sheefish. They're next.*
- **Everything is moving:** *Lupita mentioned doors and windows, walls are cracking. That's typical without exaggerating.… You walk by a home and it's 30 below and 30 knots, yet they can't close the door to keep the snow out of their porches.*

RECOMMENDATIONS

- **Science curriculum, younger input**: The curriculum for the Kali School a few years back was *A World Bridge*. A good percentage of kids in the school were involved in studying erosion, reviewing past studies, flying drones over the coastline and comparing today's photographs with yesterdays. If possible, the science teams should tap into those studies and engage the kids involved to get a perspective from those who will be here much longer.
- **Need for multiple studies and coordination**: *I think there are still some ongoing Shell studies. There is still some Shell money within the North Slope Borough. So, if we pool our efforts, work with the borough, work with the ASRC, work with Cully Corporation, there's money there to expand our studies to everything we've mentioned today, including the school, the animals, the coastline, intervillage subsidence, trails between communities, snow depth, ice quality.*
- **Indigenous knowledge, food security**: *There's a hundred Iñupiaq words for ice -- different types of ice -- and if we can just tap into a few of them and look at the changes, record the changes. Lupita mentioned how dangerous it is for our whalers, and the whale is a big part of our food security, big part of our health, so if we start to lose all these because we haven't kept up with how to do it safely, then we're hurting ourselves. Safety in this changing environment encompasses a lot of different kinds of studies*.

QUESTIONS FOR RESEARCHERS

- **Piling solutions**:
    - *One of the studies that the North Slope Borough did with UAF came up with some conclusions that if we are going to build new construction and use a piling-type foundation, we have to go deeper, and we have to use a bigger piling, and we need the slurry backfill to be more silt than gravel to prevent water penetration. This study needs to find out if that's a viable option for new construction foundations.*
    - *One of the Borough projects that was going to start this fall is now pushed to the spring, is they were going to come in with cross-bracing for our pilings, but if they are only 2- and 3-feet deep, save the lumber. Let's come up with another plan.*

    - *More gravel and silt and just completely bury the pilings once again under the houses is more of a solution.*
- **Village relocation**: *The question that needs to be answered is… do we stay and play or load and go? Are we going to stay here with our community, or are we going to consider relocating the community? That's the overall question on everybody's mind here.*
- **Ocean currents, marine ecosystem**: The community would like to know if the currents have changed. UAF did an ocean current study that hired local people to go out with their boats and work on the shorelines and place instruments in the ocean to study the currents. *As Fred Tukrook mentioned, it's not only affecting the land here and the animals, but where those animals are feeding, what they're eating now.*

Lupita Henry, Native Village of Point Lay [20:45]

Lupita Henry is the president of the local tribal government and the village liaison for the NNA-IRPS project (PI, Skip Walker). She is a member of the Kali Community/Regional Advisory Group for the NNA-IRPS project.

OBSERVATIONS

- **Housing, health & safety**: *I live on the 600 block, and I'm completely on an ice wedge, where my house is located. It is thawing at a rapid rate. My house has now got a crack down the middle of it. My doors on my outside of my porch cannot lock, because they are misaligned again. We're always struggling with being able to secure our home, and when the wind is blowing a certain way, it completely pushes the door open. So, we have to worry about our pipes freezing, and making sure our heating systems are working right. I'm fortunate to have two heating systems in my house, but I can't say that for the rest of my community.*
- **Fire hydrants**: *Our hydrants for our fire suppression… that have been put in place are now really sunken. There hasn't been too much of a study on our hydrant system here, and if we have a major fire, let's say at the school, you know, we're going to have to evacuate the school and make sure that there is enough water to even come through the pipe. If the pipe is broken, then we can't trust the system. So that is putting all of our school kids at risk, as well as our staff.*
- **Climate change**: *It's real extreme when it comes to Climate Change here in Point Lay. I really feel that we are ground zero when it comes to Climate Change.*
- **Winter travel**: *The river systems across our area for travel have been more dangerous. We've had more people falling through the ice, because the ice is not as safe as it used to be. Whaling season time we have to go 15 miles out on unsafe ice out there to try to hunt our big bowhead whales that we catch, and it's very extreme to be that far out away from any land.*
- **Sea ice**: Based on Iñupiaq knowledge of the ice, we've been really tuned in to the way our ice conditions are:
    - *They are changing. We see less ice every year. We still have open water in our ocean. Yes, that's great for ducks which come and stay with us year-round, but as far as hunting goes, it makes it really unstable.*
    - *We have a bunch of inlets on our area. Some of them are not freezing -- the deeper ones. And then some of our lagoon in our channels are changing.*
    - *When we travel for hunting, we've noticed that even in our rivers we are getting big blockades of ice that are 10 to… 30 feet high. And that has just been noticed by some of our hunters out there that the last few years our rivers are building these giant ice*

wedges in the middle of the river, making travel extremely difficult, especially through our normal trails of trying to get out there to go to fish camp, or you know trying to just go out and travel and look for subsistence game. So, things are changing at a rapid pace.

RECOMMENDATIONS

- **Weather station**: *I think that we need to have a weather station here. A weather program through either entity that we can build upon for our tribe so that we can monitor the weather system here on a daily basis, as well as our tides.*
- **Local monitoring***: I think that we need to… start reaching out from the other entities and the groups to try to come up with a plan to try to monitor what is changing on a daily basis or a weekly or a monthly basis and start hiring out of the group so that we can start monitoring some of the changes on a daily, weekly or monthly basis…. I know with COVID on the rise in our state, it's been extremely difficult to try to connect. So, we need to build some ground studies here in our community using some of the knowledge that we have, and just coming up with a plan that way with all entities that are involved.*
- **Involving school children**: *I would like to encourage some more commitment from the school and to involve our school children. They are seeing the dangers that are out there. We are always reminding them about the ice conditions and to stay off of the ice. But just bringing them in keeps them all aware as to what's changing in their land, because eventually they are going to be adults and they're going to be living here, and if they're not living here, at least they'll understand the changes for when they're buying a home. They'll look at the foundation and have some knowledge and background in that field that they will have better understanding of looking at a home and -- "Is the home secure?" -- getting some more information about it.*
- **Piling depth:** Looking at some building diagrams for TNHA, we know that we need pilings for building and infrastructure to go down further to 20–25 feet. *My dad has a structure here on 433 and his pilings are 25 feet down with a slurry mix and his structure… has very limited… subsidence. It is a very firm area and it's keeping that area right there pretty cool. There's not too much changing in that area. It still fills up with water because it's a natural run off because it's more towards… the east side of town on the east road downhill.*
- **More frequent meetings**: *I think we need to expand and broaden our outreach here and continually make this a month-by-month meeting, instead of doing this twice a year right now as we got it. Now that we're all connected together and we're started to come up with a plan, I believe we should start moving into a month-by-month meeting, or at least quarterly.*

Gordon Brower, North Slope Borough [1:06:00]

Gordon Brower is the director of the NSB Planning and Community Services Department. He is a member of the Kali Community/Regional Advisory Group for the NNA-IRPS project.

- **High cost of impacts on infrastructure:** I'm pretty familiar with some of the issues in Point Lay, and I am aware of some projects, including one through UAF that looked at ground water infiltration into ice-rich permafrost in areas where the Borough had had major infrastructure activities in the past. *Now they are severely compromised with subsidence issues… that are quite frankly wreaking havoc on millions of dollars' worth of infrastructure… it's probably like $25-40*

million dollars' worth of installation of water and sewer projects in the community that are being severely impacted on top of residential housing, commercial structures and other things.

- **Status of procurement of fine silt:** Not sure of the status of a project to use fine silt to address with ground water infiltration issues based on a recommendation from one study (UAF?). I don't know what the scope of the work was (if it was just the community water and sewer or if it was throughout the community), but it hasn't initiated yet. *I think there's current funding to $700,000…. I'm not sure if it's a procurement issue to find the types of material, to limit the ground water infiltration through the ice-rich permafrost through mediums like service barrels and things that protrude out of the tundra that are mediums for ground water infiltration to the permafrost underneath the tundra. Those are some of the ways that we are trying to act.*
- **Water system short- and longer-term fixes***: Ours is direct bury, insulated pipes within the permafrost, but… that becomes more fragile with changing issues…. Our temporary short-term fix is a reverse osmosis portable system to pump water into the water tanks. A little bit longer-term vision to fix that is to maybe drill a water well to an aquifer to provide longer term fix for water needs for the community*.
- **Wider issues but Point Lay is Ground Zero**: *We need to also consider the continuing issues of the climate that is changing, because there are more subtle changes like in the Barrow area where the ice cellar temperatures are changing for food security issues of maintaining the integrity of an entire whale to be edible. Never used to have those problems. So, there might be a wider issue, but certainly Ground Zero [is] Point Lay.*
- **Funding capacity**: *One of the things that plagued the Borough is [that] many of our communities have a lot of needs…. We get a capital needs assessment annually of about $260-300 million just to maintain the current infrastructure of all the communities within the NSB combined. Then we've got to prioritize… the most important things that may be imminent structural integrity issues; things that are phased where we have to put a little bit of money here… and then we'll get the next funding cycle on a subsequent year. We just can't fund the entire capital maintenance needs of the Borough with our bonding capacity being at $75 million. There might be some efforts to tweak that to get a more robust capital process, but I think there needs to be outside help [such as] Federal funding… that might work together to do longer term fixes.*
- **Community Winter Access Trails:** The Planning Department has funding to look at a CWAT leg that goes into Point Lay, and we're working on that. *As Mr. Bill Tracey indicated… the route that we have right now is a sea route, and it's not absolutely safe. In some places it doesn't even work and we've tried it, so there's an effort to… try to get individuals to identify a land route…. One of the things that we've envisioned to use the CWAT [for] is to [help with] some of the temporary short-term solutions, like bringing a whole bunch of septic tanks… that could turn into longer term solutions…. We are so limited in the ability to bring materials, primarily in the barge season and at very high cost. So that is some of… our justification to start to do more with CWAT community winter access trails.*
- **Solutions from oil and gas industry:** There's been a lot of work to stabilize subsidence issues in the industry that could be beneficial for local village use. Around 1999-2000, the oil and gas industry started to have serious issues with subsidence in the oilfields, including around the well head housing. The little houses that protect the well heads were starting to teeter substantially. In one pilot project in Kaktovik, ExxonMobil installed thermosiphons like the ones used to stabilize well head housing in a new ice cellar to see if they can be used to address issues

created by subsidence and coastal erosion. The monitoring is going on now. *To my understanding, it's very beneficial to the Kaktovik whaling captains. It's a very large cellar and multiple whales can be put in that one cellar.*

- **Point Lay task force:** The mayor is very concerned about issues in Point Lay and wants to help. He's putting together a task force focused solely on Point Lay to identify and make recommendations for protecting infrastructure in the community. The task force includes: Bill Tracey as a representative from the community; Max Neale and Diane Sam of ANTHC; and [Billy Connor of the Institute of Northern Engineering at UAF]. ANTHC is getting ready to do needs assessments on coastal communities and other communities on the Slope that have been identified as dealing with climate issues (climate change, coastal erosion, subsidence, permafrost issues) and also looking to get funding mechanisms in place.

RECOMMENDATIONS

- **Need for short- and long-term solutions**: *Short term meaning we got to make it livable for community residents now…. And then the longer-term solutions that underlie [how] we think about our infrastructure: Do we abandon it in place? Do we figure out a way to stabilize it?*
- **Need real recommendations***: I think we need real recommendations and then ultimately, we need synergies. We need to be able to leverage outside resources and look at a methodical approach to solving the problem.*
- **Study other cold climate regions***: We may even need to study other cold climate regions and how other countries are dealing with this type of issue, and how their infrastructure is developed in ways that might be different from how our approach is on the North Slope.*
- **Need for synergies and funding solutions**: We need to work together to identify short-term fixes and longer-term solutions for our communities and create synergies that bring together federal money and Borough money. However, it takes time to find these vehicles. Using Point Lay as Ground Zero is a model for trying to get efforts going to deal with it in that way.

Marty Awalin, Cully Corporation [1:27:44]

Marty Awalin is president of Cully Corporation, the village corporation for Point Lay established under the Alaska Native Claims Settlement Act (ANCSA). She is a member of the Advisory Group for the NNA-IRPS project.

RECOMMENDATIONS

- Under the comprehensive plan, one of the community concerns was wanting to have an emergency road out, like Point Hope and, I think, Wainwright. *I think if you look at the probability of finding another water source outside of Point Lay towards the mountains, then you resolve two issues here -- having an emergency road out and then a new fresh water source.*

Lew Eisaguirre, Venturer Enterprises [28:45]

Lew Eisaguirre is a consultant to the Cully Corporation who has been working on a natural resource mapping process called Natural Cap X.

- Layered/stratified mapping process to create a product that can be used as a decision tool by landowners
- Maps major natural resource rights and assesses their value

- Develop strategies and plans based on for how large landowners can best monetize natural resources.
- Potential opportunities for Cully Corporation:
    - Conservation easements
        - Walrus beach area
        - Peat preservation (strategies related to carbon)
        - Wildlife conservation banking
    - More conventional activities
        - Deep water port
    - Marty will be sharing results with group over time
- Planned travel to Point Lay: Summer 2021
    - Have some ideas on how to work with the team here
    - Will probably be contacting you individually how we think we can work with you as a follow up to this call.

Griffin Hagle, Tagiugmiullu Nunamiullu Housing Authority [42:20]

Griffin Hagle is executive director of Tagiugmiullu Nunamiullu Housing Authority (TNHA), the regional housing authority for the North Slope region. He is a member of the Advisory Group for the NNA-IRPS project.

OBSERVATIONS

- **No exaggeration:** *I won't add any observations that the folks in Point Lay didn't already provide. I haven't had the opportunity to visit the village since January. I just want to emphasize that there is not a shred of exaggeration in any of their descriptions. It is truly a dire situation. I've seen the fire hydrants leaning at 45 degrees…, the piling failures and the stop gap measures we've been forced to take with trying to brace them with aircraft cabling and lumber.*
- **Solutions:** *I agree with Bill. This is a solution where we need more top cover; we need more fill; and then a mechanism to hopefully keep the foundation cool enough through the summer around these buildings, which introduces a whole other problem if everywhere in the village continues to thaw and subside.*

PROJECT UPDATES

- **HUD grant submitted for new housing development:**
    - With support from the Tribal Council, TNHA has applied for a HUD grant for a major new housing development project at the site of the former BIA school, located next to the current school. The original buildings have been converted into three separate structures of multi-unit housing that are in very poor shape. TNHA has documented the problems with those buildings. If the grant is awarded, it would provide resources to demolish those structures and build safe, decent, affordable new housing there.
    - TNHA has had conversations with the community and Borough about design considerations. There is no clear way forward on what the water and sewer or piling approach looks like at this point, but as TNHA heard from the community: *Deeper and sturdier pilings are certainly going to be part of that solution.*

- **Solar-driven active hydronic cooling:**
    - TNHA is Investigating opportunities to keep fill or frozen soils chilled around foundations through the summer solar-driven active hydronic cooling -- basically a chiller with loops running through the ground. (*Link to white paper*)
    - This will get more scrutiny as a possible solution for foundations on any new housing development and possibly retrofitting some existing housing.
    - It's a big, multi-faceted challenge that has been coming at us rapidly. The comments from the community have been helpful and very appreciated.

