Preview of Award 1928237 - Annual Project Report

Cover |
Accomplishments |
Products |
Participants/Organizations |
Impacts |
Changes/Problems
| Special Requirements

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:	09/15/2019 - 08/31/2020
Submitting Official (if other than PD\PI):	N/A
Submission Date:	N/A
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	N/A

Accomplishments

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

Overview: We are studying one of the most vulnerable elements of the rapidly changing Arctic -- 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 IRPS? What roles do ecosystems play in the development and degradation of IRP? and How can people and their infrastructure adapt to changing IRP systems? 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 will develop 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***), which similar to several other coastal villages in northwest Alaska. 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 (you must provide information for at least one of the 4 categories below)?**

Major Activities:

Collaboration Plan. A NNA-IRPS project collaboration plan was developed with guidance from Pips Veazy, UAF EPSCoR program. The document establishes processes and methods to ensure an open and collaborative atmosphere over the life of the project. It provides a clear definition of the project's mission and organization and guidance regarding shared respect and collaboration among team members, conflict resolution, authorship issues, shared resources, data sharing, and mentorship of post-docs and graduate students. The collaboration plan is on the NNA-IRPS web site: https://www.geobotany.uaf.edu/nna/library/NNA-IRPS-Collaboration-Agreement-

DRAFT-Apr-2020.pdf

Project organization and leadership. The project's organization and composition and leadership for the various research and administrative components were defined in the project organization diagram, which is included in the Collaboration Plan: https://www.geobotany.uaf.edu/nna/library/NNA-IRPS-Collaboration-Agreement-DRAFT-Apr-2020.pdf (***Supporting file, Figure 5***).

Activities related to Ice-rich permafrost landscape evolution. Highlights are presented for major project components.

Permafrost component. (a) A synthesis paper regarding cryostratigraphy of the upper permafrost and risk of ice-wedge thermokarst in relation to road infrastructure will be submitted to a Special Issue of *Arctic Science* "Terrestrial Geosystems, Ecosystems and Human Systems in the Fast-Changing Arctic" (see "Other achievements: Kanevskiy et al. *In prep.*"). A conceptual model of various scenarios of IRP change is a key element of the synthesis (***Supporting file, Figure 6***). (b) We are also well along in the development of a synthesis of practice for building roads and airports on permafrost. It should be published this spring. It will include geophysical techniques for determining ice content beneath roadways and villages. (c) Observations from the 2020 field season are summarized in Significant Results.

Vegetation component. (a) New graduate student, Emily Watson-Cook, began her vegetation analysis (classification and ordination) of data from the RIRPO Colleen and Airport sites and visited the field sites during the 2020 field season at Prudhoe Bay. (b) Anja Kade's preparations for the 2021 trace gas flux studies were completed, including custom design of trace-gas analyzer for concurrent data collection of CO2 CH4 and H2O fluxes, temperature, barometric pressure and photosynthetic active radiation. (c) A synthesis paper regarding long-term vegetation and environmental effects of roads is nearling completion and will be submitted to a Special Issue of *Arctic Science* "Terrestrial Geosystems, Ecosystems and Human Systems in the Fast-Changing Arctic" (see "Other achievements: Walker et al. *In prep.*") (***Supporting files: Accomplishments 1, Figure 7***). (d) Another paper regarding the cumulative landscape effects of the Prudhoe Bay Oilfield is in preparation to be submitted to a special issue of *Ecology and Society (see "Other achievements: Papers in preparation").*

Hydrology component. Ronnie Daanen investigated the elevation products that are available in the area for use and how we can approach our hydrological efforts based on the elevation during the 2021 field season. We now have a better idea where research sites are going to be so we can be more targeted in our next efforts.

Modeling component. (a) Setting up ground-temperature monitoring network. We determined several characteristic sites, e.g. undisturbed tundra, thermokarst affected tundra, coastal bluff, gravel pad, and building impact sites. A total of eight sites were preliminary selected in Point Lay (***Supporting file, Figure 8a***). Aerial and satellite data were used to pick appropriate locations for the temperature sensor installations, but the location selection will eventually depend on the community feedback. (b) Assembling of the ground temperature profilers: We purchased and constructed ground temperature profilers for all site installations. The profiler deployment was going to take place this summer but due to the COVID-related travel restrictions it was cancelled. We will explore various alternatives to do in-person visits to advance the field work.
(c) Preliminary assessment of permafrost degradation. Results from our previous research on permafrost for the North Slope region includes end of the century projections of ground temperature for the RCP 8.5 scenario (***Supporting file, Figure 8b)***. Existing maps are being analyzed for the data incompleteness to determine

additional model inputs needed to improve hazard maps.

Remote-sensing component. (a) We ooordinated with the North Slope Borough GIS Department and Alaska DGGS on obtaining recently acquired airborne LiDAR and orthophotography datasets for the Prudhoe Bay Oilfields and Point Lay. (b) We requested the full time series of DigitalGlobe, Inc. imagery available for Point Lay and the Prudhoe Bay Oilfields from the NSF-funded Polar Geospatial Center. (c) We conducted collaborative work with the NSF-funded PermaSense project related to acquisition of microtopographic information and high-resolution multi-spectral data in ice wedge polygonal tundra using a UAV-RTK system. (d) A variety of preliminary remote sensing products were produced for Point Lay and Prudhoe Bay to explore some of the new sensor capabilities for examining permafrost change at a variety of scales (***Supporting file, Figure 9***).

2020 summer field season. Dr. Mikhail Kanevskiy, Dr. Helena Bergstedt, Emily Watson-Cook and Dr. Skip Walker traveled by truck to Prudhoe Bay, 13-20 Aug 2020 and established a field camp at Mile 405 of the Dalton Highway. Accomplishments included: (a) Training and field-site overview for graduate student and post doc; (b) an overview of current conditions along the Dalton Highway including changes since the 1970s; (c) monitored water and thaw depths every meter along eight ≥100-m transects at Jorgenson, Colleen, Airport, and Natural Ice-Rich Permafrost Observatory (NIRPO) sites; (d) examined 9 previously ice-wedge boreholes at the Colleen site to check the current status of ice wedges; (e) reconnaissance of the new NIRPO site; (f) obtained basal peat samples from 5 drained-thaw lake basins in the NIRPO.

Activities related to adaptations to change. (a) Coordination and codevelopment of the NNA-IRPS project and the village of Point Lay were initiated during the 2019 Alaska Federation of Natives Convention in Fairbanks, at a side meeting in the Cold Climate Housing Research Center, 19 Oct 2019. (b) Followup meetings by audio and video conference established a Point Lay Village Liaison, a Village Steering Committee, and an Advisory Group. Remote meetings also advanced a draft collaboration plan with the Native Village of Point Lay to guide codevelopment; planning for a permafrost and infrastructure symposium at Point Lay; education outreach with the Kali School; plans (and then postponement) for a 2020 summer field activities in Point Lay; and coordination with NSF research projects funded to work in Point Lay. (c) Planned and facilitated first annual Advisory Group meeting via Zoom with local and regional stakeholders and codevelopment partners and other projects funded to work in Point Lay. (d) The Cold Climate Housing Research Center (CCHRC) is developing a series of mitigation strategies that will be applied to the housing situation at Point Lay. Toward these goals, CCHRC interviewed 20 individuals with expertise on various permafrost topics and started a list of mitigation strategies that will form the core of a feasibility analysis for Point Lay and could be applied more broadly at Barrow and other villages. CCHRC also reviewed over 130 resources, which are organized into a spreadsheet by geographic region.

