Cover

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Project Title:	Cumulative Effects of Arctic Oil Development - planning and designing for sustainability
PD/PI Name:	Donald A Walker, Principal Investigator Gary P Kofinas, Co-Principal Investigator Yuri L Shur, Co-Principal Investigator
Recipient Organization:	University of Alaska Fairbanks Campus
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Submitting Official (if other than PD\PI):	Donald A Walker Principal Investigator
Submission Date:	08/31/2016
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?**

Cumulative Effects of Arctic Oil Development -- Planning and Designing for Sustainability

Goals of the Project:

Developing arctic oil & gas resources requires extensive networks of roads, pipelines and other forms of infrastructure. The cumulative environmental and social effects of expanding developments are difficult to assess and impossible to predict — especially in the face of rapid climate change and unpredictable politics, oil markets, and social and economic changes. Previous analyses of the cumulative effects (CE) of oil and gas development in northern Alaska have recommended comprehensive adaptive planning approaches to 1) minimize the spread of infrastructure across land that is used by indigenous people for subsistence, and 2) reduce the indirect effects of infrastructure that result in the thawing of ice-rich permafrost. A sustainable approach to CE requires collaboration between indigenous people, industry, and scientists from a broad spectrum of disciplines to address these infrastructure-related concerns. This project does that with detailed ground studies, local community input, industry involvement and an international perspective. A project has three major components:

1) Case study of the cumulative effects of industrial infrastructure at Prudhoe Bay, Alaska. This component focuses on infrastructure-related effects associated with gravel mines, roads and other areas of gravel placement. The study includes ground-based studies, an examination of infrastructure and landscape change at multiple scales, and a human dimension component that includes evaluation of adaptive management planning for infrastructure in northern Alaska and CE studies associated with the Iñupiat village of Nuiqsut. The study is developing a process-based understanding of infrastructure-related permafrost/ landform/ vegetation succession in terrain undergoing thermokarst formation (the development of highly eroded landforms that result from the thawing of ice-rich permafrost). The study will help to answer the questions “What will these areas look like in 50-100 years?” and “Can adaptive management methods address the complex issues related to placement, usage and decommissioning of infrastructure in Northern Alaska?”

2) Arctic Infrastructure Action Group: Rapid Arctic Transitions due to Infrastructure and Climate (RATIC). The goal of RATIC is to bring cumulative-effects-of-infrastructure issues to greater prominence within the international Arctic research community and encourage research on the joint effects of climate change and expanding infrastructure in the Arctic. The initiative was developed during the Climate Change 2014 Conference in Ottawa and the Third International Conference on

Arctic Research Planning (ICARP III) in Yohama, Japan. RATIC consists of permafrost scientists, ecologists, hydrologists, engineers, social scientists and educators seeking to develop adaptive management strategies that address the unique issues related to networks of infrastructure in arctic permafrost environments.

3) Education/outreach component. A new field course is training students in arctic system science and introducing them to the issues of industrial development and adaptive management approaches. The 21-day course includes a 16-day expedition along the Elliott and Dalton highways in Alaska. The course includes a visit to Minto, an Athabascan village on the Tolovana River; Wiseman, an old mining community along the Dalton Highway; and the Prudhoe Bay Oilfield, where they learn firsthand about the issues with oilfield infrastructure, its impacts and the oil industry's ecological monitoring and vegetation rehabilitation practices.

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

Major Activities:

1. Analysis of historical changes o infrastructure, landscapes and vegetation in the Prudhoe Bay Oilfield. We published two key papers describing the historical trends of infrastructure- and climate-related changes in northern Alaska: T

The first paper, published in *Global Change Biology* (Raynolds et al. 2014), documented the cumulative geoecological effects of 62 years (1949–2011) of infrastructure- and climate-related changes in the Prudhoe Bay Oilfield, the oldest and most extensive industrial complex in the Arctic, and an area with extensive ice-rich permafrost that is extraordinarily sensitive to climate change.