Kaare Sikuaq Erickson, UIC Science [46:00 / 51:20]

Kaare Erickson is the Science Liaison for UIC Science, which provides logistics support and outreach services for National Science Foundation-funded projects doing research on the North Slope. He is a member of the Kali Community/Regional Advisory Group for the NNA-IRPS project.

- **New contract with National Science Foundation (NSF)**: Starting February 1, the new contract will allow UIC Science to spend more time and resources supporting the outreach and engagement for NSF projects.
    - Because the projects in Point Lay in particular have large teams devoted to working with the community, I'll only help where and when needed.
    - *One example: we'll be able to interview the projects here, and then those interviews will be on KBRW. We have a lot of ideas that are coming down the line, but I won't get into all of those details. I'm just kind of soaking in the knowledge and listening. Qayanaq.*
- **Working with NSB schools to coordinate outreach with curricula:** For the last 5 years we've been working to create mutually beneficial engagement between scientists and classrooms by trying to correlate outreach efforts with the curricula. Most of this has been done in Barrow, because that's where we're located. A couple examples of what we're doing now:
    - *We're working with one marine researcher who is developing little buoys, and we're going to try to work with all the different high schools late in the year, hopefully, to create these… swift buoys [that will] collect a bunch of information. They'll send them back to Barrow for us and we'll deploy them.*
    - *We're also working with Apollo Elementary… to create six learning modules, where we create these little kits to send home with kids.*
    - *I've been talking to the administration about how we do this more systematically and not just drop in and have this be an add-on to your normal curriculum. I just had that meeting last week. So, in the next few weeks you should probably hear from me directly about this.*

Ray Atos, Iñupiat Community of the Arctic Slope [47:38]

Ray Atos is the Natural Resources Director for ICAS, the Iñupiat Community of the Arctic Slope, which is a regional Alaska Native tribal organization comprised of all North Slope villages and their members. He is a member of the Kali Community/Regional Advisory Group for the NNA-IRPS project.

PROJECT UPDATE

- **PFAS issues in lagoons:** ICAS is using some of its EPA IGAP funds to work with the NSB Department of Wildlife on the PFAS issues in some of the lagoons here, like our north-south(?) lagoon. [Editor's note: PFAS is the acronym for a group of man-made chemicals (per- and polyfluoroalkyl substances) in use in the U.S. since the 1940s and which persistent in the environment and the human body. There is evidence that exposure to PFAS can lead to adverse human health effects.]
- **Fish mold**: There are other studies we will be working on with the State of Alaska. The NSB is getting baseline water tamps on some of these rivers we're dealing with because of the issues with fish mold -- that's becoming more and more apparent when you hear from some of our local hunters.

Brett Stirling, Kali School [31:55]

Brett Stirling is the principal at Kali School for the 2020-21 school year. He is a member of the Kali Community/Regional Advisory Group for the NNA-IRPS project.

- No specific questions or comments at the moment. Still very new.
- Learning process - helpful to see scope and breadth of research being done, and think about ways to incorporate that into our classrooms

Updates from Research Projects

Project recap:

- What is the overall focus or goals of your project, particularly as it relates to Point Lay

Research Activities/Findings:

- If you were able to make progress on village-related research during COVID, please share what you did and learned

2021-2022 Plans:

- What are the next steps you hope to accomplish in 2021 or as soon as travel allows? Do you have tentative or hoped for timeframe for a visit to the community?

Questions for Advisory Group:

- What questions do you have for the community or regional advisors either now or at a future community meeting?

Navigating the New Arctic: People-Infrastructure-PErmafrost-Resilience (PIPER) [55:10]

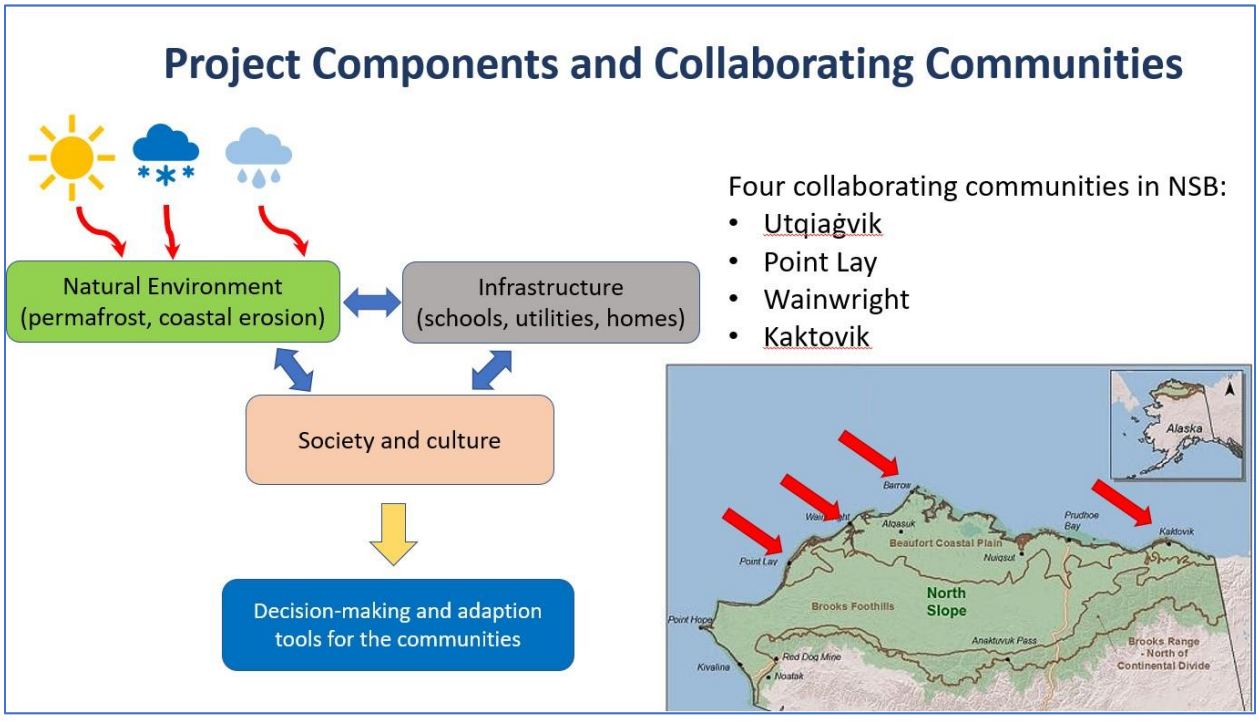
PROJECT OVERVIEW

- **Project title**: Resilience and Adaptation to the Effects of Permafrost Degradation-Induced Coastal Erosion: People-Infrastructure-PErmafrost-Resilience (PIPER)
- **Principal investigator**: Dr. Ming Xiao, Penn State, *mzx102@psu.edu*
- **Funding**: National Science Foundation, Navigating the New Arctic program
- **Website**: *nna-piper.org*

MING XIAO, PENN STATE UNIVERSITY

Dr. Ming Xiao is a civil engineer and associated professor at Penn State University. He is the PI of the PIPER project.

- We have eight principal investigators on this project, and today all of us are here, and in addition we have another postdoc and three students at this meeting.
- We cover three areas of expertise. In the natural environment, we're looking at how permafrost degrades with warming air temperature, how we can create a permafrost model, and how the properties of the permafrost change and how that will affect the infrastructure performances. And within this are the social issues that are closely tied with natural environment and coastal erosion, permafrost degradation and infrastructure damages.
- We plan to develop a decision-making tool to share with local communities to show where infrastructure is more likely to be damaged and where a better site for infrastructure development could be.
- Before we can design any solutions, it's important for us to first understand the issue and look at the natural environment. We'll need more input from the advisors, like today, and community residents. We also plan to do a survey.
- **Four collaborating communities**: Utqiaġvik, Point Lay, Wainwright, and Kaktovik



LOUISE FARQUHARSON, UNIVERSITY OF ALASKA FAIRBANKS

Dr. Louise Farquharson is a geologist in the Permafrost Laboratory at UAF's Geophysical Institute. She is a co-PI on the NNA PIPER Project.

PRELIMINARY FIELD PLAN IN 2021

- **December-February**: In the next month, we would like to start working with community members on where to install ground temperature sensors in the natural environment as well at sites where disturbance occurs. We have some idea of different types of locations that would

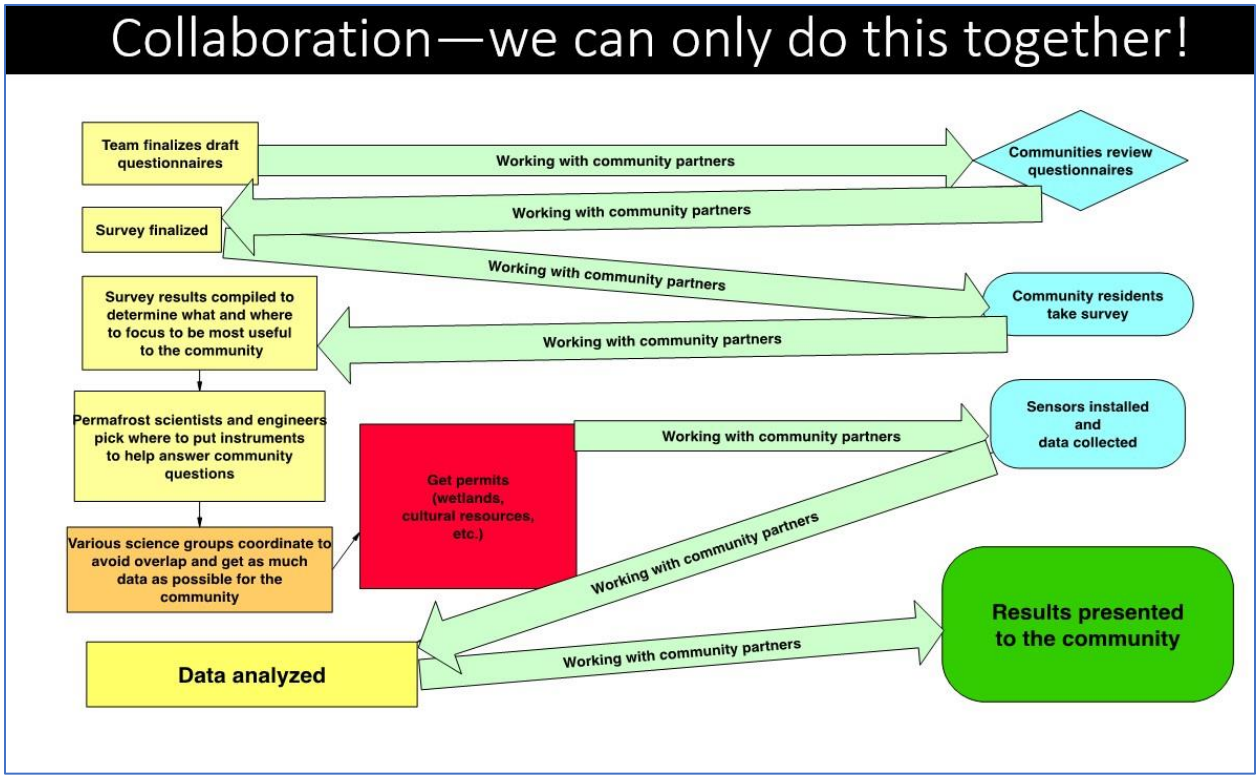
give us the most information about how disturbance will impact infrastructure around communities: some sites in open tundra, some underneath buildings (e.g. houses, school), sites in gravel, and coastal bluffs. It would be great to find members of the community that could help contribute to where these sites should be.

- **March:** Once we've worked with community members to identify areas to put sensors, we need to begin applying for permits, depending on who the landowners are.
- **May-June**: Discuss the installation options; if COVID is not over, find local support for instrument installation through training.
- **July-August**: Traveling to the community for instrumentation installation, or through help of local residents for the installation
    - If we can come out to the field by this summer, we'll start installing sensors. If not, there's potential for local communities to install the sensors themselves. They are actually quite easy to install, and we can ship everything so it's ready to go. It requires auguring 1-2" holes in the ground to around a one-meter depth, and you can initiate the sensors using a laptop computer.
- **September-April**: Rely on local support to measure the snow depth distribution.
    - The final component we're interested in is to bring in high school students to measure snow depth distribution using iButtons at different locations around the community, as snow depth has a really important role on permafrost temperature.
- That's our preliminary field plan, but as with everybody's plans – very COVID dependent.

ANNE JENSEN, UNIVERSITY OF ALASKA FAIRBANKS

Dr. Anne Jensen is an archaeologist and anthropologist at the University of Alaska Fairbanks and a co-PI on the PIPER project. She is a resident of Utqiaġvik and a Senior Scientist at UIC Science.

- This is not just for Point Lay, it's for all four communities. All those green arrows involve working with folks – collaboration with folks in the community and the folks at the universities. The blue stuff is things that the community does. SO, we're almost done with this draft questionnaire. It's basically put together to help the scientists figure out where they ought to be putting the sensors, what things are important to each community – what do you see as problems? what kinds of things are you encountering? – so we can address things that are problems for your community. Once that's finalized, we'll work with someone in the community to help get the survey done. We're going to coordinate with the various groups here that are on this call to make sure we're not overlapping and what not.
- I put getting permits in a big red box because if it isn't thought of in a timely enough fashion, it can throw a wrench in the works. This is federally funded activity so we have to comply with things like wetlands permits, endangered species permits, and imagine you probably have some eider ducks who nest there, so we have to avoid that. There may be cultural resources. None of these things are show stoppers; we just have to be aware and attempt to avoid them.
- Once the sensors are installed and the data gets collected, we'll analyze the data and hopefully we'll be able to present the results to you, including a decision tool that is hopefully useful to you in making future decisions about what to do about your infrastructure, because I agree with everybody. It's pretty dire in Point Lay.