Specific Objectives: See "Goals of the Project"

Significant Results: **Significant results from Summer 2020 permafrost observations:**In August 2020, 9 sites with ice wedges were re-examined at Transect 1 (Colleen Site) to check the current status of ice wedges originally sampled in August 2014. While six ice wedges have not experienced significant changes (or have experienced some minor stabilization) since 2014, one ice wedge has experienced significant degradation (detected by deeper ice-wedge trough with water depth >30 cm; this ice wedge was

degrading in both 2014 and 2020, but in 2014 the trough was dry and shallow). Two ice wedges adjacent to the Spine Road that 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. The obtained data show that degradation and stabilization of ice wedges may occur within the same area simultaneously. Similar results were obtained from the adjacent Jorgenson's Site, where 21 sites were re-drilled in July 2019 at the same locations where ice wedges had been either degrading or stabilizing during our studies in 2011 and 2012. Ice wedges, which form continuous network of ice-wedge polygons, are widespread within the Arctic Coastal Plain, Alaska. Volume of ice wedges in this area typically varies from 10 to 30% of the volume of the upper permafrost to a depth of approximately 3 m. Located close to the soil surface, ice wedges are sensitive to climate change and development, and their degradation triggers modification of soil surface, results in thaw settlement, and under certain conditions may lead to formation of thaw lakes. Infrastructure development in areas with ice wedges presents a great engineering and environmental challenge.

Key outcomes or Other achievements:

Data management. (1) Major progress was made on developing the Alaska Arctic Geoecological Atlas (AAGA: https://arcticatlas.geobotany.org) including an archive of plot and map data from Prudhoe Bay and other Arctic Alaska locations that are being used in the landscape evolution portion of our NNA-IRPS project. We are in the process of converting our plot and map data management system (Alaska Arctic Geobotanical Atlas, AAGA, https://arcticatlas.geobotany.org) to a more stable interface. (2) Three key data reports describing the Colleen site, Airport site, and winter investigations and associated data files were submitted to the NSF DataOne archive. One report has received a doi number and the other two are in process:

Walker, D.A. et al., 2015. *Infrastructure-Thermokarst-Soil-Vegetation Interactions at Lake Colleen Site A, Prudhoe Bay, Alaska*, Fairbanks. Available at: WalkerDA2015_agc15_01_datarpt.pdf. doi.org/10.18739/A2M61BQ8M.

Walker, D.A. et al., 2016. *Airport study site, Prudhoe Bay, Alaska, Summer 2015: Road effects data report*, Fairbanks, AK: Alaska Geobotany Center. Available at: https://cn.dataone.org/cn/v2/resolve/urn:uuid:614dcab5-9be8-472e-a13f-6883ae963ba1.

Walker, D.A. et al., 2018. *2016 ArcSEES data report: snow, thaw, temperature, and permafrost borehole data from the Colleen & Airport sites, Prudhoe Bay, and photos of the Quintillion fiber opitic cable impacts, North Slope, Alaska* D. A. Walker et al., eds., Fairbanks: Alaska Geobotany Center. Available at: https://www.geobotany.org/library/pubs/WalkerDA2018_agc18-01_datarpt.pdf.

(3) We are in the process of writing a data report for the 2020 field seaon.

Unpublished presentations at meetings

Connor, B. Alaska vulnerability assessment. Project monthly meeting, 26 June 2020.

Jones, B.M. and Bergstedt, H. Thermokarst lakes and lake drainage on the Arctic Coastal Plain - impact on community drinking water source lake in Pt. Lay. Kali Community/Regional Advisory Group Zoom Meeting, 21 February 2020.

Liljedahl, A. and Daanen, R. NNA-IRPS hydrology. Project monthly meeting, 28 February 2020.

Jones, B.M. What can remote sensing do for you? Overview of image sources and

tools available for NNA-IRPS. NNA-IRPS Kick-Off Meeting, 12-13 November 2019.

Walker, D.A. and Peirce, J.L. Navigating the New Arctic with a focus on ground ice: Landscape evolution and adapting to change in ice-rich permafrost systems, IARPC Permafrost Collaboration Team Meeting, 19 Feb 2020.

Nicolsky, D. Presentation to vegetation map development meeting. 30 July 2020.

Publications in preparation:

M. Kanevskiy, Y. Shur, D.A. Walker, T. *Jorgenson*, M.K. Raynolds, J.L. Peirce, B.M. Jones, M. Buchhorn, G. Matyshak, A. Liljedahl, R. Daanen. *In prep*. Cryostratigraphy of the Upper Permafrost and Risk of Ice-Wedge Thermokarst in Relation to Road Infrastructure, Prudhoe Bay Oilfield, Alaska. *Arctic Science*.

D.A. Walker, D.A. Walker, M.K. Raynolds, M.Z. Kanevskiy, Y. Shur, V.E. Romanovsky, T. Jorgenson, M. Buchhorn, J. Šibík, J.L. Peirce. *In prep.* Long-term vegetation and environmental effects of a road in an ice-wedge polygon landscape. *Arctic Science*.

D.A. Walker, M.K. Raynolds, M.Z. Kanevskiy, Y. Shur, T. Jorgenson, B. Connor, B.M. Jones, A. Liljedahl, V.E. Romanovsky, G. Kofinas, J.L. Peirce, K.J. Ambrosius, M. Buchhorn, T. Kumpula, B.C. Forbes, M.O. Leibman, A. Khomutov, W. F. Vincent, M. Allard, P. P. Schweitzer, A. Bartsch, N. I. Shiklomanov, D. A. Streletskiy, G. Grosse, J. Brown, P.J. Webber *In prep*. Cumulative landscape impacts of infrastructure and climate change in ice-rich-permafrost regions. *Ecology and Society*.

Meetings and talks

- "Bridging Science, Art, and Community in the New Arctic Workshop", U. Virginia (in person, talks by Liljedahl and Walker, 23–25 Sep 2019
- Reception for Point Lay participants at Alaska Federation of Natives (AFN) Convention (in person CCHRC, 19 Oct 2019)
- NNA-IRPS Project Kickoff Meeting (in person, UAF, 12 Nov 2019)
- Monthly Project Meeting on data flow (in person, UAF, 4 Dec 2019)
- Meeting with PIs and CoPIs from other NSF-funded projects working in Point Lay (Zoom, 17 Dec 2019)
- RATIC T-MOSAiC infrastructure Action Group meeting (Zoom, 18 Dec 2019)
- NNA National Coordination Meeting (Zoom, 19 Dec 2019)
- Remote sensing coordination meeting (in person, 16 Jan 2020)
- Collaboration Plan Meetings (in person, 17 & 24 Jan 2020)
- Alaska Native Science and Engineering Program (ANSEP) undergraduate recruiting presentation and meeting (in person, UAF, 4 Feb 2020)
- IARPC Permafrost Working group meeting (Zoom, 19 Feb 2020)
- Soup and Science project meeting (Helena Bergsted talk, 14 Feb 2020)
- Kali Community Advisory Group Meeting (Zoom, 21 Feb 2020
- Pt. Lay Summer field trip meeting (Zoom, 11 Mar 2020)
- T-MOSAIC initiative update meeting (Zoom 26 Mar 2020)
- Vegetation team meeting (Zoom, 13 Apr 2020)
- Summer logistics planning (Zoom, 15 Apr 2020)
- NNA online investigators meeting (Zoom, 16 Apr 2020)
- Summer logisitcs planning with CPS (Zoom, 29 Apr 2020
- Revised summer field work and outreach logistics meeting with CPS (Zoom, 1 May 2020)
- EGU General Assemby 2020 meeting, presentation by Helena Bergstedt (On line, 4–8 May 2020)