The second paper, published in *Environmental Research Letters* (Raynolds et al. 2016), used Landsat TM and ETM+ data between 1985 and 2011 to examine trends in the Normalized Difference Vegetation Index (NDVI) and tasseled-cap transformation indices, and related them to high-resolution aerial photographs, ground studies, and vegetation maps.

2. Ground-level investigation of changes associated with intensive thermokarst along roads. We conducted field studies adjacent to two of the oldest and most heavily traveled roads in the Prudhoe Bay region, the Spine Road (Lake Colleen Site A) and the Dalton Highway (Airport Site) during four field campaigns, 1-15 Aug 2014, 3-15 Jul 2015, 26 Mar-1 Apr 2016, and 15-19 Aug 2016. These included two midsummer campaigns to establish field plots and transects on both sides of the roads to measure vegetation, soil, microtopography, water, and permafrost characteristics. A late winter campaign measured and described snow along both transects, and a late summer campaign collected iButton® temperature loggers and measured active layer and water depths along the road transects. The results of the field studies are being published in three data reports (Walker et al. 2015, 2016 in prep., 2017 in prep.), conference presentations (Shur et al. 2016, Kanevskiy et al. 2016, Walker et al. 2016) and several papers in preparation (Kanevskiy et al. in prep., Walker et al. in prep.)

3. Human dimensions studies. Interviews of local people and industry personnel are being used to determine their perceptions of change, implications to their livelihoods, and assessment of adaptive management for infrastructure in Northern Alaska. Fifteen BP Exploration Alaska, Inc. staff were interviewed in September and December, 2015, to document oil industry perspective on cumulative effects management of North Slope of Alaska oil fields. Respondents' roles are primarily focused on environmental management. Interviews took place in Anchorage Alaska, lasting 45 minutes to one and a half hours. Respondents were asked to report on their criteria of successful management of the environmental conditions in North Slope oil development, the challenges associated with development, BP's approaches to environmental adaptive management, and cumulative effects. Respondents commented on specific issues, such as thawing permafrost and ecosystem fragmentation, and evaluated their professional relationship with agencies and academic researchers. Industry staff interviews are the first of three groups to be included in the study. We are now

analyzing the results of interviews with industry staff people and all results at this point are preliminary. Respondents reported that major challenges to environmental management on the North Slope of Alaska included balancing cost with sound environmental management, aging infrastructure, and increasing complexity of the regulatory environment. BP staffers did not commonly reference the terms “cumulative effects” and “adaptive management”, now used extensively in the academic literature of resilience theory and adaptive governance. However, respondents did report many examples of “learning by doing” through on-going monitoring activities and long-time experience. They also noted that BP has instituted company policies that are similar to adaptive management principles. Examples of learning by doing included improved methods for habitat remediation, and improvements to drilling technology leading to a smaller operating footprint. Respondents also noted that the motivation to try new approaches was often driven by opportunities for cost savings. Most said that there is currently little collaboration between industry and academia and while some respondents had strong feelings that there should be more collaboration, others did not see a value in it, given the groups’ different interests. Respondents also mentioned that their interactions with agencies were mostly related to regulation. As well they reported that there was not much collaboration with competitors (i.e., other large oil companies). Some people felt research initiatives would be more productive if there was. We also interviewed 28 residents of Nuiqsut, documenting their perceptions of environmental change in their homeland on the central North Slope of Alaska, including aspects of oil development and climate change. Interviews asked residents if change had occurred in specific areas and if so, how change had occurred. We also asked how changes were occurring, if they were affected livelihoods and where and or how they had received information on the change. Most interviews were completed as face-to-face questioning, using a recorder and a touch screen map to capture spatial data on local knowledge. We also distributed a mail-out survey to add to our sample, but few people responded to the survey. Data have been entered and analyzed. We are also making an Endnote annotated bibliography regarding the topics of cumulative effects and adaptive management. Future interviews will target agency staff and leaders of Alaska Native organizations.