VLAD ROMANOVSKY, UNIVERSITY OF ALASKA FAIRBANKS

Dr. Vladimir Romanovsky is a permafrost scientist at UAF's Geophysical Institute. He is a co-PI on both the NNA-IRPS and NNA PIPER projects.

- **What installation looks like**: It's a pretty small box on the ground. So, each of the distributed sites will be pretty small impact on the environment, and we will not go there very often – once a year – and members of the community can visit them if interested.

Navigating the New Arctic: Landscape Evolution and Adapting to Change in Ice-rich Permafrost Systems (NNA-IRPS) [1:46:25]

PROJECT OVERVIEW

- **Project title**: Navigating the New Arctic: Landscape Evolution and Adapting to Change in Ice-rich Permafrost Systems (NNA-IRPS)
- **Principal investigator**: Dr. Donald A. (Skip) Walker, UAF, *dawalker@alaska.edu*
- **Funding**: National Science Foundation, Navigating the New Arctic program
- **Website**: *www.geobotany.uaf.edu/nna*

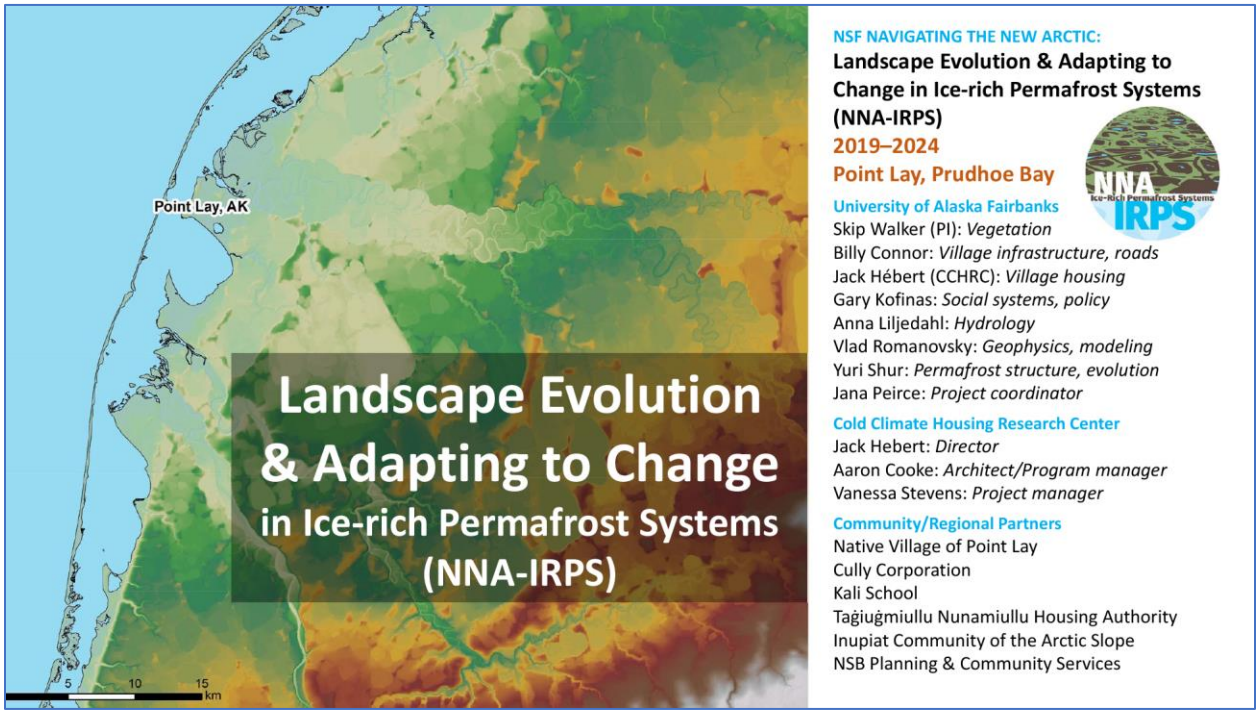
SKIP WALKER, UNIVERSITY OF ALASKA FAIRBANKS

Dr. Donald A. (Skip) Walker is a vegetation and ecosystem scientist and director of the Alaska Geobotany Center at UAF's Institute of Arctic Biology. He is the PI of the NNA-IRPS project.

- I'm really touched by the conversation I'm hearing right now. What Fred was just talking about: That fact that we're all human beings. This is a really key piece of the conversation, and I hope

we can develop that because I guess I feel that's the breakdown we're having all over our country right now…. All of the divisions that we're have among us. But at the base we're human beings and we have to try to work to help each other survive. I'm not sure we can say this project is going to do that, but that's where we have to come from. It's a pleasure to just be able to listen to what's going on.

- I'm a vegetation scientist, so right now my own participation is small because we don't have a clear picture of what the vegetation [is] and if there are any issues. Certainly, vegetation plays a big role in the stability of permafrost and the ground temperatures, etc. [We'll see] whether or not we need to understand it better, or map it.
- The team that is directing the big effort here is Vlad Romanovsky and Ben Jones, who is using remote sensing tools to uncover some of the patterns we see in the landscape. That's really important work that's not too expensive. It's stuff we can do pretty easily with information we already have.
- **Past studies**: Various people have mentioned specific studies done in the past. I think a thorough review of past studies is needed.
- **More frequent meetings**: We know the problems are huge and we need to keep conversing. I like Lupita's idea of monthly meetings if we can do that. I hope next summer we can get to Point Lay in person.
- I want to thank everyone that has participated. It's been eye opening for me, and I hope we can be of some benefit. We have a number of people [Billy Connor, Misha Kanevskiy, Cold Climate Housing Research Center] who have some prior experience in the area, who know the problems, understand the geotechnical aspects, and who can be a benefit if we draw on their knowledge.

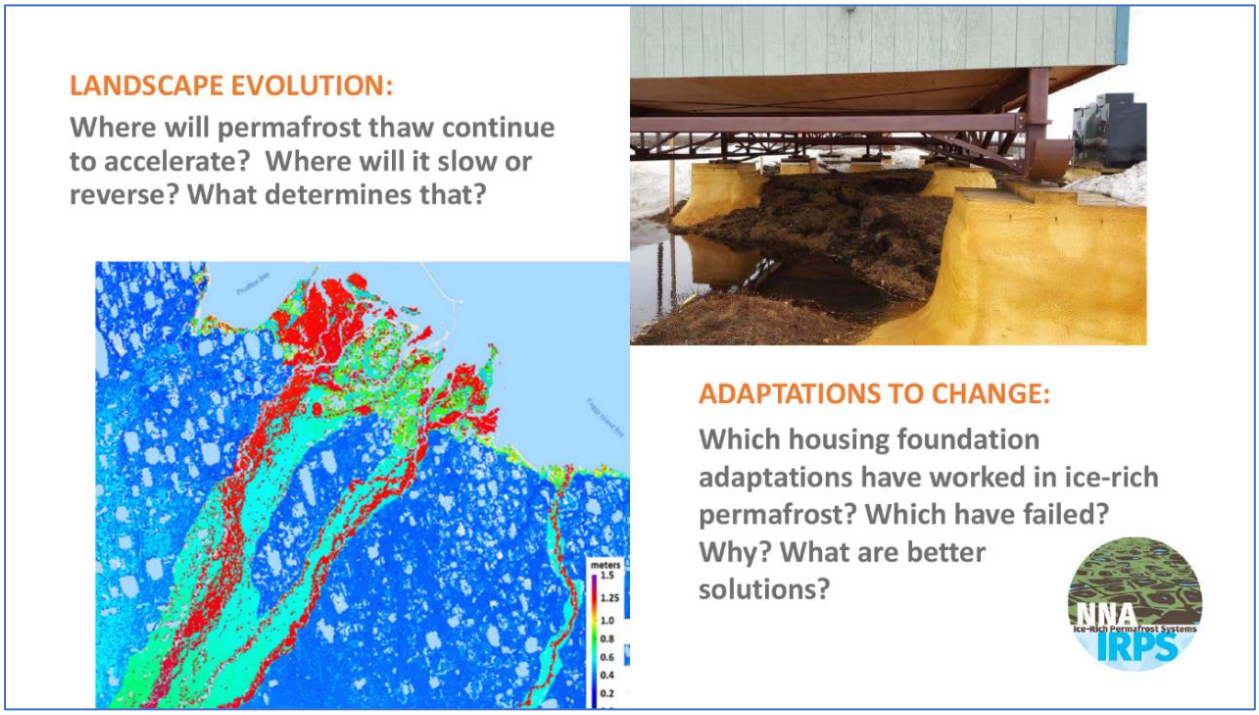


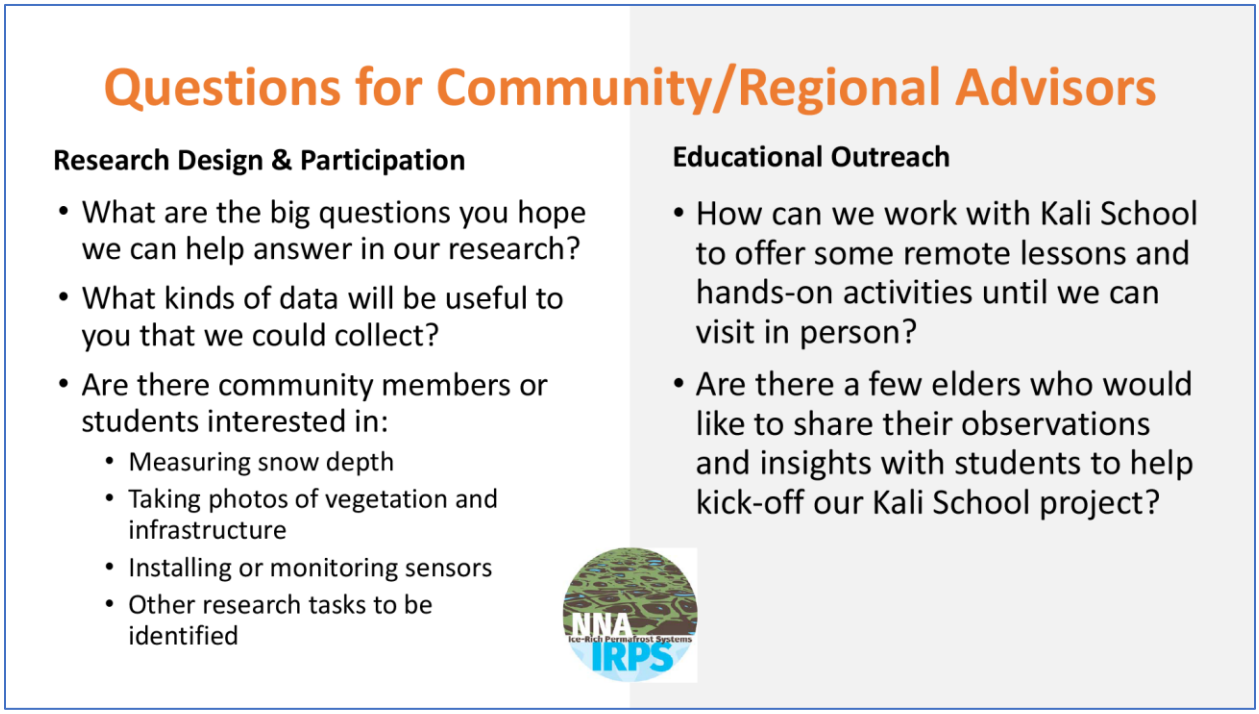
JANA PEIRCE, UNIVERSITY OF ALASKA FAIRBANKS

Jana Peirce is a communications specialist at UAF's Alaska Geobotany Center and the project and outreach coordinator for the NNA-IRPS project.

PROJECT RECAP AND QUESTIONS FOR COMMUNITY

- See slides





2020 ACTIVITIES

- **Collaboration and outreach activities:**
  - Completed Project Collaboration Agreement with Native Village of Point Lay. (Purchase Order from UAF in progress.)
  - Advisory Group met in February & November
  - **Coming Dec. 2** – Meeting with Kali School teachers and UIC Science to talk about permafrost lessons or activities we could do remotely in Spring 2021.
- **Research activities:**
  - Two trips cancelled due to COVID-19
  - Housing study launched (See CCHRC update below)
  - Reviewed geotechnical reports and Alaska Vulnerability Assessment for Point Lay.
  - Worked on research design for improving permafrost modeling in/around Point Lay using remote sensing, machine learning, and ground observations.
  - Began analysis of existing remote sensing imagery to refine research questions.

2021-2022 PLANS

- **Early Summer 2021: Reconnaissance visit**
  - **Who:** Small team to introduce the project and develop plan for working together.
  - **Planned activities:** Meet with steering committee and others; look at possible research sites; educational activities for students; opportunity to recruit local research assistants.
- **September 2021: Establish research site**
  - **Who:** Our permafrost science and engineering team
  - **Planned activities**: Study permafrost structure and distribution in Point Lay and where it might be expected to stabilize or degrade further; install monitoring equipment; study other questions defined by the community; engage local research assistants.
- **Summer 2022: Permafrost Symposium**
  - **Who:** US and International permafrost scientists and engineers
  - **Planned activities**: Tour Point Lay, hear local experience, share expertise from similar locations, and identify knowledge gaps.

VANESSA STEVENS, COLD CLIMATE HOUSING RESEARCH CENTER [1:56:20]

Vanessa Stevens is a scientist at the Cold Climate Housing Research Center (CCHRC) at the National Renewable Energy Laboratory in Fairbanks, Alaska. She is the project manager for the NNA-IRPS housing adaption component.