- Collaboration plan with TRIBN and North Slope Borough (Zoom, 26 May 2020)
- Project monthly meeting, Walker talk, revisiting the big picture (Zoom, 29 May 2020)
- Vegetation team meeting (Zoom, 12 Jun 2020)
- T-MOSAiC Infrastructure Action Group meeting (Zoom, 20 Jun 2020)
- Project monthly meeting, Connor Talk (in per person, 26 Jun 2020)
- Remote sensing coordination meetng (in person, 8 July 2020)
- Prudhoe Bay and Dalton Highway field work planning meeting (Zoom, 21 July 2020)
- Meeting with UIC Science to coordinate educational outreach with Kali School: "UIC Sci/NNA-IRPS Educational Outreach discussion (Zoom, 27 July 2020)

Other activities

- Recruited one post doc, Dr. Helena Bergsted, and one graduate student, Emily Watson-Cook.
- Coordinated with Hillcorp Alaska LLC., the new managers of the Prudhoe Bay Oilfield, to continue working at our established and proposed research sites within the PBO.
- Applied for and obtained permits and permission from the North Slope Borough. We are currently working with State DNR and Army Corps of Engineers to obtain necessary permits for field work in 2021–2024.
- Developed cross-project collaboration with Melissa Ward Jones, who is applying for an early-career NASA award.
- Four members of the project (Walker, Kanevskiy, Bergstedt, and Watson-Cook) completed COVID self quarantine and testing in preparation for summer field work (27 Jun – 7 Aug 2020).
- Major progress has been made with codevelopment of "Adaptations to Change" research with the community of Point Lay in preparation for when we are able to go to community.
- Previous research conducted during the ArcSEES "Cumulative effects of Arctic Oil development — planning and designing for sustainability" project is being summarized in two papers (Kanevskiy et al. *In prep.* and Walker et al. *In prep. Cited above)* will be submitted to a Special Issue of *Arctic Science "Terrestrial geosystems, ecosystems and human systems in the fast-changing Arctic"*

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

- We recruited a new Post-doc researcher, Helena Bergsted from the University of Vienna, who is working with Dr. Ben Jones and Skip Walker on applications of remote sensing, especially high-resolution multispectral imagery, Lidar, and SARS to issues related to ecosystem response to infrastructure.
- We recruited a new M.S. graduate student, Emily Watson-Cook, who is developing a thesis related to vegetation response to roads.
- We are in the process of recruiting two undergraduate researchers who will help with the Trace Gas monitoring (Kade) and several aspects of the field work associated with the "Landscape Evolution" portions of the project.
- CCHRC recruited and employed one research intern, Alaina Bankston, to work on the project in the spring 2020 semester. She graduated in May 2020 with a Bachelor's degree in Natural Resources Management.
- Over summer 2020, CCHRC recruited three additional research interns, all of whom are working on the literature and interview review process and will help with the feasibility analysis. Two are UAF students (majoring in math and Arctic Studies) and one is an individual exploring the possibility of returning to school.

*** How have the results been disseminated to communities of interest?**

Education and outreach. (a) Several websites have been created for the project and related activities such as RATIC and T-MOSAiC, and the Alaska Arctic Geoecological Atlas**.**

- NNA-IRPS: https://www.geobotany.uaf.edu/nna/
- Rapid Arctic Transitions due to Infrastructure and Climate (RATIC): https://www.geobotany.uaf.edu/ratic/

- T-MOSAiC Infrastructure Action Group: https://www.t-mosaic.com/infrastructure.html
- ArcSEES: Cumulative effects of Arctic Oil development — planning and designing for sustainability: https://www.geobotany.uaf.edu/arcsees/
- Alaska Arctic Geoecological Atlas: https://arcticatlas.geobotany.org

(b) Walker and Peirce made an undergraduate recruiting presentation and met with students at the Alaska Native Science and Engineering Program (ANSEP), 4 Sep 2019. (c) We are currently working with the Kali School at Point Lay and the North Slope Borough to develop an education component that involves students at Point Lay, and will try again to recruit ANSEP students in 2021.

Because of COVID, we were unable to recruit undergraduate students in 2020. The planned 2020 summer field course was also canceled.

International outreach (RATIC and T-MOSAiC). The international outreach component of the project is the IASC Rapid Arctic Transitions due to Infrastructure and Climate (RATIC) initiative is organized under the Terrestrial Working Group of the International Arctic Science Committee (IASC). The goals are to promote data sharing, adaptive approaches to understand system changes due to infrastructure. RATIC has been incorporated as the Infrastructure Action Group of T-MOSAiC (Terrestrial Multidisciplinary distribute Observatories for the Study of Arctic Connections), another initiative of IASC that is addressing terrestrial-related issues during the transit of the German icebreaker *Polarstern* across the Arctic Ocean during 2019–2020. Planning for RATIC and T-MOSAiC Zoom meetings were conducted on 13 Apr & 20 Jun 2020.

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

- Final publication of two papers in preparation for *Arctic Science* Special Issue (see significant results
- Draft of Cumulative effects paper for *Ecology and Society*
- Feasibility analysis for adaptation strategies for Point Lay infrastructure.
- Visit Point Lay and formalize plan for collaborative research
- Participation in the "Northern Roads and Railways: Social and Environmental Effects of Transport Infrastructure" Special Session for Arctic Science Summit Week 2021 (Lisbon)
- Development of "road dust impacts" section of the Landscape Evolution component
- Completion of the Arctic Alaska Geoecological Atlas including the ArcGIS Online user interface
- AGC Data Report of the data collected during the 2020 field season
- 2020 Field Season: Establish NIRPO research sites, complete vegetation studies of WC M.S. Thesis

Supporting Files

Filename	Description	Uploaded By	Uploaded On
Goals and Accomplishments Fig. 1 thru 9.pdf	Goal and Accomplishments Figures 1 thru 9.	Donald Walker	08/31/2020

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, 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 = OTHER.

Schneider von Deimling, H. Lee, H, T. Ingeman-Nielsen, S. Westermann, V. Romanovsky, S. Lamoureaux, D.A. Walker, S. Chadburn, L. Cai, E. Trochim, J. Nitzbon, S Jacobi, M. Langer. 2020 in press. Consequences of permafrost degradation for Arctic infrastructure - bridging the model gap between regional and engineering scales. The Cryosphere.. Status = OTHER.

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 = OTHER.

Licenses

Other Conference Presentations / Papers

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. https://doi.org/10.5194/egusphere-egu2020-11919*. EGU General Assemby 2020. Vienna. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Other Products

Other Publications

Patents

Technologies or Techniques

Thesis/Dissertations

Websites

Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Walker, Donald	PD/PI	4
Kofinas, Gary	Co PD/PI	1
Liljedahl, Anna	Co PD/PI	0
Romanovsky, Vladimir	Co PD/PI	1
Shur, Yuri	Co PD/PI	1
Breen, Amy	Co-Investigator	1
Connor, Billy	Co-Investigator	1
Jones, Ben	Co-Investigator	1

Kade, Anja	Co-Investigator	2
Kanevskiy, Mikhael	Co-Investigator	2
Nicolsky, Dmitry	Co-Investigator	1
Peirce, Jana	Co-Investigator	5
Bergstedt, Helena	Postdoctoral (scholar, fellow or other postdoctoral position)	3
Druckenmiller, Lisa	Technician	3
Raynolds, Martha	Technician	1
Daanen, Ronald	Consultant	0

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: 4

Contribution to the Project: PI, Project direction, Vegetation component direction