4. Arctic Infrastructure Action Group: Rapid Arctic Transitions due to Infrastructure and Climate (RATIC). The RATIC initiative is a new forum for developing and sharing new ideas and methods to facilitate the best practices for assessing, reponding to, and adaptively managing the cumulative effects of Arctic infrastructure and climate change. The intiative is being developed through the International Arctic Science Committee (IASC). The primary activities this past year were publication of a white paper has been produced that describes five international case studies, conclusions, and recommendations for steps to develop scientific research plans aimed at sustainable infrastructure development (Walker et al. 2015) and presentations of the RATIC initiative to the 2015 AGU meeting (Walker et al. 2015b), Arctic Science Summit Week 2015 and 2016, the Eleventh International Conference on Permafrost (Walker et al. 2016c), and the Interagency Arctic Research Policy Committee, and Polar Research Board.

Specific Objectives:

Significant Results:

1. Cumulative effects of development and climate change. In the GCB paper (Raynolds et al. 2014), we demonstrated that thermokarst has recently affected broad areas of the Central North Slope Arctic Coastal Plain, and that a sudden increase of thermokarst began shortly after 1990 corresponding to a rapid rise in regional summer air temperatures and related permafrost temperatures. We also present a conceptual model that describes how infrastructure-related factors, including road dust and roadside flooding contribute to extensive thermokarst in areas adjacent to roads and gravel pads. We mapped the historical infrastructure changes for the Alaska North Slope oilfields for 10 dates from the initial oil discovery in 1968–2011. By 2010, over 34% of the intensively mapped area was affected by oil development. In addition, between 1990 and 2001, coincident with strong atmospheric warming during the 1990s, 19% of the remaining natural landscapes (excluding areas covered by infrastructure,

lakes and river floodplains) exhibited expansion of thermokarst features resulting in more abundant small ponds, greater microrelief, more active lakeshore erosion and increased landscape and habitat heterogeneity. This transition to a new geoecological regime will have impacts to wildlife habitat, local residents and industry. Significant, mostly negative, changes in NDVI occurred in 7.3% of the area, with greater change in aquatic and barren types. Large reflectance changes due to erosion, deposition and lake drainage were evident. Oil industry-related changes such as construction of artificial islands, roads, and gravel pads were also easily identified.

2. Remote-sensing interpretations of change are confounded by increases in surface water due to thermokarst. The paper publilshed NRL (Raynolds et al. 2016) showed that although regional NDVI trends decreased in NDVI for most vegetation types, but increases in tasseled-cap greenness (56% of study area, greatest for vegetation types with high shrub cover) and tasseled-cap wetness (11% of area), consistent with documented degradation of polygon ice wedges, indicating that increasing cover of water may be masking increases in vegetation when summarized using the water-sensitive NDVI. Results from both these studies were a major component of a recent paper published in Nature Geoscience regarding pan-Arctic ice-wedge degradation in warming permafrost and its influence on tundra hydrology (Liljedahl et al. 2016).

3. Report on a major catastrophic thermokarst event related to aufeis and flooding on the Sagavanirktok River and description of a new form of thermokarst. A catastrophic aufeis and flooding event of the Sagavanirktok River occurred in Spring 2015 adjacent to one of our road study sites. Several presentations describing the event and its consequences were made to IARPC, the Polar Research Board, and other forums. A paper describing a newly recognized form of underground massive permafrost thermokarst was presented at the 11th International Conference on Permafrost (ICOP XI, Potsdam, Germany) (Shur et al. 2016), and a journal publication is in preparation (Shur et al. in prep.)

4. Advances in the human dimension of oilfield cumulative effects: Interviews of industry members and local residents recorded perceptions of change, and the processes of adaptive management of cumulative effects of infrastructure. A Ph.D. dissertation is in preparation (Currie, in prep.), and several papers that summarize the results are in press (Berman et al. 2016 in prep.), or in preparation (Forbes and Kofinas, in prep. Currie et al. in prep.) A new visualization tool using the UAF Decision Theater North facility was created to convey information on the cumulative effects of roads and to engage stakeholders in related discussions (Currie et al. 2016).