2020 ACTIVITIES

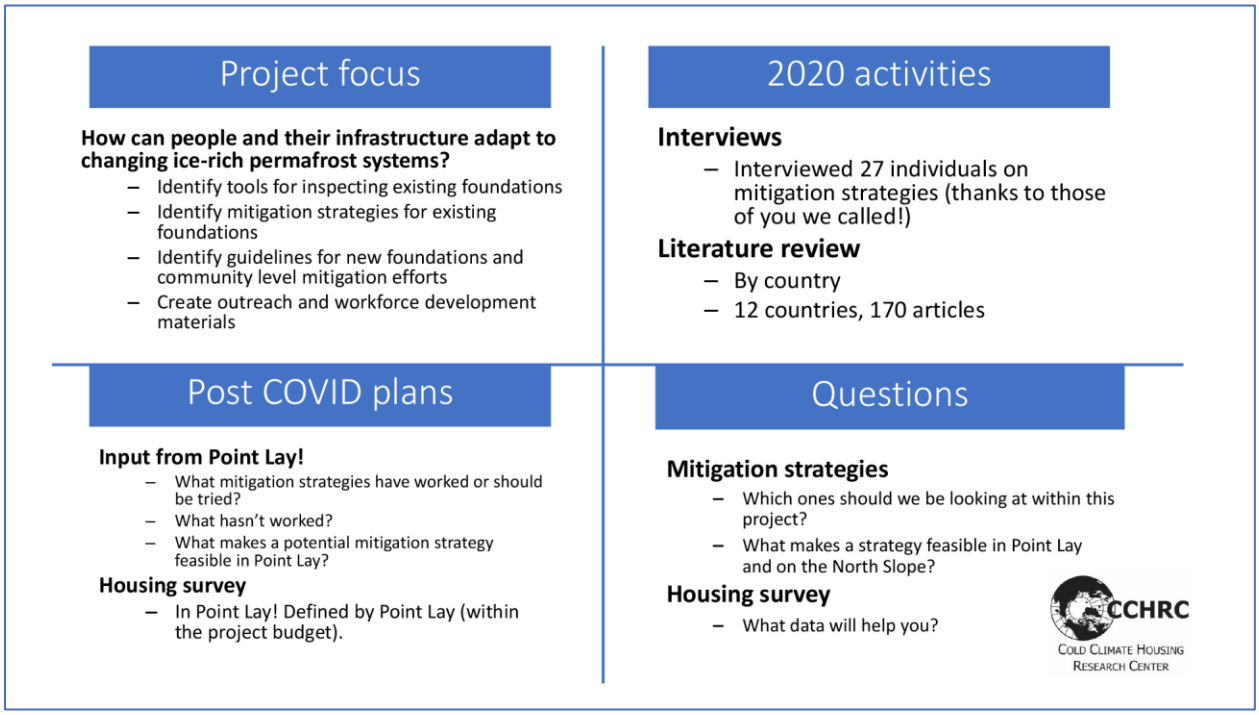
- Like everyone else, we were unable to visit Point Lay last year due to COVID, so we've been doing everything we could from here in Fairbanks in 2020.
- We are looking at what other communities on ice-rich permafrost that's thawing have done. We've interviewed 27 people, many from Alaska, but a few from other countries with permafrost: Europe, Russia and Canada. Lars Nelson and Griffin Hagle were some of our interviewees, along with the NSB, so thank you for your time.
- We've completed a literature review of 170 articles from around the globe on different strategies that communities are considering for infrastructure on thawing permafrost.

POST-COVID PLANS

- What we haven't been able to do is get input from Point Lay, so talking to people there will be our next step. You know your community the best. You know what has worked, what hasn't worked. You are the experts on ideas on what could work there. From Lupita, I highlighted in my notes what you mentioned—that you planned to monitor what is changing on a daily, weekly, or monthly basis and involving school children. We can certainly help with that.
- Secondly, we have some money for a housing survey. We know that TNHA conducted a housing survey last spring, so we hope to build on that. But as to what gets surveyed, how it gets surveyed, or who does the surveying…. That's 100% defined by Point Lay. We're looking forward to the [steering] committee in order to inform those plans.

QUESTIONS FOR COMMUNITY

- **Mitigation strategies**: We're really hoping to get input on which mitigation strategies we should be looking at to help us narrow down the ones we found through interviews and the literature review, and what makes a strategy feasible on the North Slope of Alaska.
- **Housing survey**: What data can help you moving forward?



RESPONSE FROM BILL TRACEY, SR., NATIVE VILLAGE OF POINT LAY [2:07:45]

- *With vegetation, it's not all negative up here, because our salmon or cloud-berry patch – whatever you call that particular berry in your location — those are abundant now. We used to have to travel 10, 15 miles to find these salmon berries, but now we can walk to these berry patches. So that's a positive.*
- *What we call stink weed is becoming more and more available, and it's a bigger plant now.*
- *The willows, of course, that's going to be our next tree. They were small shrubs, but the willows now provide shade… or even a blind if you are hunting.*

- *A new species is dill, whether it's a dill weed or a dill plant, it's a… wild herb and my yard is becoming a jungle of dill. And I believe it's edible, so we're going to actually harvest some next summer…. That plant is really hardy, and it stays green after the snow has covered the ground. So, it's not all negative as far as vegetation goes, unless it's considered invasive and it's going to change things differently.*

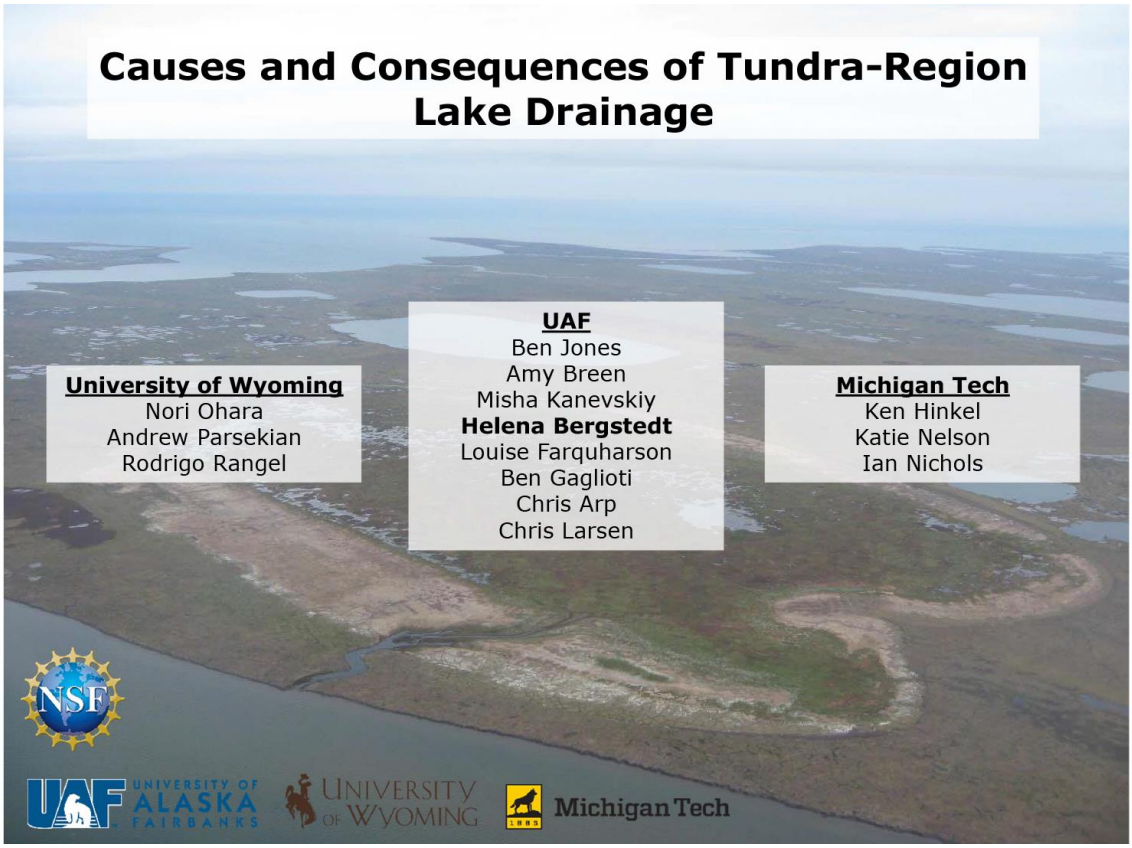
Drained Thaw Lake Basins (DTLB) [1:59:42]

HELENA BERGSTED, UNIVERSITY OF ALASKA FAIRBANKS

Dr. Helena Bergsted is a scientist who specializes in geoinformatics and remote sensing. She is a postdoctoral researcher on the DTLB and NNA-IRPS projects. Helena presented a project update on behalf of Ben Jones.

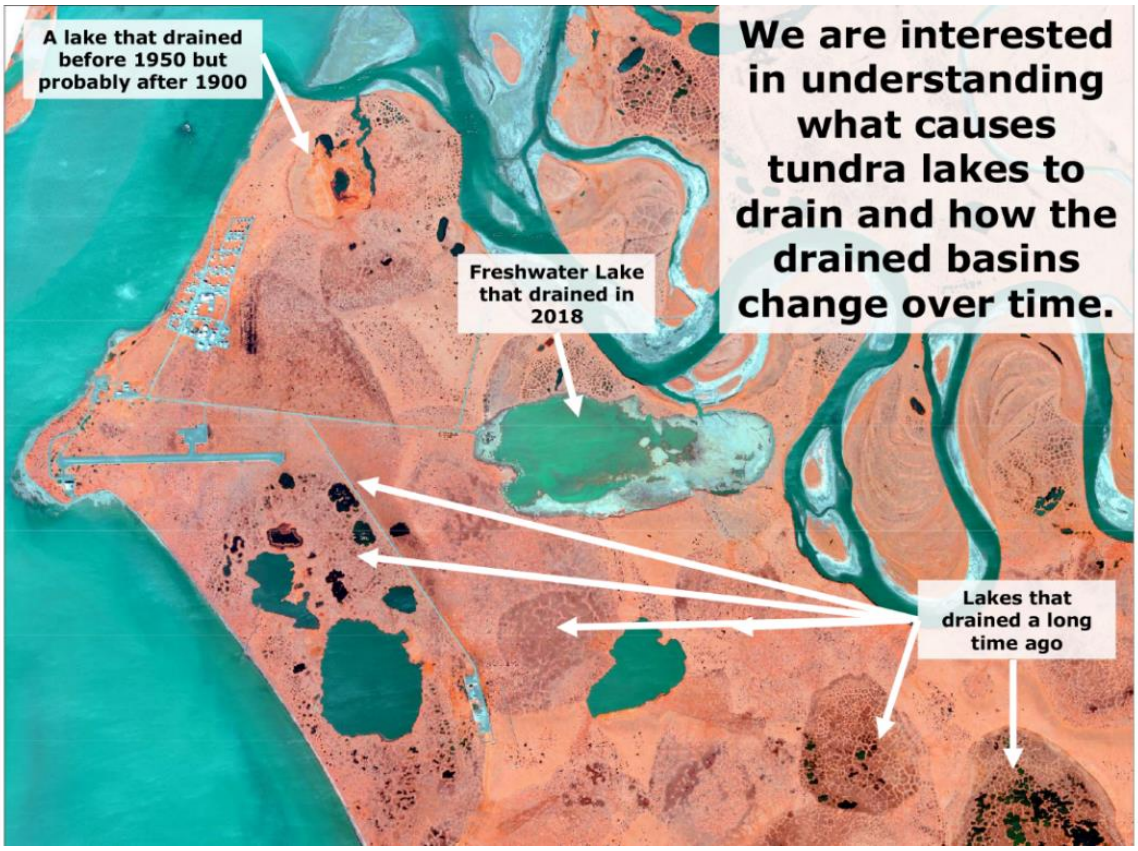
PROJECT OVERVIEW (SEE SLIDES)

- **Project title**: Collaborative Research: Causes and Consequences of Catastrophic Thermokarst Lake Drainage in an Evolving Arctic System (DTLB)
- **Co-Investigator**: Dr. Benjamin Jones, University of Alaska Fairbanks, *bmjones3@alaska.edu*
- **Funding**: National Science Foundation, Arctic System Science program
- **Website**: *arcticlakedrainage.org*



PROJECT FOCUS

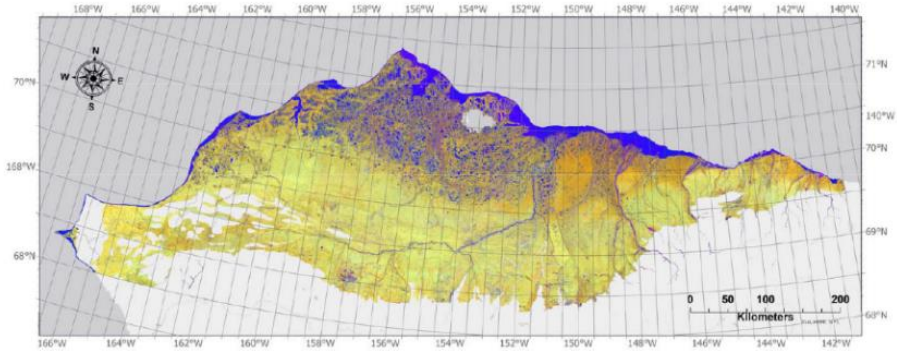
- We are primarily interested in what causes tundra lakes to drain and how the drained lake basin (DLB) may change over time. This includes those that drained a long time ago, in the last 100 years or so, or very recently — like Point Lay's fresh water lake.
- We are very interested in working with community members to discuss lakes that have drained in the area. For example, based on satellite imagery we can tell the lake shown near the delta on this slide probably drained before 1950 but after 1900. Those would be areas where we would really appreciate any input that the community would be able to provide.
- We are also interested in learning more about what caused the drinking water lake in Point Lay to drain in 2018. Going forward we would be interested in studying any changes in this now DLB with respect to plants, permafrost, snow in the winter, and water above and below the permafrost while it develops in the drained basin.
- To address these questions, we're conducting studies all across the North Slope to study permafrost and plant changes in drained basins in different tundra and soil types using geophysics methodologies to study water above and below the permafrost. We're using remote sensing satellite imagery and methods to develop a map of areas of drained lake basins on the entire North Slope that will hopefully inform further studies and help us to focus on the most relevant areas. This is something we were able to work on this year without going into the field.



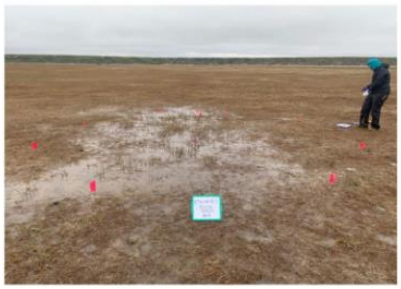
What caused the Freshwater Lake to Drain in August 2018?

DigitalGlobe Inc. Satellite Imagery

What happens to the plants, permafrost, and water in the years following lake drainage?