Funding Support: This grant, and UAF, IAB institute support

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: Co PI, Human dimension adaptations to change

Funding Support: This grant

International Collaboration: No
International Travel: No

Anna Liljedahl
Email: aliljedahl@whrc.org
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 0

Contribution to the Project: Co-PI, hydrology component, collaboration with Permafrost Gateway project

Funding Support: This grant and Woodwell Climate Research Center

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: co-PI, climate and permafrost component

Funding Support: This grant and UAF Geophysical Institute

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: co-PI, permafrost component, landscape evolution

Funding Support: This grant and UAF Institute of Northern Engineering

International Collaboration: No
International Travel: No

Amy Breen
Email: albreen@alaska.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

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: 1

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: 1

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: 2

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: 5

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: 3

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

Lisa Druckenmiller
Email: ladruckenmiller@alaska.edu
Most Senior Project Role: Technician
Nearest Person Month Worked: 3

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

Ronald Daanen
Email: "Daanen, Ronald P (DNR)"
Most Senior Project Role: Consultant
Nearest Person Month Worked: 0

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
Cold Climate Housing Research Center	Other Nonprofits	Fairbanks, AK

Full details of organizations that have been involved as partners:

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

What other collaborators or contacts have been involved?

Jozef Sibik, University of Bratislava and Slovak Republic Academy of Science: Consultant and collaborator on vegetation component for data analysis and vegetation classification.

Impacts

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

The project has had a major impact on the emphasis that is being placed on scientific analysis of cumulative effects of infrastructure and climate change at the national and international level. The Navigating the New Arctic (NNA initiative and this project have greatly expanded the focus on infrastructure within the U.S. Arctic scientific community. This is also demonstrated at the international level where our Rapid Arctic Transitions due to Infrastructure and Climate (RATIC) initiative now forms the core of IASC T-MOSAiC Infrastructure Action Group, which is observing and monitoring consequences to the built environment to Arctic social ecological systems and developing an Arctic infrastructure observing network.

What is the impact on other disciplines?

The very nature of NNA requires a high level of interdisciplinary collaboration. Our NNA project has internationally known permafrost, hydrology, vegetation, remote sensing, and social scientists that are regularly making major contributions to their respective fields. This is also illustrated by the project's impact at the international level by the cross disciplinary activities of the IASC RATIC project, which involves numerous investigators from Terrestrial, Social and Human, Cryosphere Working groups.

What is the impact on the development of human resources?

Nothing to report.

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.

Changes/Problems

Changes in approach and reason for change

- **Work in the village of Point Lay.** CCHRC had hoped that members of the Point Lay community would have been able to provide input to the housing issues thus far, but due to current COVID travel restrictions that has not been possible. We had hoped to visit the village of Point Lay in 2020 to begin a collaborative research program there related to addressing their housing and infrastructure problems caused by degrading permafrost. We are continuing dialogue via Zoom meetings with the village leadership, the school administration and teachers, and with UIC and plan to hold in person meetings as soon as travel restrictions to the village are lifted. We are doing an initial feasibility analysis of mitigation strategies this fall, so that it is ready for input from Point Lay and TNHA when restrictions are lifted.
- **Summer field course.** The summer field course of the education component had to be cancelled because of COVID. We are thinking of moving toward an education component with more direct involvement of the Kali School at Point Lay. We have had two online meetings with Kaari Erickson of UIC to discuss the possibilities.
- **Conversion of data management system.** We are in the process of converting our plot and map data management system (Alaska Arctic Geobotanical Atlas, AAGA, https://arcticatlas.geobotany.org) to a more stable interface. This was an emergency unanticipated cost that was needed because the Geographic Information Network of Alaska (GINA, UAF), which currently houses the AAGA, no longer supports gLynx.

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

1. **COVID-related issues**. COVID has had major impacts to the project including: (a) The PI contracted COVID-19 and was able to work at a much reduced pace for 3 months. (b) Progress on the project was and still is greatly hampered by the University Lockdown and limited access to university facilities. It also affects the work schedules of project participants and adminstrative staff resulting in delayed progress on two major publications and other activities associated with the project. (c) Planning for the field season took enormous energy and several plans had to be scrapped due to numerous changes in COVID restrictions and policies of the CDC, State of Alaska, and UAF. COVID prevented participation of several members of the project in the 2020 field season, and also created numerous logistic problems associated with a much reduced length and scope for the field season, including the necessity to use personal vehicles because of limited number of people allowed in the vehicles, no access to Toolik Lake Field Station and lodging facllities at Prudhoe Bay. This made it necessary to establish field camps. (d) A much reduced field season in 2020 will cause major changes to plans for the 2021 field season, We are currently reviewing the plans for 2021 field season and will likely develop two plans: one which assumes that we will be able to use oilfield camp facilities for lodging and meals, and one where conditions will be similar to this past summer.Nonetheless, we have worked overtime to try to stay on schedule during the first year and successfully completed a 10-day field season that provided essential training and experience for the the post-doc and graduate student on the project. It also provided a reconnaissance of a planned new remote research area near Deadhorse — all of which will help us plan for next summer.

2. **Conversion of data management system.** We completed conversion of the plot archive data management system from gLynx to CKAN (Comprehensive Kerbal Archive Network) under a no-cost extension of our NSF ArcSEES grant (award no.1263854). CKAN is a widely used open-source cataloging system, and the conversion to CKAN will make the data catalog and user interface more stable and more portable for long-term security of the data. We are not in the process of converting the map archive to an ArcGIS Online interface that will make the data much easier to view and download. This work was initiated under a no-cost extension of our previous NSF ArcSEES Award and is continuing with some support from the NNA award.

Changes that have a significant impact on expenditures

1. **COVID-related issues**. The inability of several members of the project to participate in the 2020 field season because of mandatory COVID restrictions including a 14-day self quarantine will mean that much of the initial familiarization with the field conditions will be done next year and could increase the total logistic costs for the project. We are currently developing plans for an expanded 2021 field season. The delays related to COVID could necissitate a no-cost extension to complete the work depending on progress in the next four years.
2. **Conversion of data management system.** We estimate that approximately $70K is needed to complete the conversion of our Alaska Arctic Geoecological Atlas data management system, which includes critical archives of plot and map data for the NNA-IRPS project, to CKAN catalog and ArcGIS Online viewing interface. We are hoping to partially cover the above expenses with carry-over funds remaining in a a no-cost extension from our earlier NSF ArcSEES award (no. 1263854), and some delayed spending on the current NNA-IRPS award because of COVID-related reasons. Any additional costs due to conversion of our data management system will need to be addressed when we have a better picture of our year-1 total expenditures.
3. **Possible unanticipated field-logistics costs for 2021**: We are anticipating the need for helicopter support to move necessary field equipment to our new remote field site which is 2 km from the nearest road in the Prudhoe Bay Oilfield. Equipment that will need to be transported will include climate, permafrost, and hydrology monitoring instruments, permafrost coring instruments, and trace-gas flux instrumentation. We are also anticipating the need for a fly camp at the NIRPO site for short 24-hour monitoring of trace-gas fluxes at the NIRPO site.

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.

Special Requirements

Responses to any special reporting requirements specified in the award terms and conditions, as well as any award specific reporting requirements.