5. Rapid Arctic Transitions due to Infrastructure and Climate initiative (RATIC): RATIC workshops and topical sessions were conducted at Arctic Change 2014 (Ottawa, Canada), Arctic Science Summit Week 2015 (Yohama, Japan), and the. A RATIC white paper was prepared for the International Arctic Research Committee (Walker et al. 2015b) and presented at ASSW 2016 (Fairbanks, AK). Presentations describing RATIC were made to IARPC and the PRB. An international RATIC workshop is planned for Arctic Science Summit Week 2017 in Prague.

Key outcomes or Other achievements:

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

1. The project has supported the PhD studies of Tracie Curry, who is pursuing her degree in Natural Resources and Sustainability in the School of Natural Resources and Extension at UAF. Tracie has participated in Scenario Workshops of the North Slope Science Initiative, traveled to Native villages where she has interacted with local residents and Tribal leaders and presented to these groups.
2. Seven students were trained in Arctic System Environmental Change in 2016 during the summer field course, bringing the total trained during the project to 21.
3. A post-doctoral student, Dr. Marcel Buchhorn, was trained and accpeted a job offer from VITO in Belgium, a a leading

European independent research and technology organisation in the areas of clean technology and sustainable development..
4. Funds from the ArcSEES project were used to help involve Arctic Polar Early Career Scientists to the RATIC meetings in Canada and Japan during the past year.
5. Dr. Jozef Sibik, a visiting scientist from the Slovak Republic,and his graduate student, Silvia Chasnikova, visited for 5 months to receive training in our methods of data collection and analysis methods, and background in projects including our ArcSEES project.
6. Dr. Ksenia Ermokhina, a visiting scientist from Moscow State University and the Russian Academy of Science Earth Cryosphere Institute, visited for 2 months in August and September 2016 to be trained in methods of vegetation archiving and analysis and visited the ArcSEES research site at Prudhoe Bay.

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

1. We have made presentations about the project to several groups in Alaska, including The North Slope Borough Wildlife Management Department, to graduate students at UAF, community organizations in Nuiqsut and Wainwright, Interagency Arctic Research Policy Committee (IARPC), the Bureau of Land Management's new cumulartive effects of development initiative, and the Polar Research Board, and a public lecture at the UAF Institute of Arctic Biology's seminar series.
2. Two new websites archive information and provide all project details from the project. One provides general information from the ArcSEES project with information on the projects goals, proposals, annual and other reports, publications, workshops, and key data (http://www.geobotany.uaf.edu/arcsees/).The other is a Geoecological Atlas is being developed in collaboration with a NASA ABoVE (Arctic and Boreal Vulnerability Experient)
project (http://geobotanical.portal.gina.alaska.edu). This site contains all the map and plot data produced by this project and others that the Arctic Geobotany Center has been involved with during its 45-year history.
3. The new AGC publication series provides web and hard copy data reports from the project. Copies of three of these reports are included in the supporting files.
4. Special RATIC Session at the the Arctic Change 2014 meeting in Ottawa, Canada. The workshop included 40 participants, who presented a variety of case studies from aroung the Arctic. Two topical sessions included 10 oral presentations and 17 posters, with first authors from the U.S. (9 papers, Russian (9 papers), Canada (6 papers), Finland (2 papers), and Norway (1 paper).

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

1. Two data reports on 2015 and 2016 field seasons at Prudhoe Bay (Walker et al. 2016a, 2017a).
2. Archive data in the ARCSS Data Archive at NCAR/EOL.
3. Complete interviews on adaptive management and cumulative effects. Respondents will be selected through members of the North Slope Science Initiative Oversight Panel, who represent all organizations involved in North Slope land management.
4. Organize a regional workshop and panel at a conference on Arctic Alaska landscape change, undertaken in cooperation with EPSCoR Northern Test Case Project.
5. Organize a RATIC workshop at Arctic Science Summit Week 2017, Prague.
6. Use the Decision Theater North with North Slope stakeholders to make presentations to and have discussion. The process will be used to test the effectiveness of the visualization on roads in conveying information on the topic and informing decision making.
7. Conduct a 21-day field course entitled Arctic Alaska Environmental Change in Jun 2017.
8. 2016 AGU Fall Meeting presentation: *D.A.Walker, M. Kanevskiy, Y. Shur, M.K. Raynolds, and M. Buchhorn,* Cumulative effects of climate change and ice-wedge degradation on infrastructure and ecosystems in the Prudhoe Bay oilfield, Alaska.
9. Publication in press: Berman, M., Kofinas, G., and Burnsilver, S. (Forthcoming in 2016). Measuring Community Adaptive and Transformative Capacity in the Arctic Context, in *Arctic Sustainabilities*, Gail Fondahl and Gary Wilson (eds.), Heidelberg: Springer.
10. Draft, finalize and submit several publications including: Ice-wedge degradation, impacts on infrastructure, Barrow and Prudhoe Bay. Misha Kanevskiy et al. To be submitted to *Geomorphology*, *Permafrost and Periglacial Processes*, or *Journal of Geophysical Research.*