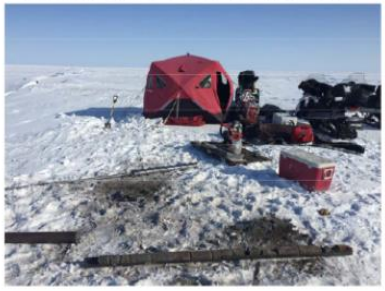


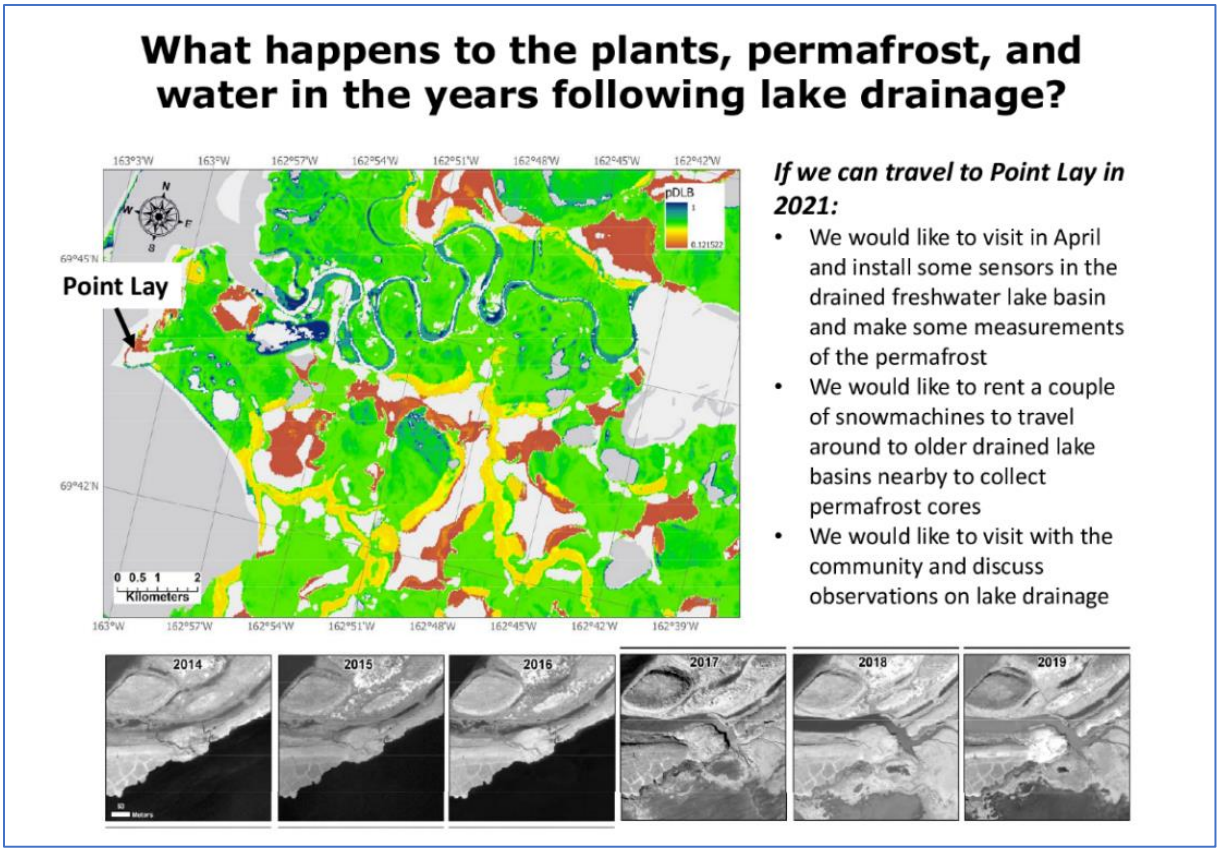
Plant Surveys in Drained Lake Basins



Imaging Permafrost and Groundwater

Coring Permafrost and Measuring Ground Temperature





- The last slide shows an example of the work we've been able to do without going into the field using remote sensing to develop a map of areas (in green and blue) that are likely to be DLB — it's not a yes or no kind of thing — which areas would be interesting to study further with more in-depth methodologies.

PLANS FOR 2021 (OR WHEN IT'S SAFE TO TRAVEL)

- If it is safe to travel to Point Lay in spring or summer 2021, we would like to visit in April to install sensors in recently drained fresh water lake basins to measure what happens to the permafrost now that the lake has drained.
- During that time, we would also like to rent a couple of snowmachines to travel to some of the lake basins that have drained long ago and collect some permafrost cores.
- Most importantly, we would like to visit with the community members to discuss their observations on lake drainage — knowledge that exists within the community that is not available to us through satellite imagery and other means.

RESPONSE FROM MARTY AWALIN, CULLY CORPORATION [2:06:40]

- We have a project to clean up that lake in Point Lay. We were scheduled to go into Point Lay in mid-April, and the lake was already thawing out. You might need to plan for earlier in April if you're going to put in sensors or in March, because it thaws out early now.

RESPONSE FROM BILL TRACEY, SR., NATIVE VILLAGE OF POINT LAY [2:09:21]

- *My father and mother-in-law, were the only family left in Point Lay when the BIA pulled everybody out for school. I asked Dad about the dry lake: When did that dry up? And he*

remembers it being a lot wetter when he was a kid. He passed on several years ago. They remember that being wet when they were young, but it was already breached into the mouth of the Kokolik River. And Dad seemed to think that it was similar to what happened to our fresh water lake. The area that breached got wet. It started to sink, and then I was there with a video camera recording the actual breach, and it looked like… the ice lens was exposed and there was a hole going through it like an ice cave. And that, once the lake started draining, that just got bigger and bigger, wider and wider, and the ground started falling in, and it became a channel. And it drained right into the river. So, what both these bodies of water had in common was Kokolik River and their distance from the river was getting closer and closer each and every year. The river was, like Lupita mentioned, it's expanding, and I think it took out both bodies of water: that dry lake that's to the north of Point Lay, and our fresh water lake — both… succumbed to the Kokolik River. And no telling if that water source that we've identified six miles away, if that's going to be the next lake that drains.

- **Use gravel and silt from drained fresh water lake:** *We'd have to clear all this with Cully Corporation, and the State and everybody else. We're looking for a gravel source; we're looking for a silt source, and we're looking for a fresh water lake. If we were allowed to repair the fresh water lake, and extract gravel and silt from that lake — it was only 11-feet deep when we were using it (really too shallow for a year-round water source). But if we were able to extract gravel and silt from there for construction, we'd also make that body of water a viable water source again. So not only questions, but possibly some answers here.*

Combining remote sensing with local knowledge to inform measures protecting Alaskan coastal communities from erosion and permafrost thaw [Chat]

TOM DOUGLAS, U.S. ARMY COLD REGIONS RESEARCH AND ENGINEERING LABORATORY

Dr. Thomas Douglas is a civilian research chemist in the Alaska Projects Office of the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) in Fairbanks. He is the PI on this new short-term CRREL project.

PROJECT OVERVIEW

- **Project title**: Combining remote sensing with local knowledge to inform measures protecting Alaskan coastal communities from erosion and permafrost thaw
- **Principal Investigator**: Tom Douglas, CRREL, *Tom.Douglas@erdc.dren.mil*
- **Funding**: Department of Defense, Strategic Environmental Research and Development Program

INVITATION TO COLLABORATE [CHAT]

- The Department of Defense has a lot of interest in infrastructure and environmental change work across the North Slope. We have seed funds to work at Point Lay and Kaktovik to identify needs, establish a research and collaboration team that includes the community, and, as a group, develop a much larger 4- to 5-year research and engineering effort.
- **Communities**: Point Lay, Kaktovik, additional communities may be added
- Contact me if you have ideas or are interested in more info or collaborating.

Permafrost Discovery Gateway [Email]

ANNA LILJEDAHL, NNA-IRPS PROJECT AND PERMAFROST DISCOVERY GATEWAY

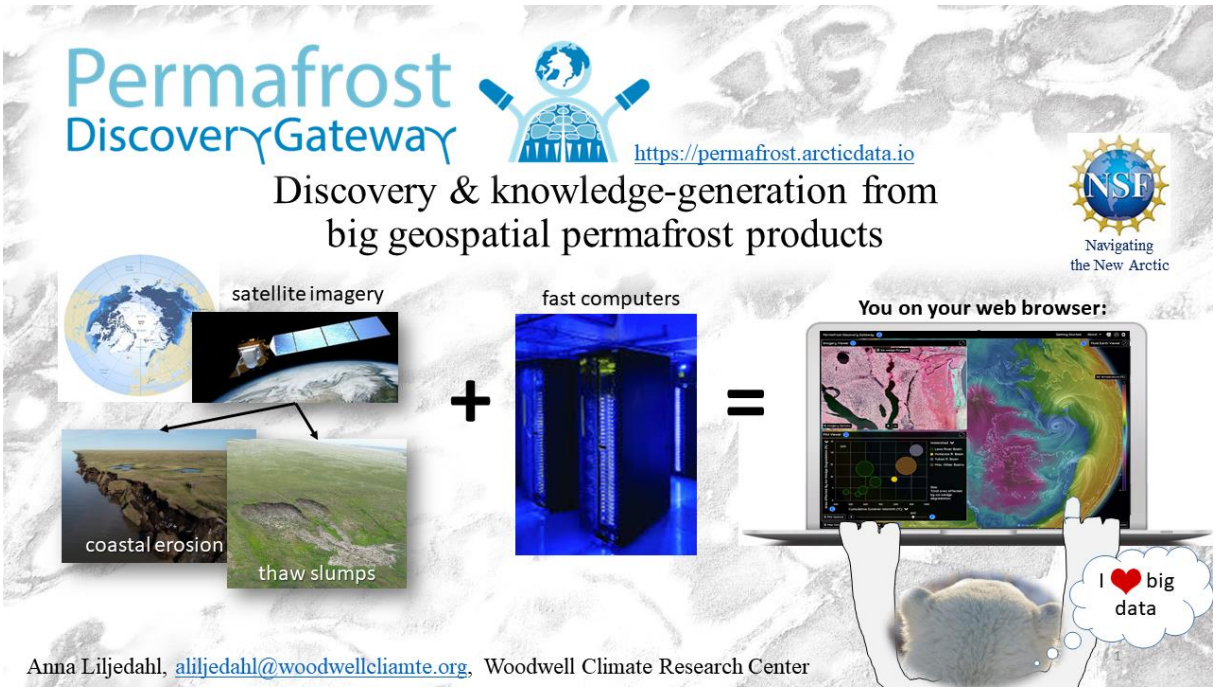
Dr. Anna Liljedahl is a hydrologist with the Woodwell Climate Research Center. She is the PI for the NSF Permafrost Discovery Gateway and a co-PI on the NNA-IRPS project

PROJECT OVERVIEW

- **Project title**: The Permafrost Discovery Gateway: Navigating the new Arctic tundra through Big Data, artificial intelligence, and cyberinfrastructure
- **Principal Investigator**: Anna Liljedahl, Woodwell Climate Research Center, *aliljedahl@woodwellclimate.org*
- **Funding**: National Science Foundation, Navigating the New Arctic
- **Website**: *https://arcticdata.io/catalog/portals/permafrost*
- We ran out of time to show this slide about the *Permafrost Discovery Gateway (PDG)*. The goal of this "big data" project is to create an online portal that will make information of changing permafrost conditions available throughout the Arctic by providing access to very high-resolution satellite data products and new visualization tools that will allow exploration and discovery for researchers, educators, and the public at large.
- The PDG will include geospatial datasets such as pan-Arctic maps of ice-wedge polygons, ice-wedges, ice-wedge degradation, and surface water in a 0.5m resolution. Additional coarser pan-Arctic maps (5 to 30 m resolution) will include lakes, thaw slumps, and fire scars and they all will also show changes over time.

QUESTIONS FOR COMMUNITY

- Anna is interested in any advice on how you would like to interact with the data. There is a mock-up of the visualization tool to give people an idea how it can look like.



Q & A

Weather Station and Data Formats for Community Use [34:20 / Chat]

ANNA LILJEDAHL, NNA-IRPS PROJECT AND PERMAFROST DISCOVERY GATEWAY

- **Data formats:** What format would be useful for you to receive data on the changes that are happening? For example, we can create geospatial products or maps from remote sensing and satellite imagery.

BILL TRACEY, SR., NATIVE VILLAGE OF POINT LAY

- **Weather station**: Kali used to have a weather station that would record daily weather, wind, temperature. (Fred Tukrook added that the weather station was back in the '50s and was operated by his sister.)
- **Data sharing, website**: In terms of how we want to follow along with studies, whether it being the weather, ice or permafrost conditions: *If we could set up a website of some sort that we could access on a daily basis and if the information was presented in a layman's form, and maybe some comparison diagrams of maybe what was -- what we knew in the past and moving forward -- that would be one way that we could stay in touch in between meetings.*

VLADIMIR ROMANOVSKY, NNA-IRPS AND NNA PIPER PROJECTS

- **Weather station**: We can help with that most likely. It will require finding some money. Modern weather stations are automated, so they require no manual work. We'll see what's the best way to transfer the data – possibly using cell phone connections.
- **Data formats**: The question will be how to make the data available for use by the community (graphs, numbers, etc.). Because it will be near real-time collection, you will be able to see the numbers, but the question is how to present them in the most useful way.

BILLY CONNOR, NNA-IRPS PROJECT

Billy Connor is a civil engineer with the Institute of Northern Engineering (INE) at UAF, and director of INE's Arctic Infrastructure Development Center (AIDC).

- **Weather station**: The National Weather Station has a weather station at the airport. *https://www.wrh.noaa.gov/mesowest/timeseries.php?wfo=arh&sid=PPIZ&num=48*

Internet Speed [34:20 / Chat]

ANNA LILJEDAHL, NNA-IRPS PROJECT AND PERMAFROST DISCOVERY GATEWAY

- What is your Internet speed and connectivity? Is that a limiting factor for receiving and accessing data? I am asking because I am leading the Permafrost Discovery Gateway (the development of fine resolution geospatial data across the Arctic tundra and the development of visualization tools): *https://arcticdata.io/catalog/portals/permafrost/About*

BRETT STIRLING, KALI SCHOOL

- Our internet speeds are pretty poor. All internet connections are via satellite. Even at the school we struggle running web-based curricular programs. I can try to get some specific speed data if that will help. Send me a request via email and I can respond that way:

ANNA LILJEDAHL, NNA-IRPS PROJECT AND PERMAFROST DISCOVERY GATEWAY

- I will take you up on that. My email is *aliljedahl@woodwellclimate.org* and I am in Homer.

ANNE JENSEN, NNA PIPER PROJECT

- The other issue with internet is that there are data caps and exceeding them can be EXTREMELY expensive.