Figure 1. NNA-IRPS Conceptual diagram

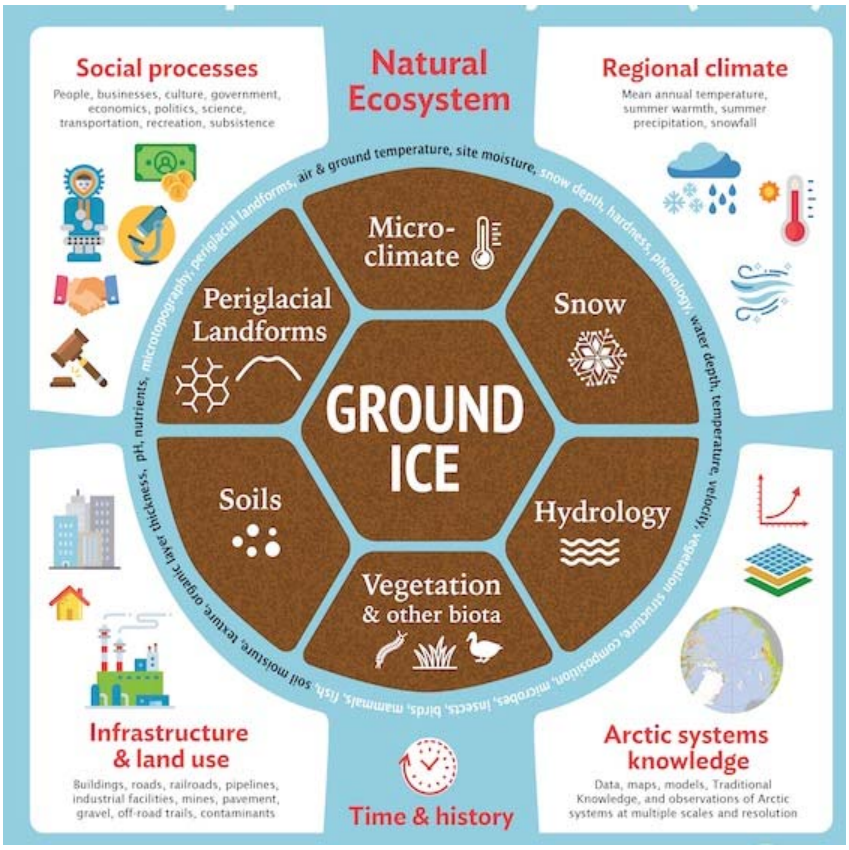


Figure 2. Location of research sites for the Roadside Ice-Rich Permafrost Observatory (RIRPO) and the Natural Ice-Rich Permafrost Observatory (NIRPO) in the Prudhoe Bay Oilfield.

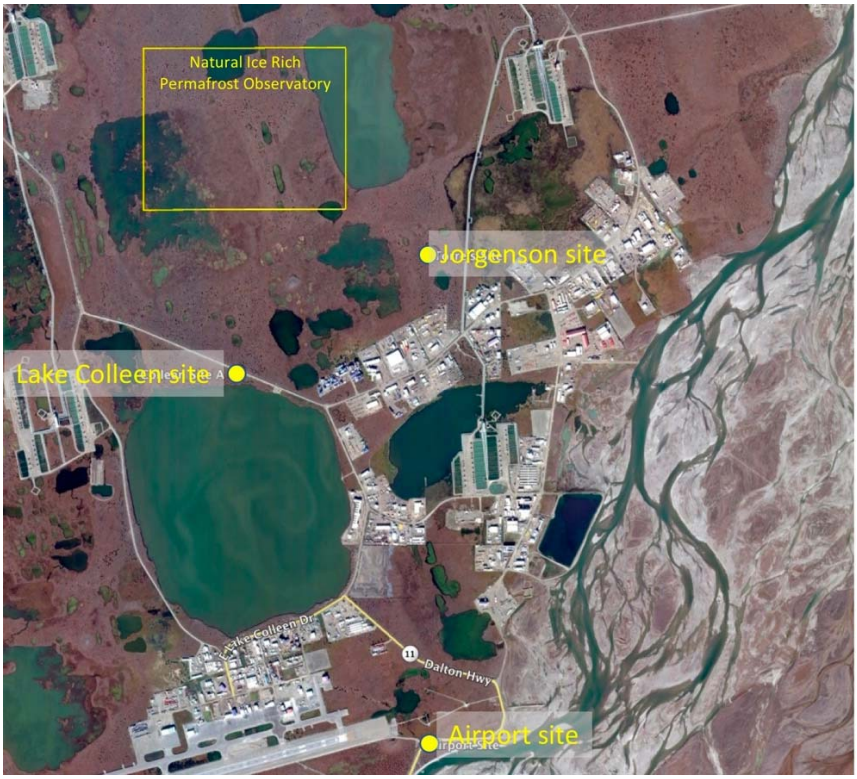
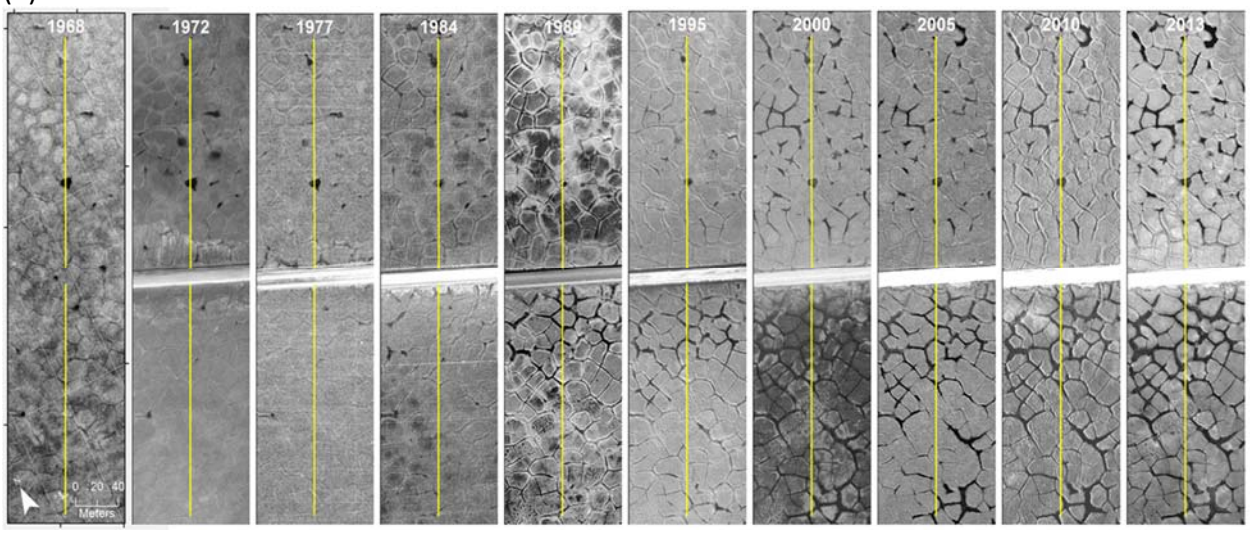


Figure 3. (a) Historical thermokarst development along the main Spine Road in the Prudhoe Bay oilfield (1968–2013). The 1968 photo shows conditions that existed prior to development with little change between date of the first aerial photographs by the U.S. Navy in 1949 (not shown) and 1968. The yellow line is the location of 200-m microtopography transects T1 (NE side of the road) and T2 (SE side of the road). (b) Microtopographic survey of Transect T1, showing transitions in patterned-ground relief feature, vegetation, thaw depth, thickness of dust layer, and leaf area index (LAI). Data are from Walker et al. *in prep.*

(a)



(b)