- Underground thermokarst erosion: a newly described permafrost process. Shur et al. To be submitted to *Geomorphology*, *Permafrost and Periglacial Processes*, or *Journal of Geophysical Research.*
- Cumulative effects of Arctic roads to the soils and vegetation after 45 years, Prudhoe Bay region, Alaska. Walker et al. To be submitted to *Applied Vegetation Science* or *Phytocoenologia.*

- Comparing Indigenous Peoples with Oil and Gas development with climate change in Yamal Russia and North Slope Alaska Experiences of, Bruce Forbes and Gary Kofinas
- Managing Cumulative Effects in Arctic Alaska – Theory and Practice, Tracy Currie, Gary Kofinas, Skip Walker, Yuri Sur.
- PhD dissertation by Tracie Curry.

Products

Books

Walker, D. A., M. K. Raynolds, M. Buchhorn, and J. L. Peirce (Eds.). (2014). *Landscape and permafrost change in the Prudhoe Bay Oilfield, Alaska* Alaska Geobotany Center, University of Alaska, AGC. University of Alaska Fairbanks. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; OTHER: http://www.geobotany.uaf.edu/library/pubs/WalkerDA2014_agc14-01.pdf

Book Chapters

Inventions

Journals or Juried Conference Papers

Bieniek, PA, US Bhatt, DA Walker, MK Raynolds, JC Comiso, HE Epstein, JE Pinzon, CJ Tucker, RL Thoman, H Tran, N Mölders, M Steele, J Zhang, and W Ermold. (2016). Climate drivers of changing seasonality of Alaska coastal tundra vegetation productivity. *Earth Interactions*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Buchhorn, M., Prakash, A., Hampton, D. L., Cristóbal-Rosselló, J., Waigl, C. F., Stuefer, M., D.A. Walker (2016). HyLab: Alaska's in-state capability for Aairborne imaging spectroscopy – applications for permafrost. Abstract 882.. *11th International Conference on Permafrost, Potsdam, Germany*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Buchhorn, M., Raynolds, M. K., Kanevskiy, M., Matyshak, G., Shur, Y., Willis, M. D., Peirce, J.L., Wirth, L.M., Walker, D.A. (2016).Presented at the (2016). Effects of 45 years of heavy road traffic and climate change on the thermal regime of permafrost and tundra at Prudhoe Bay, Alaska (p. Abstract 811).. *11th International Conference on Permafrost, Potsdam, Germany.*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Kanevskiy, M., Shur, Y., Strauss, J., Jorgenson, M.T., Fortier, D., Stephani, E. and Vasiliev, A. (2016). Patterns and rates of riverbank erosion involving ice-rich permafrost (yedoma) in northern Alaska.. *Geomorphology*. 253 370. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: doi:10.1016/j.geomorph.2015.10.023

Kanevskiy, M., Shur, Y., Walker, D. A., Buchhorn, M., Jorgenson, T., Matyshak, G., et al. (2016). Evaluation of Risk of Ice-Wedge Degradation, Prudhoe Bay Oilfield, AK.. *Poster presented at the 11th International Conference on Permafrost, Potsdam Germany.*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Kofinas, G., Curry, T., Streever, B. & Bader, H. (2014). Adaptive management of cumulative effects: theory vs. reality.. *Talk presented at the Arctic Change 2014 conference*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Liljedahl, A. K., Boike, J., Daanen, R. P., Fedorov, A. N., Frost, G. V., Grosse, G., ...Raynolds, ...Walker, D.A. et al. (2016). Pan-Arctic ice-wedge degradation in warming permafrost and its influence on tundra hydrology.. *Nature Geoscience*. 9 (4), 312. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: http://doi.org/10.1038/ngeo2674