GRIFFIN HAGLE, TNHA

- For reference we have a 5Mbps DIA at our office in Utqiaġvik. It cost TNHA ~$4k more per month to increase this from 3Mbps which was an absolute necessity with our increased VPN usage. I have a 10Mbps download home connection. No data cap on that plan but it's $2/GB up to 100 GB and $1 thereafter. Our ISP is ASTAC.

ANNA LILJEDAHL, NNA-IRPS PROJECT AND PERMAFROST DISCOVERY GATEWAY

- For improving future internet connectivity, it may be a good idea if a bunch of you signed up as beta testers for the SpaceX new project: *https://www.starlink.com*. More info is here: *https://en.wikipedia.org/wiki/Starlink*. Early beta testers are reporting amazing results, sustained 150Mbps over the LEO satellites with very reasonable prices.

GRIFFIN HAGLE, TNHA

- Signed our office and warehouse locations up for updates on the Starlink program. Looks intriguing!

Clean Water Act Grant [1:25:00]

MARY AWALIN, CULLY CORPORATION

- Has the Borough accessed grants under the Clean Water Act for water systems or to study the place for a new fresh water lake? I have addressed this topic with the Borough before.

GORDON BROWER, NORTH SLOPE BOROUGH

- When we get those kinds of funds to create a project, we hand it over to Capital Improvement Program Management (CIPM) to carry out: get contractors, do the public noticing, etc. We want to have participation from Public Works and from CIPM. That would be the group to better answer that. The Planning Department, as a community service, tries to help by being part of a dialog and help putting project requests together. *I'm not too savvy on how CIPM leverages outside funding. It might be something where we work more closely together at Planning so that when it does go to CIPM (or some other vehicle is used to get projects underway) that we include the synergies in there to make a full package so that the projects are not so fragmented.*
- *Right now, a lot of the projects that the Borough moves forward with are very fragmented. Let's give this project $2 million this year, because we can't afford to fund it fully, but we need to fund some other projects in another community to get that going as well. So, we tend to do a lot of*

phasing, and then projects start to take a very considerable period of time to get adequate funding to complete them sometimes. I know it's not the perfect answer, but that's kind of the system that we work with.

Sites to Install Sensors [1:28:46]

BILL TRACEY, SR., NATIVE VILLAGE OF POINT LAY

- **Community expansion**: We are on a bluff and there's only three directions we could actually increase our footprint. One would be a strip of land between the village and the air force base, although land ownership would have to be cleared and permits obtained. There is also possible land to the north, beyond the 900 block. What seems to be most favorable is going east. It's lower ground, but it's not part of this ice lens. It seems to be a little more stable down there. It gets wet so we'd have to deal with that, but at least on the north end of town we could go east without being in real wet ground.
- **Possible test sites:**
    - **Road to proposed water source:** *If we're talking about putting in ice test sites, we should look at something Marty [Awalin] just mentioned, and we're all in agreement here: that if there is another water source (and I think we've identified one 6 miles away) maybe a test sites or two along a proposed trail to that.*
    - **Kuchiak Coal** : Finally, some of us thought we should put a test site where the coal mine is at Kuchiak. *That's more or less building on rock, because we're on the foothills there, and rock seems to last a whole lot longer than ice.*

LUPITA HENRY, NATIVE VILLAGE OF POINT LAY

- **Ice wedges in town:** Looking at NSB's water and sewer diagram will give you a clear idea of where the ice wedges are right now in the community…. *I live on the 600 block and I'm sitting on top of an ice wedge, and it's potentially endangering my structure, my household. So that area… that's right behind the Episcopal Church…, is significantly dropping at a rapid rate. I would suggest that one test site be right there where all the ice wedges are located, so we can see the rate that they're defrosting at.*
- **Lagoon ice:** *I suggest we get an ice monitor on our lagoon system just to see how fast it's freezing and how long it's staying frozen, and that will tell us a little bit of the ice condition.*
- **Sea ice:** *I think that there needs to be a testing site on the ocean in the water to test the ice grade level and that will give our hunters even some idea of safe ice when we look at some of the studies that are done.*
- **By river**: I believe we need to have a sensor over by our river, because our river is expanding and changing. *Since the water break of that one water lake that we had, it's changed the channel a little bit and it's changed a lot of other things…. With that amount of fresh water going out, it's increased the different types of fish that we have like Bill was mentioning: the tomcod that we're getting and sheefish are right behind them. Those are invasive species…. I think getting [NSB Wildlife Department] on board with this to keep up with the studies on that.*

Water Tank Failure [1:36:14]

MING XIAO, NNA PIPER PROJECT

- A quick question for Bill: I'm surprised to hear that the water tank broke again, because it's only 10 years old. I don't know what the plan is for the retrofitting of it. If this will be rebuilt, I'm wondering if we could put some sensors to measure the temperature of the gravel pad and displacement under the foundation, so we can better understand the performance and see if it's really insulating the ground.

BILL TRACEY, SR., NATIVE VILLAGE OF POINT LAY

- **Water tank failure:** The water tank that just failed is the original one. We have three of them, and this was the first one built. It's not only subject to permafrost degradation, but it's also in the line of an underground fuel spill, and the tank sits on Styrofoam. You've probably realized that Styrofoam and diesel don't mix. What actually caused the rupture isn't known yet, because it just happened. But they're assuming it came from the bottom of the tank. That would mean the tank either eroded or it's tipping and it's moving—like everything else. *Everything is moving here… and if it is on a pad, that pad is ancient. The insulation is compromised from diesel… and it's [a] flooded area. So, it's basically an island other than the road it's attached to. And so are the other two newer water tanks. Those become islands during spring break up. That's a big factor on what's happening to some of this surface stuff.*
- **Other pads that can be tested:** *We have a few buildings sitting on slab on grade, which are on a gravel pad, and as the ground around those pads is subsiding, those pads are following it. And so, it won't be long before those slab on grades start moving radically. We have a basketball court in the middle of the community behind the school and the store and all that. That's a slab on grade. It's built where there was an old pad, and we've noticed that being an exposed pad (no building on it), it's starting to crack; the expansion joints are widening. We fear we're going to lose that playground if we can't get fill around it and calk in those expansion joints. So, things are moving… pretty rapidly.*

Citizen Science Opportunity: Tracking infrastructure issues with smart phones [Chat]

ANNA LILJEDAHL, NNA-IRPS PROJECT AND PERMAFROST DISCOVERY GATEWAY

- If anyone in Point Lay or Utqiaġvik is interested in being part of a project to track and document infrastructure problems with permafrost thaw using your own smart phone, let me know. The info would inform economic analyses assessing this climate risk and options. Email *aliljedahl@woodwellclimate.org*

Longevity of Air Force Facilities: Have there been any studies? [2:14:05]

MARY AWALIN, CULLY CORPORATION

- I look at the air force facilities in Point Lay and how long they've been there. They've been built since 1957. Has anyone ever looked at how they stand so strong on their padding? I don't know if it's an 8-foot, 10-foot, 12-foot padding they built. They're big structures, and they just stand straight. So, I'm just curious about that – if there have been any studies done on that.

Closing Comments

Jana Peirce, University of Alaska Fairbanks

- As Gordon Brower mentioned, the North Slope Borough mayor has also started a task force on Point Lay that Bill Tracey, Sr., will be on, along with Billy Connor from our team, and some folks at ANTCH have agreed to serve on. That's another way these problems can be discussed and addressed. Then hopefully funding for some of the solutions these research projects help identify will be the next step.
- I will work with Lupita and Ming and others to see how we can have these conversations more often, because it's truly valuable. The fact that we both discussed the very, very big picture questions, and some very specific, detailed information that's useful has been fantastic.
- I want to thank everyone for their time, and I want to apologize that we didn't get to everything and everybody that we could have.
- Thank you especially to the community, to the advisors, and to the project researchers who joined us today.

Lupita Henry, Native Village of Point Lay

- I'd just like to say thank you to everybody that's online. Thank you for hearing us out and hearing our concerns. I'm real excited for the future of this. I will be reaching out with my Council out to the federal side and seeing where we can open up some avenues for funding.
- As far as working with the corporation, Marty if you can get ahold of me at the office, and try to help mitigate some of this information that needs to go out, including our school.
- I'd like to see our school district on board next time. That way they can coordinate and even in the other communities to try to make this an outreach program for the children across the slope, because I know that Point Lay is not the only community that is facing climate change, and being on the coast there are some other communities identified. I would like to see the school district and see their partnership.
- I'm thankful for our principal here, Brett, for having the opportunity to come and have a Zoom meeting here at the school. I just hope that our Internet service stays up. We have snail mail when it comes to snail mail. So, if you send anything by post office, understand that it may take up to a month or two months to get here depending on how you send it.
- You can email our office directly (*ptlay.ira@gmail.com*) and our phone number is (907)833-5052 if any of the entities would like to collaborate a little bit more or provide some more information.

Meeting Participants

Advisory Group Members

Native Village of Point Lay: Lupita Henry (President), Frederick Tookruk (Elder), Bill Tracey, Sr. (Elder)

Cully Corporation: Marty Awalin (President/CEO), Lew Eisaguirre (consultant)

Kali School: Matt Stirling (Principal)

NSB Planning and Community Services: Gordon Brower (Director), Mabel Kaleak (Deputy Director)

Tagiuġmiullu Nunamiullu Housing Authority (TNHA): Griffin Hagle (Executive Director)

UIC Science: Kaare Sikuaq Erickson (Science Liaison)

Iñupiat Community of the Arctic Slope (ICAS): Ray Atos (Environmental/Natural Resources Director)

Project Teams

NSF NNA-IRPS project: Donald (Skip) Walker (Principal Investigator, UAF), Jana Peirce, Anna Liljedahl (Woodwell Climate Research Center), Vlad Romanovsky (UAF), Dmitry Nicolsky (UAF), Billy Connor (UAF), Helena Bergstedt (UAF), Vanessa Stevens (CCHRC/NREL)

NSF NNA PIPER project: Ming Xiao (Principal Investigator, Penn State), Vlad Romanovsky (UAF), Dmitry Nicolsky (UAF), Anne Jenson (UAF), Louise Farquharson (UAF), Xiong Zhang (Missouri University of Science & Technology), Lilian Alessa (University of Idaho), Christopher McComb (Penn State), Sierra Hicks, Min Liew

NSF Drained Thaw Lake Basins project: Helena Bergstedt (UAF), Andrew Parsekian (University of Wyoming), Louise Farquharson (UAF)

DoD CRREL project: Thomas Douglas (Principal Investigator, CRREL)

EXPLORING SNOW

Did you know?

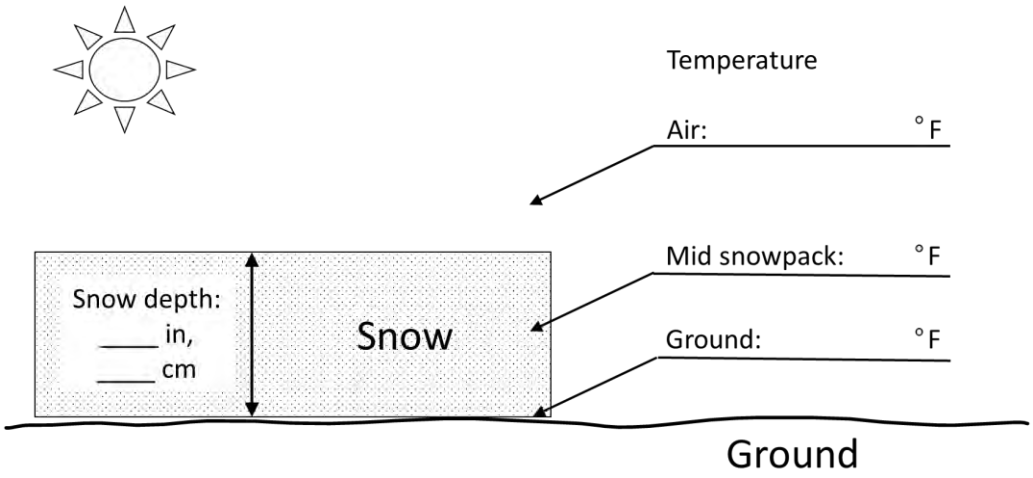
- Snow forms when frozen ice crystals fall from a cloud.
- Snow crystals can have many different shapes.
- Snow traps air and is a good insulator. (An *in-su-la-tor* keeps the temperature of an object the same.)

Get ready!

- Dress warm! Bring a shovel, measuring tape and thermometer.
- Find an undisturbed patch of snow.
- Dig through the snow until you hit the ground; scrape one side wall of your hole smooth.

Record measurements

- With your thermometer, measure the temperature of
  - the air above the snow
  - the snow in the middle of the snowpack
  - the ground below the snowpack
- Use the measuring tape to see how thick the snowpack is.
- Write your data on the lines in the diagram below:



- Look at the snow crystals: What shapes can you find towards the top and bottom of the snowpack?

_____

Think about it

- Where did you find the lowest temperature? _____
- Where did you find the highest temperature? _____
- Some small animals spend the winter in or below the snowpack. Can you think of any?

_____

Measuring Snow Depth and Temperature

Did you know?

Snow is very important in the Arctic environment. It insulates the ground from cold winter air, providing shelter for plants and animals who stay warmer beneath the snow cover. In spring, snowmelt becomes an important source of water in the Arctic landscape.

Scientists monitor snow depth and air temperature to know how cold the ground is. Less snow means less insulation and colder ground. More snow keeps the ground warmer and can lead to permafrost thaw, especially in places where snow berms form along roadsides, snow fences and other infrastructure. If there is more snow, there will also be more water flowing into lakes and rivers next summer. If there is late snow, birds and plants may be in trouble.

Scientists working on our project at the University of Alaska Fairbanks want to know: What is the threshold? How much snow can be on the landscape given recent climate trends before ice-rich permafrost degrades? This is where young scientists in the community can help by measuring the depth of snow, air temperature, and ground surface temperature in different places and at different times throughout the winter.

Get ready

- In spring, plan to take your measurements in the morning before the day warms up.
- Equipment: Measuring stick, 4 temperature sensors (thermistors) and a data logger with digital display
- Handheld GPS (or camera with GPS enabled to geotag photos)
- Datasheet to record your data (on back of this page)
- Put the measuring stick with the sensors outdoors ~30 minutes before you plan to start.
- Watch the video on how to use the equipment to measure snow.