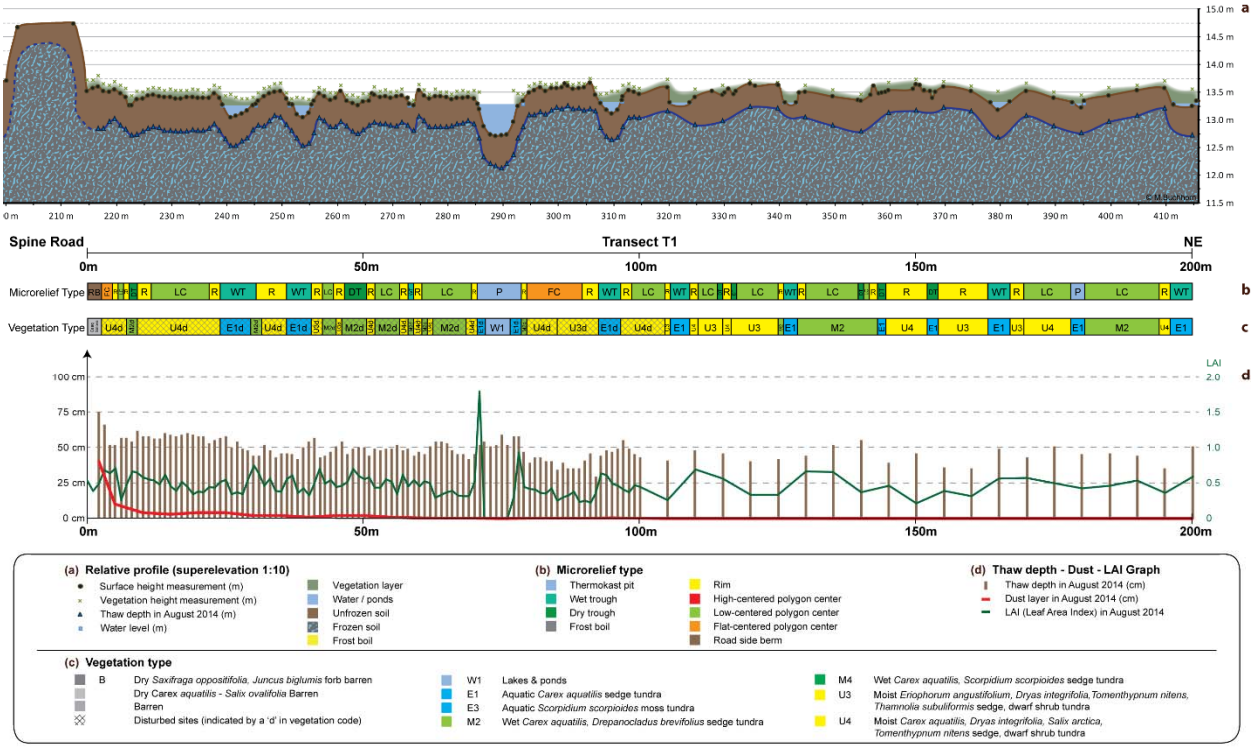


Figure 4. Subsiding ground beneath Point Lay house. In late 1980s, the base of the steps was at ground level and there was no thermokarst. Photo: Courtesy of CCHRC.

"The effects of warming temperatures, more rain, wetter snow, longer summers, erosion and subsidence have taken a toll on the community of Point Lay especially in the past ten years. We have lost our fresh water source due to erosion. Streets, gravel pads, foundations and pilings are failing and anything sitting directly on the ground is sinking and tilting such as fuel tanks, water tanks, sewage holding tanks, stairways and ramps into our homes are failing. The longer we do nothing to correct, slow down and or stop these conditions the problem only gets worse."
Bill Tracy, Sr.
NSB Assembly member from Point Lay, October 8, 2019

Figure 5. NNA-IRPS project organization.

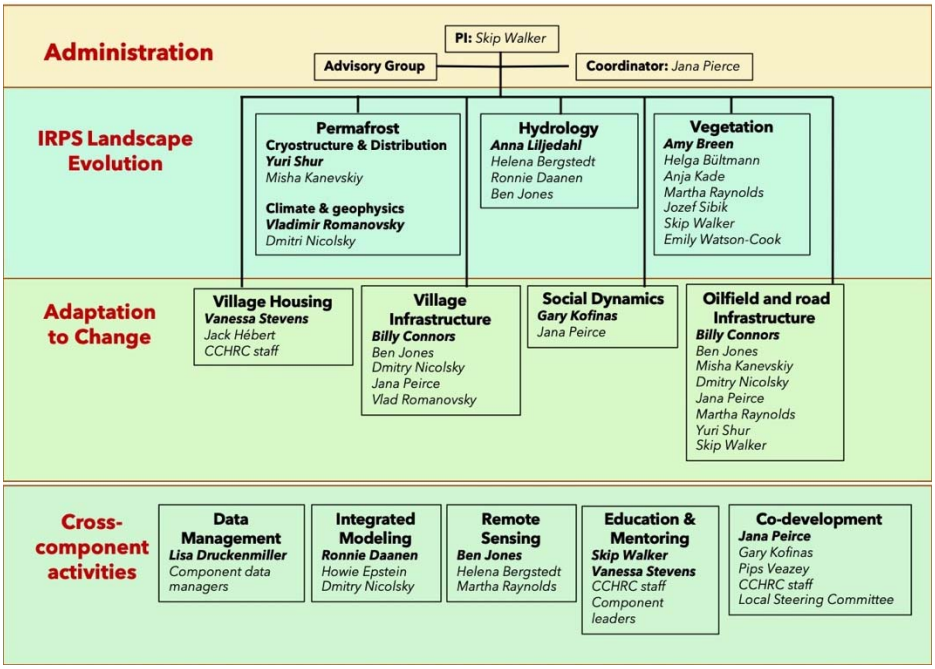


Figure 6. Permafrost characterization and evolution.

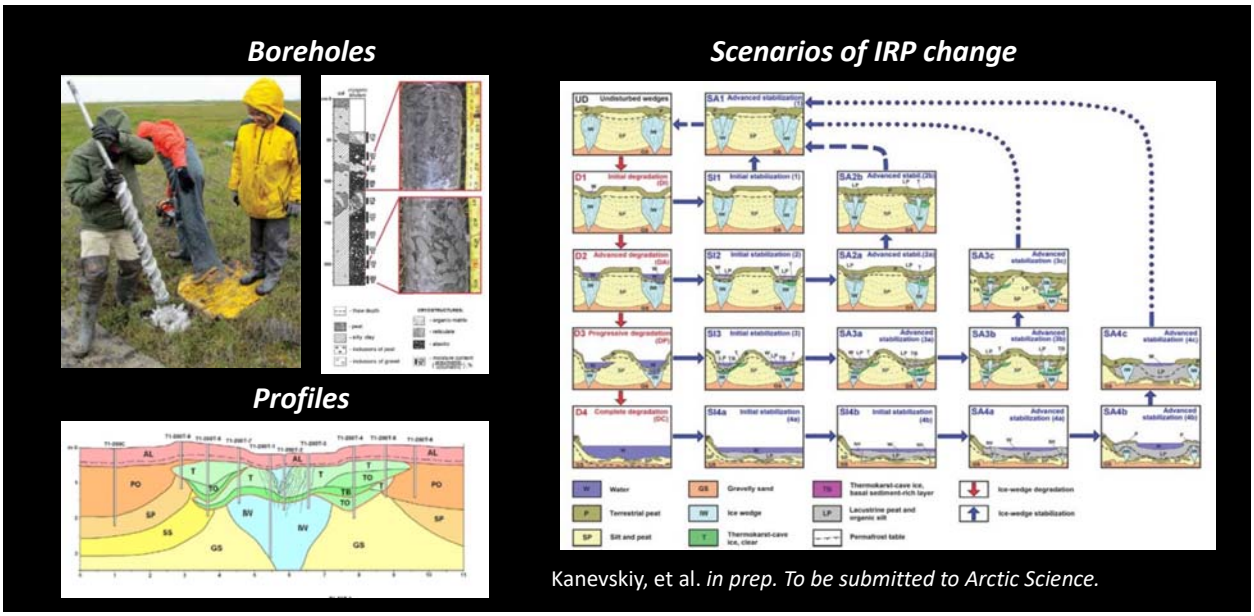


Figure 7. Vegetation change at Colleen site. (a) Ordination of the Colleen plots sampled in 2014 in relationship to plots in comparable undisturbed moist, wet, and aquatic tundra sampled in 1974–1975 (Walker 1985). (b) Directions of change of clusters of Colleen plots sampled in 2014 in relation to comparable cluster of plots sampled in the 1970s. Arrows indicate the primary direction of environmental change for plots sampled in 2014 compared to the 1970s in reference to red arrows in (a). (Walker et al. in prep., to be submitted to *Arctic Science*).

(a) (b)

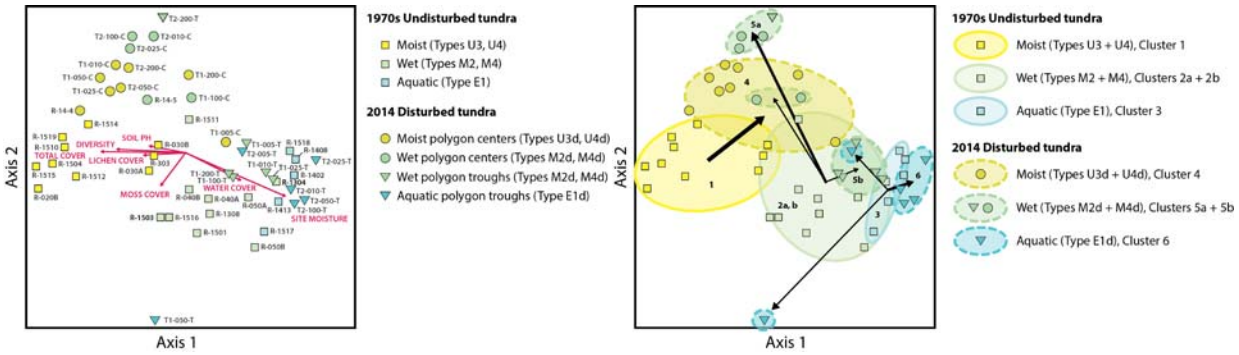


Figure 8. Modeling component activities. (a) Preliminary selection of permafrost monitoring sites at Pt. Lay for modeling component. (b) Preliminary modeling of ground temperatures at Pt. Lay.

(a)

(b)

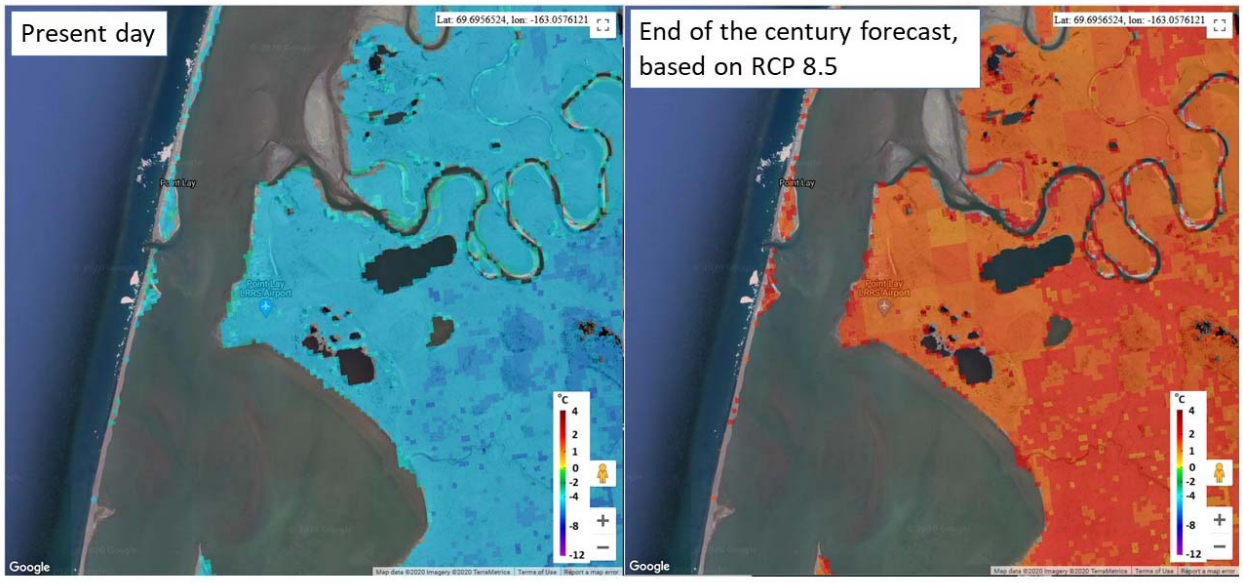
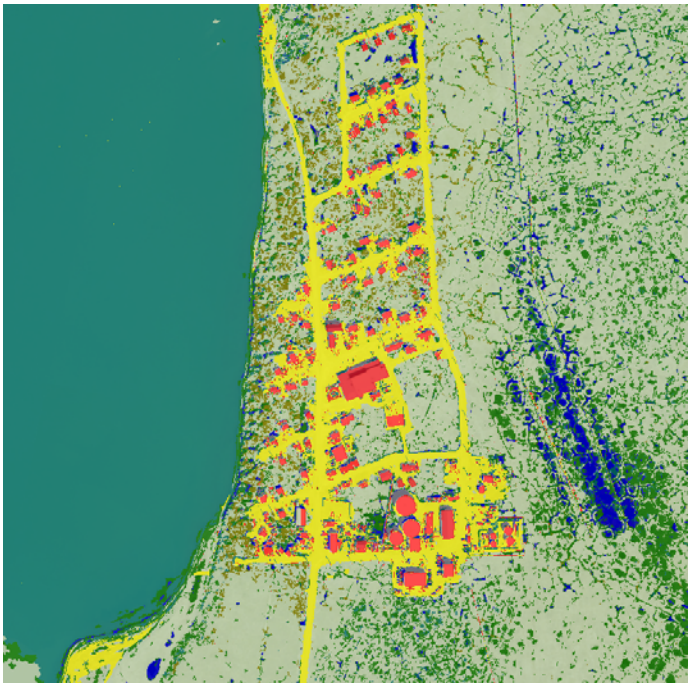
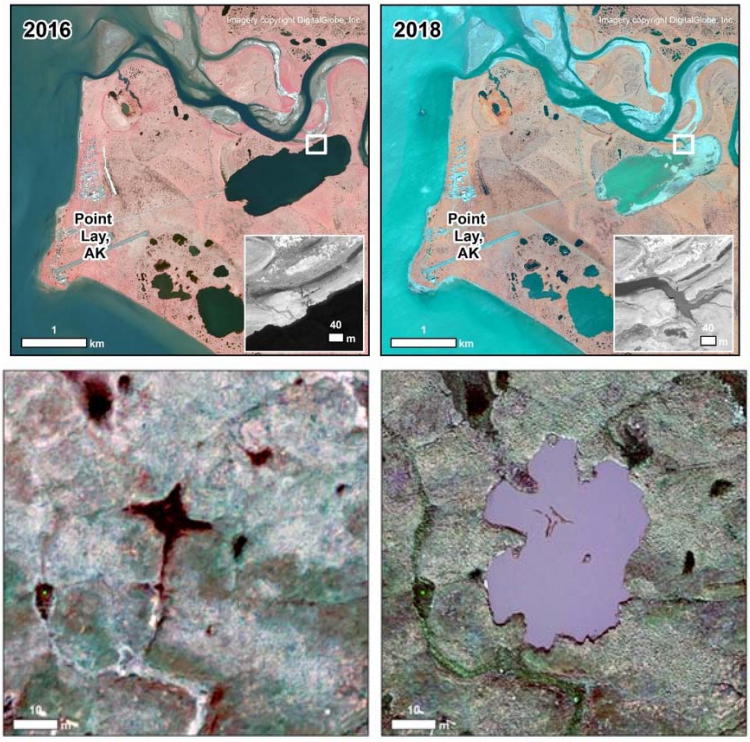


Figure 9. Preliminary Remote Sensing components results.