Measure and record

- Choose a variety of locations to measure snow depth and temperature. Some good places are:
    - Near buildings and other infrastructure (examples: along roads where snowplows leave snow, between houses, beneath elevated houses, along snow fence and other places with snowdrifts)
    - In undisturbed locations further away from human infrastructure
- Press the button on top of the HOBO data logger to turn it on. Follow instructions in the video.
- If the snow has a wind-packed crust on top, first use a pole to make a small hole in the snow to prevent the thermistors being damaged or dislodged when measuring stick is pushed through the icy crust.
- Record the snow depth and the temperature of each for each channel on the datasheet.
- Record the geolocation using the handheld GPS or by taking a photo from the spot.
- When you are finished using the equipment for the day, press the power button on the data logger again to turn it off so the battery doesn't drain.
- Back inside, enter your data in the Excel worksheet. Give each record a unique ID number. Save your photos in the same folder with your data. Either record the filename of the photo in the Excel datasheet, or rename the photo with the unique ID of the record.

Repeat

- Place a pole with a flag in some of the spots you measured in the morning and take measurements again in the afternoon and/or evening.
- Watch the 5-day forecast. If a strong warming or cooling trend is forecast, put the measuring stick in a spot that's easy to visit and return each day to take measurements throughout the event. (Turn the power off between visits.)

Record your data

Student Name	Date	Time	Snow depth (in.)	Temperature (°F)				Location			
				Channel 1 (air)	Channel 2 (snow)	Channel 3 (snow)	Channel 4 (snow)	If photo: Filename	Latitude	Longitude	Description of location

Note: If you don't have a GPS device, you can download a free smart phone app or a desktop app for a Windows or Mac computer to view the latitude and longitude of your geotagged photos.

Thermal Image Scavenger Hunt

Did you know?

- Normally infrared radiation, or heat, is invisible to human eyes.
- Thermal imaging cameras translate infrared radiation, or heat, into colors.
- Thermal imaging cameras are used by engineers and scientists to discover where heat is traveling in or from a building.

Materials

- Thermal imaging camera

Get ready!

- Try to use the thermal imaging camera so you are familiar with how it works. You might try using it to look at a person! What areas are the warmest? Which areas are the coldest? HINT – compare a person's core temperature to that in their hands.
- This lesson works best in the fall or winter when it is cold outside.

Go! See if you can find the following images.

- A car or snow machine that has been turned off for at least a few hours AND one that was just turned off.
- The window in a building and the surrounding wall. Which part – the window or the wall – is leaking the most heat to the outdoors?
- A door and the surrounding wall. Is there an area that is leaking heat to the outdoors? Is the door better at holding heat inside the building, or is the wall better?
- The roof of a building. Is there heat leaking out of the roof to the air?
- The floor of a building. Is there heat leaking out of the floor to the air?
- A baseboard inside a building. Is the heating system currently on or off? Can you tell from the picture?
- An oven in a kitchen. Is it on or off? Can you tell from the picture?

The window frames in this image are much warmer than surrounding air – this means that the materials are transferring heat from inside the house to the outside. That's lost energy! A material that was a better **insulator** would help keep heat inside the house where it can ensure people are warm.

Where else on this house is leaking heat to the outdoors?

Thermal Imaging!

Did you know?

- Thermal cameras detect temperature by recognizing and capturing different levels of infrared (IR) light. IR is invisible to the human eye, but can be felt as heat if the intensity is high enough.
- IR is a frequency of electromagnetic radiation produced when atoms absorb and then release energy. All objects in the universe emit some level of IR radiation, but the most obvious are the sun and fire.
- There are satellites equipped with similar but more expensive high-resolution thermal cameras that look at the earth to study weather and earth systems and look out to space to learn more about the universe.

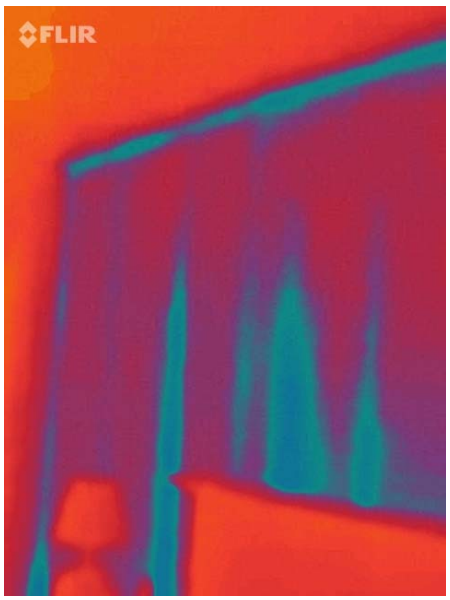
Get ready!

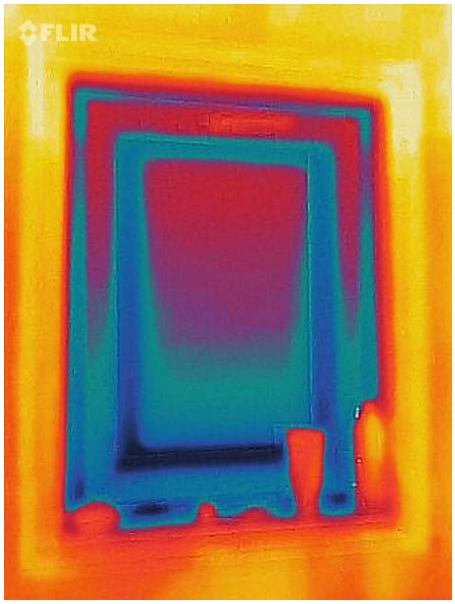
- Remove the FLIR One camera from its rubber case and charge it with the supplied cable.
- On the iPad or smart phone you will be using, go to the App Store to download and install "FLIR One." This is the software you use with the FLIR camera.
- Connect the camera to the bottom of the iPad or phone with the lenses facing away from the screen and turn the camera on.
- Once you open the FLIR One app you should see an infrared image. Use the camera to look around and you should see bright colors for relatively hot areas and darker colors for relatively cold colors.
- Take a practice photo. Photos taken with the FLIR app can be saved to the camera roll and downloaded.

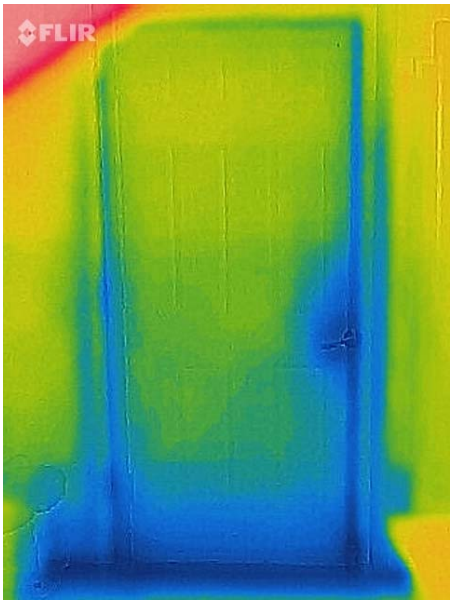
Activity 1: Windows, Doors and Walls

The goal of this activity is to show how remote sensing such as IR cameras can be used to find hot and cold areas.

- Point the camera at the walls on a cold day. You should be able to see the studs because they are colder than the insulation. Why is this?
- Point the camera at a window and note the windows are much colder than the wall. Is the area around the window hot or cold compared to the rest of the wall? How might this be avoided?
- Do the same for exterior doors.







Activity 2: Water tank thermosyphons

The goal of this activity is to see if the thermosyphons on the village's water storage tanks are doing their job.

- Thermosyphon (or thermosiphon) is a method of passive heat exchange based on natural convection, which circulates a fluid without the need of a pump. Thermosyphons are used to keep the ground cold beneath some roads, buildings and pipelines in Alaska by removing heat from the soil beneath them. Thermal imaging using infrared cameras has been used to test the performance of thermosyphons installed in vertical support members on the Trans-Alaska Pipeline and identify problems.
- Take some photos of the water storage tanks in town. The tops of the thermosyphons should be brighter than the surrounding areas on the tank if they are working. If they aren't working, it's because the gas inside has leaked out. Without them, the soil beneath the tanks will likely thaw, causing the tank to fail.

Activity 3: Taking temperature with the infrared camera

The goal of this activity is to introduce students to the idea that temperature can be measured with IR cameras.

- Have students take pictures of each other using the infrared camera. Why are noses and ears are dark in color (cold)? Why are the cheeks and forehead brighter (warmer)?
- Have a student press their hand on a table for about 30 seconds while someone else points the camera at the hand. Right after the hand is removed, take a photo of the table. Does an imprint of the hand remain? Why is this?

Take it further, even out to space!

Use the web to learn about infrared imagery taken from satellites and drones.

- How can we use thermal imagery to learn about the earth's "skin temperature"? Search on "infrared remote sensing" or "thermal remote sensing" to discover how thermal imagery is being used to study snow and ice cover, identify sea ice leads, map wildfires, study vegetation and ocean health, and much more.
- How is thermal imaging being used in the real world to improve people's lives? Search on "thermal imaging drone use" to learn how drones equipped with thermal cameras are being used in search and rescue, firefighting, agriculture, infrastructure inspections, public safety and security.
- Check out www.nasa.gov/stem/forstudents/9-12 and search on "infrared" for more activities.

What happens when permafrost under a building thaws?

Did you know?

- The warming climate is causing permafrost to thaw.
- Heat from a building can cause permafrost to thaw.
- Water can cause permafrost to thaw.

Background

- This lesson is slightly adapted from outreach materials provided by "Hot Times in Cold Places." You can find educational videos and a photo of the lesson set up on their website: http://www.permafrosttunnel.org/index.html

Materials

- Large tray (to hold the permafrost while it is thawing)
- Medium tray (to make your permafrost)
- Small pans for the base of houses
- Popsicle sticks for roofs and foundations of houses

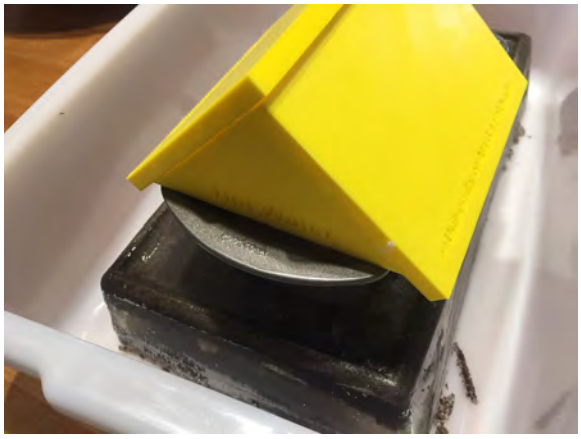
Get ready!

- Teachers – you will need to make permafrost before you conduct this experiment. This takes a day so be sure to plan ahead.
    - Put some soil or dirt in the medium tray. Fill the tray with water and freeze the soil / water mixture.
- While the permafrost is freezing, students can create houses. Use the popsicle sticks to create a roof for a house. They can also be used to make an **elevated** foundation. Elevated means lifted off the ground.

Image courtesy of "Hot Times in Cold Places" website.

Go!

- Once the permafrost is frozen, you are ready to go! Place the permafrost block in the large tub.
- Fill the small pan with hot water and place on the permafrost block. Make sure the roof is on it, so you know it is warm house (our roof is a yellow model, instead of popsicle sticks). This part of the experiment represents a house that is built directly on permafrost.



- Fill another small pan with hot water and place it on your post-and-pad foundation on the permafrost block. (our foundation is a model, instead of being made from popsicle sticks). This part of the experiment represents a house that is built on an **elevated** foundation.

- Watch what happens!

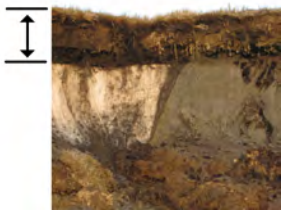
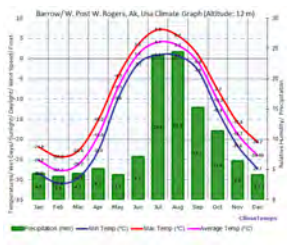
Think about it

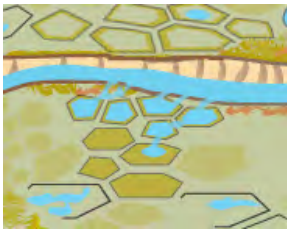
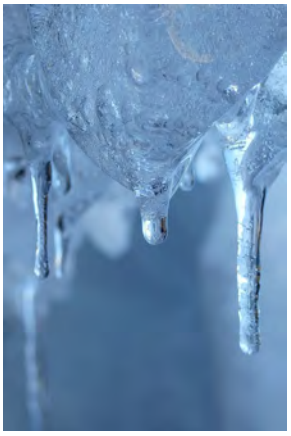
- What happens to the house that sits directly on the permafrost?
- What happens to the house that has an **elevated** foundation?
- Why do you think there is a difference?
- Can you think of other ways to prevent permafrost thaw underneath warm buildings besides elevating the building off the ground?
- What buildings in Point Lay have elevated foundations?
- When you lift the model houses what does the permafrost underneath feel like? Is there a difference between what the permafrost feels like under the house with the elevated foundation and the house sitting directly on the permafrost?

Words about permafrost and landscape change in the Arctic

This vocabulary worksheet is for first and second grade students in Ms. Shirrell's class to complete over the winter break. During the spring semester, scientists from the University of Alaska Fairbanks will join the class by video to talk about how the Arctic landscape is changing and the role played by permafrost and water.

Instructions:
Learn the vocabulary words related to permafrost and landscape change. If possible, interview an older family member or neighbor to learn if they know an Iñupiaq name or another local word for the same thing.

Picture	Word	Meaning	Iñupiaq or local word
	permafrost	Ground that remains frozen all year long. Permafrost is made of ice, soil, rocks, and sand, and may contain the remains of ancient plants and animals.	
	active layer	The top layer of soil above permafrost that thaws in summer and refreezes in the fall.	
	weather	Day-to-day variation in local temperature, wind, rain and snow conditions	
	climate	Typical weather patterns in a region measured over many years.	