(a) Preliminary landcover classification for Point Lay based on OBIA and Machine Learning classification algorithm.

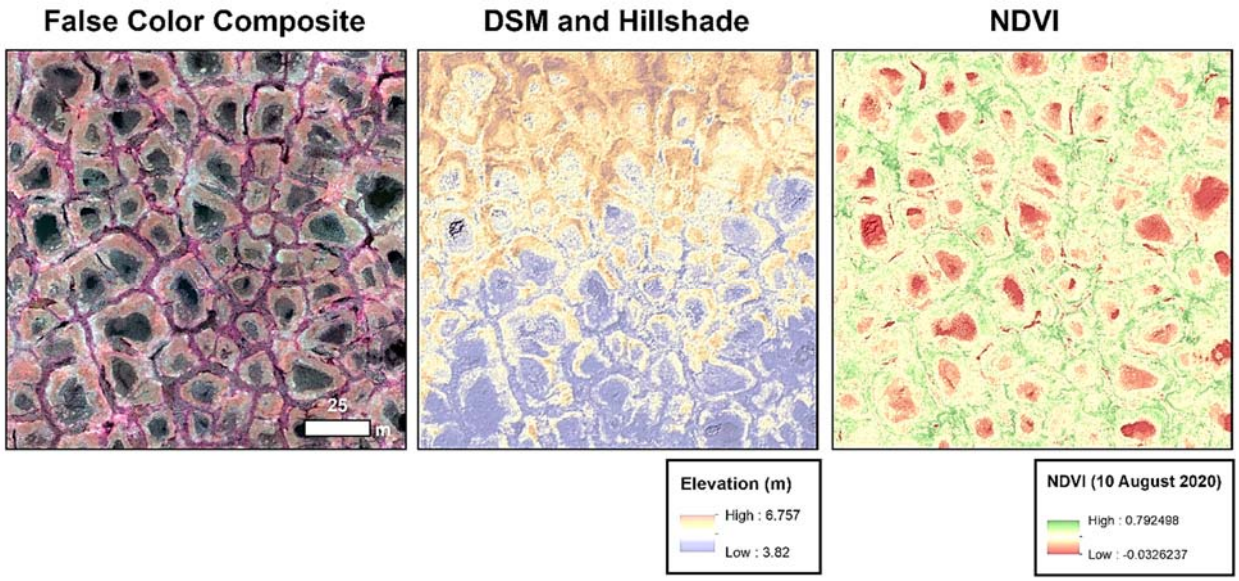


(b) DigitalGlobe imagery time series showing drainage of the drinking water source lake in Pt. Lay.

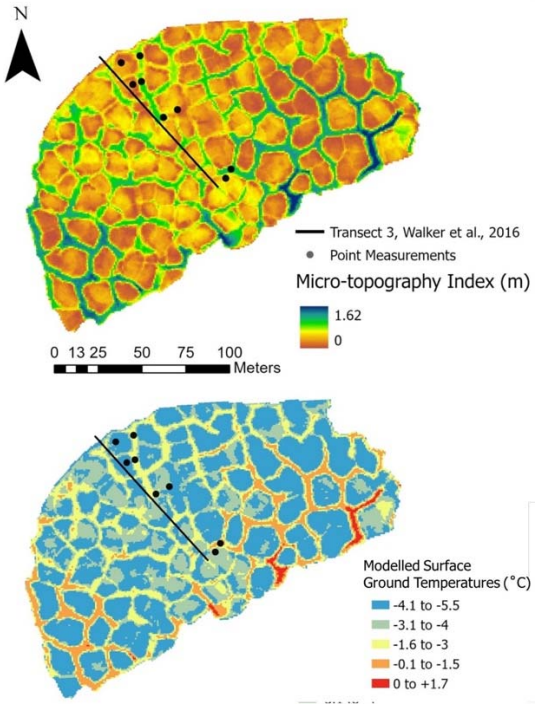


(c) Tracking thermokarst pond development in ice-rich permafrost near Pt. Lay, Alaska. The upper image is from 2017 and the lower image is from 2 019.

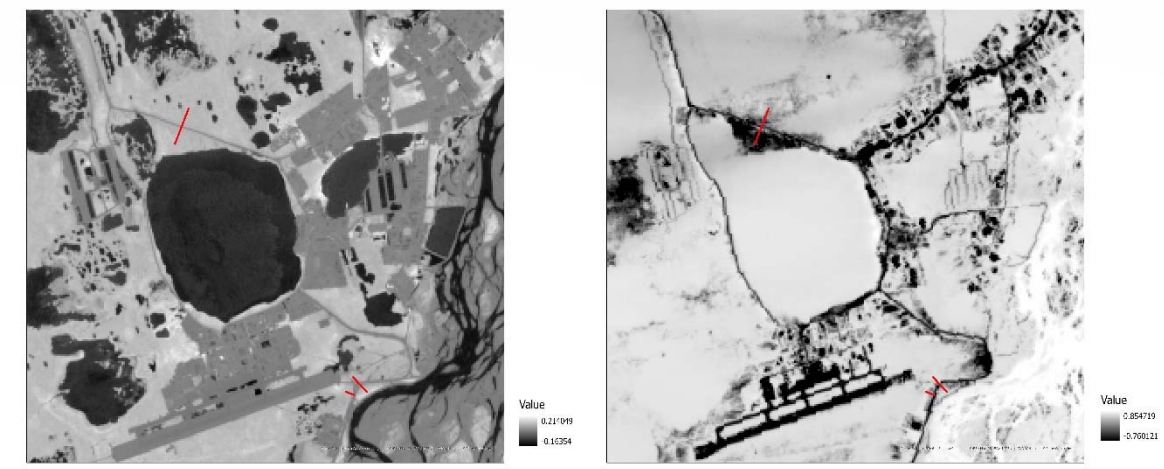
(d) UAV-RTK multispectral data acquired on 10 August 2020 in ice-rich permafrost system in collaboration with PermaSense project. This system will be used to acquire time-series imagery for NNA-IRPS sites during planned 2021 field season.



(e) Estimating near-surface ground temperatures using a microtopography index derived from airborne lidar data and ground temperatures acquired under the ArcSEEs project. Linkage between NNA-IRPS, PermaSense, and M.K. Ward Jones NASA early career award proposal.



(f) examples of Sentinel-2 based NDVI (Normalized Difference Vegetation Index) and NDSI (Normalized Difference Snow Index) for the Prudhoe Bay area. Time series of NDVI and NDSI (among other data) will be used to assess spatial and temporal distributions and impacts of road dust. Colleen and Airport transects are in red.



(g) Preliminary results for classification of drained lake basins (yellow), surface water (blue) and residual/older surfaces (green) in the area of Point Lay.