	Ice wedge	Ice that forms when water flows into the cracks in the permafrost and freezes. Ice wedges can grow very large over time.	
 	Ice-wedge polygons	A landscape pattern that forms on the ground above ice wedges in permafrost landscapes. Some polygons become flooded with water from melting snow or nearby lakes and rivers.	
	thaw	The melting or softening of ice, snow and other frozen things as the result of warming.	

	erosion	The wearing away of the earth by water, wind, and other forces.	
	foundation	The lowest part of a building that supports the weight of the building and connects it to the ground.	
	stable	Firmly fixed	
	unstable	Likely to change or move	

Photo and picture credits: Ben Jones, Mikhail Kanevskiy, Jana Peirce, Thot Pro, Inc., GRID-Arendal, reuters.com

Building houses on snow - Grades 1-2 poster project

Class bulletin board created by Kali School teacher Dianne Shirrell

Virtual Classroom Visit with Ms. Shirrell's class

Kali School - May 3, 2021

Cold Climate Housing Research Center
CCHRC

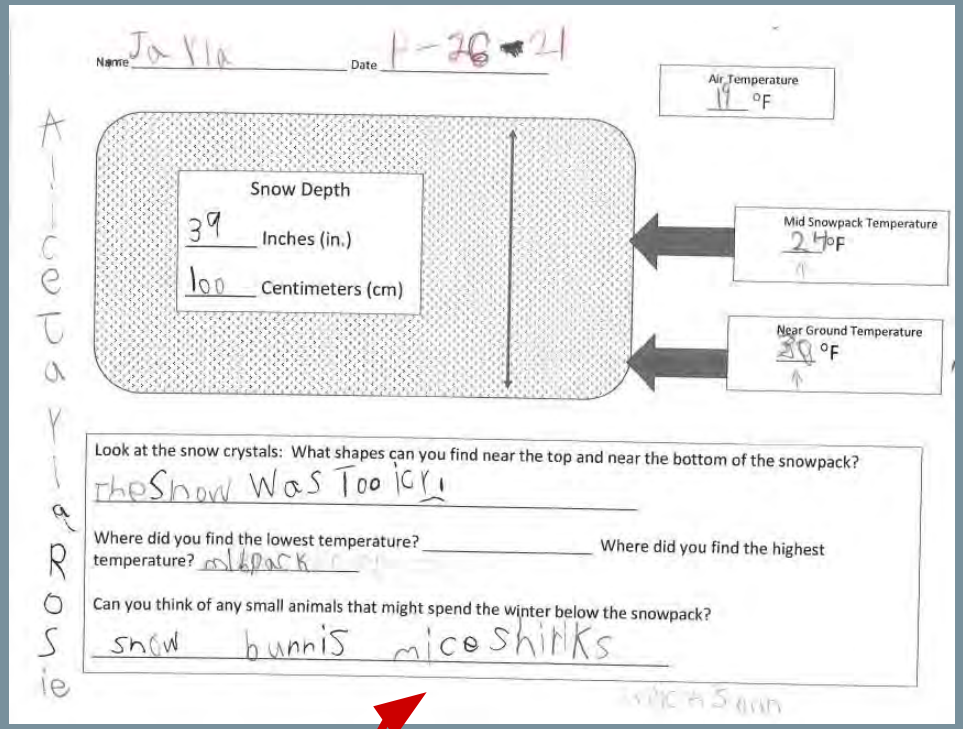
UAF
University of Alaska Fairbanks

Measuring Snow like Lief!

Lief lives in
Fairbanks

Lief and
his Mom
say Hi!

Junior Scientists in Kali



Name Jaylia Date 1-26-21

Air Temperature 19 °F

Snow Depth
39 Inches (in.)
100 Centimeters (cm)

Mid Snowpack Temperature 24 °F

Near Ground Temperature 30 °F

Look at the snow crystals: What shapes can you find near the top and near the bottom of the snowpack?
theSnow Was Too icy.

Where did you find the lowest temperature? _____ Where did you find the highest temperature? snowpack

Can you think of any small animals that might spend the winter below the snowpack?
snow bunnis mice shirks

Alicia Rosie

What small animals live beneath the snow?

It's warmest at the bottom!

19 °F

24 °F

30 °F

How can we build houses on top of permafrost?

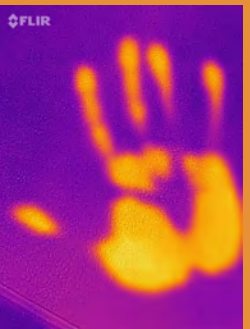

fog
sleet
snow
hail
Tristan
House on "grade"


sleet
snow
Arielle
House on pilings


Leonard
"Raft" foundation

Virtual Classroom Visit with Mr. Griffis class

Kali School - May 3, 2021



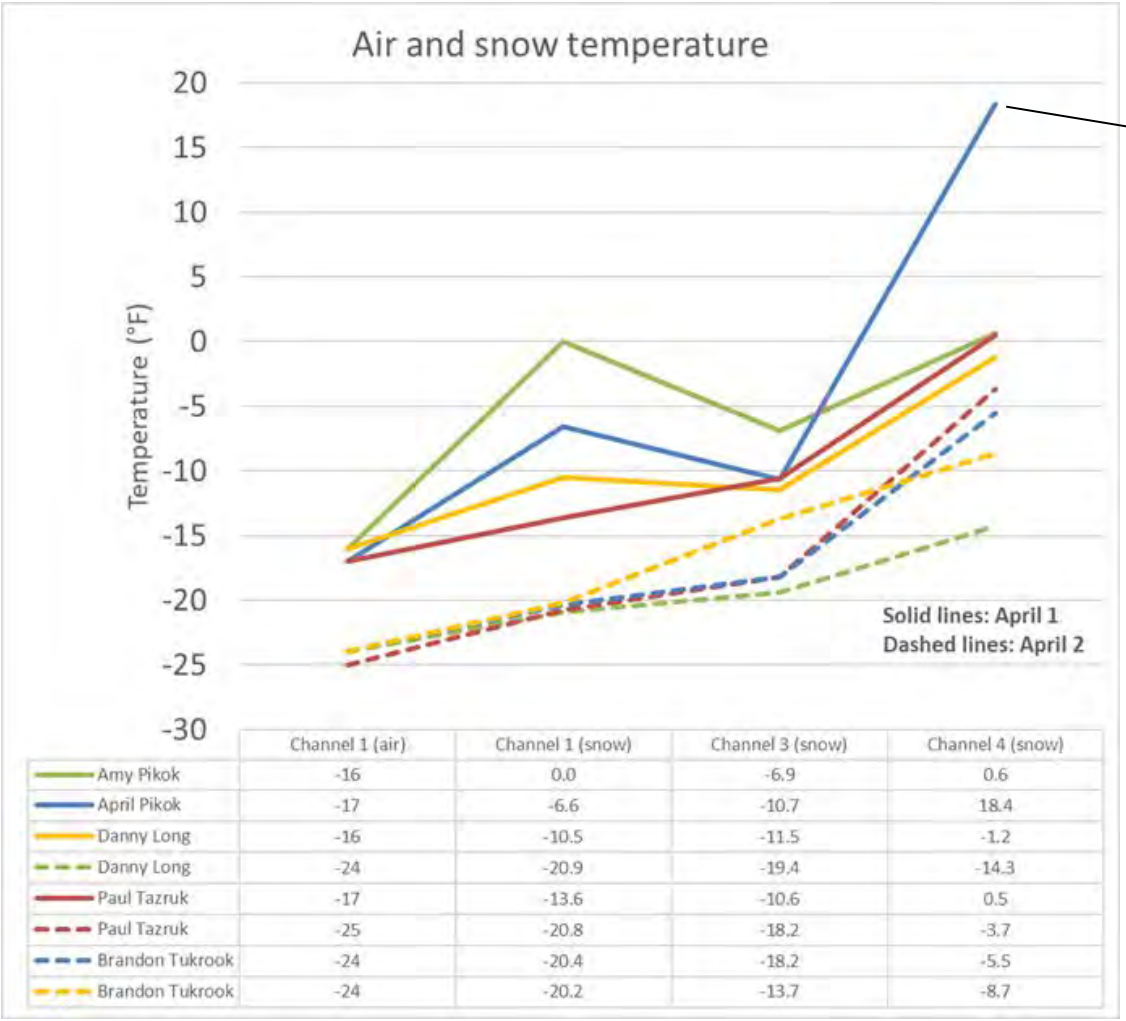
Cold Climate Housing Research Center

CCHRC

UAF University of Alaska Fairbanks

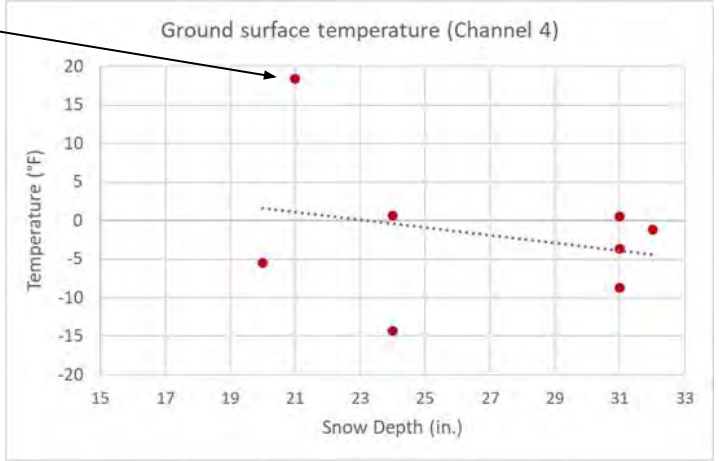
Snow Measurement

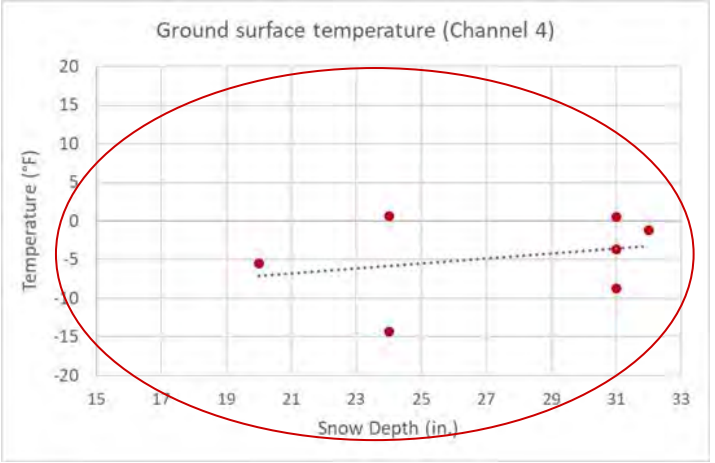
With Vladimir Romanovsky



	Channel 1 (air)	Channel 1 (snow)	Channel 3 (snow)	Channel 4 (snow)
Amy Pikok	-16	0.0	-6.9	0.6
April Pikok	-17	-6.6	-10.7	18.4
Danny Long	-16	-10.5	-11.5	-1.2
Danny Long	-24	-20.9	-19.4	-14.3
Paul Tazruk	-17	-13.6	-10.6	0.5
Paul Tazruk	-25	-20.8	-18.2	-3.7
Brandon Tukrook	-24	-20.4	-18.2	-5.5
Brandon Tukrook	-24	-20.2	-13.7	-8.7

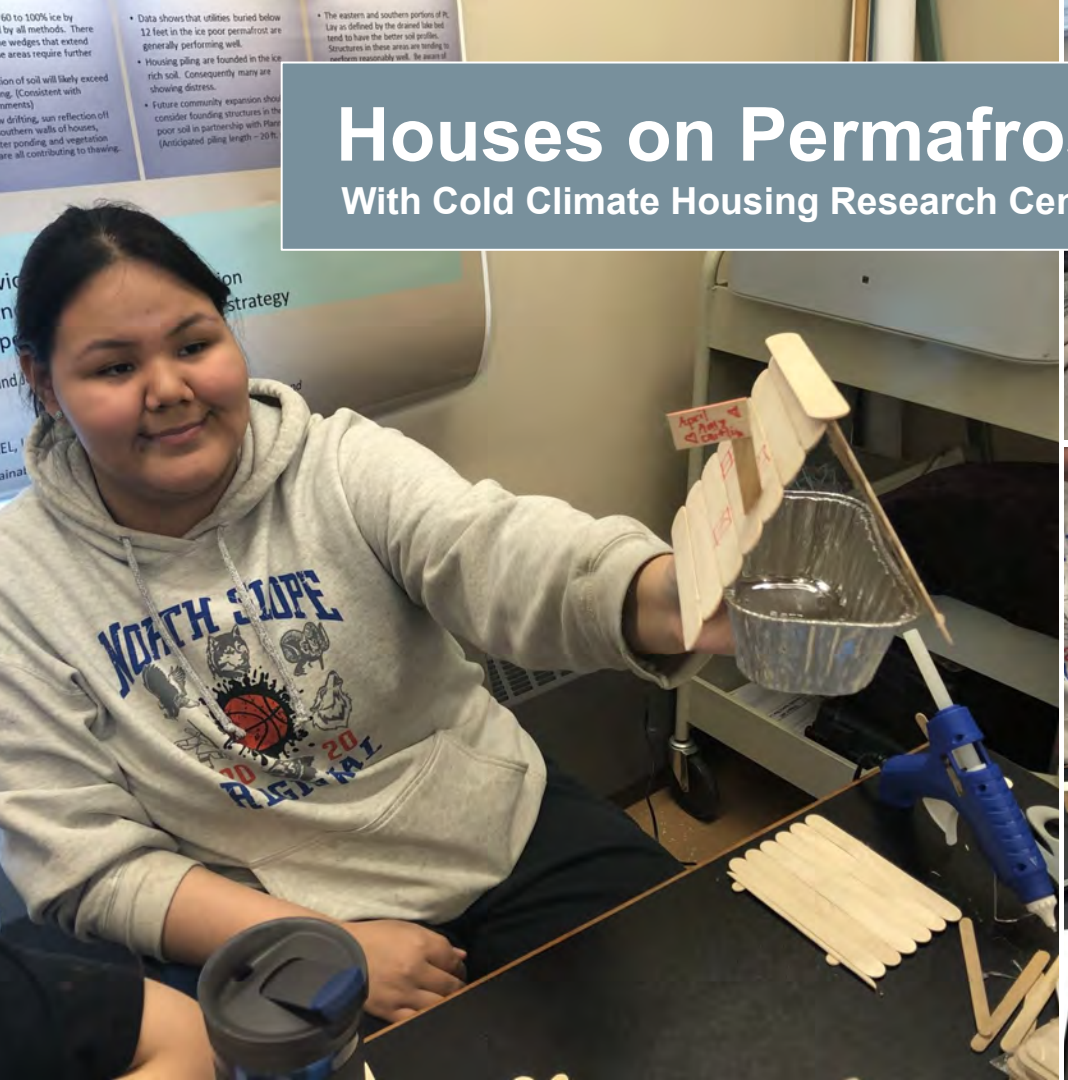
What effect does snow depth have on ground surface temperature?





Houses on Permafrost

With Cold Climate Housing Research Center



Virtual classroom visit with Kali School - February 2021