Raynolds, M. K., & Walker, D. A. (2016). Increased wetness confounds Landsat-derived NDVI trends in the central Alaska North Slope region, 1985–2011. *Environmental Research Letters*. 11 (8), 085004. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: http://doi.org/10.1088/1748-9326/11/8/085004

Raynolds, M. K., Walker, D. A., Ambrosius, K. J., Brown, J., Everett, K. R., Kanevskiy, M., et al. (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 (4), 1211. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: http://doi.org/10.1111/gcb.12500

Shur, Y., Kanevskiy, M., Walker, D. A., Jorgenson, M. T., Buchhorn, M., & Raynolds, M. K. (2016). Permafrost-related causes and consequences of Sagavanirktok River flooding in Spring 2015. *Abstract 1065. Talk presented at the 11th International Conference on Permafrost, Potsdam, Germany.*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Walker, D. A., Daniëls, F. J. A., Alsos, I., Bhatt, U. S., Breen, A. L., Buchhorn, M., et al. (2016). Circumpolar arctic vegetation: A hierarchic review and road map toward a consistent international approach to survey archive and classify plot data.. *Environmental Research Letters*. 11 (5), 055005. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: http://doi.org/10.1088/1748-9326/11/5/055005

Walker, D. A., Peirce, J., Kumpula, T., Leibman, M. O., Matyshak, G., Streletskiy, D., et al. (2016). Rapid Arctic Transitions due to Infrastructure and Climate (RATIC): An ICARP III initiative focusing on the cumulative effects of Arctic infrastructure and climate change.. *Abstract 499. Poster presented at the 11th International Conference on Permafrost, Potsdam, Germany.*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Walker, D. A., Peirce, J., Kumpula, T., Leibman, M. O., Matyshak, G., Streletskiy, D., et al. (2016). Rapid Arctic Transitions due to Infrastructure and Climate (RATIC): An ICARP III initiative focusing on the cumulative effects of Arctic infrastructure and climate change.. *Abstract 499. Poster presented at the 11th International Conference on Permafrost, Potsdam, Germany.*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Licenses

Other Conference Presentations / Papers

Kumpula, T. and Forbes, B.C. (2016). *Changing pasture land, rapid land cover changes and their impacts on Nenets reindeer herding on the Yamal Peninsula, Russia.*. International Arctic Science Committee ICARP III Working Group meeting on Infrastructure in the Arctic (and elsewhere) as a Social and Ecological Challenge. January 15-16. Vienna, Austria,. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Other Products

Other Publications

Walker, D. A., Buchhorn, M., Kanevskiy, M., Matyshak, G. V., Raynolds, M. K., Shur, Y. L., & Peirce, J. L. (2015). *Infrastructure-Thermokarst-Soil-Vegetation Interactions at Lake Colleen Site A, Prudhoe Bay, Alaska.*. Alaska Geobotany Center, University of Alaska Fairbanks, AGC Data Report 15-01, Fairbanks, AK.. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Walker, D. A., & Peirce, J. L. (Eds.) (2015). *Rapid Arctic Transitions due to Infrastructure and Climate (RATIC): A contribution to ICARP III. Walker, D. A., & Peirce, J. L. (Eds.).*. White paper presented to the International Arctic Research Committee. Prepared by Alaska Geobotany Center, University of Alaska Fairbanks, AGC 15-02, Fairbanks, AK.. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Patent Applications

Technologies or Techniques

Thesis/Dissertations

Buchhorn, Marcel. *Ground-based hyperspectral and spectro-directional reflectance characterization of Arctic tundra vegetation communities: field spectroscopy and field spectro-goniometry of Siberian and Alaskan tundra in preparation of the EnMAP satellite mission.*. (2013). Potsdam University. Acknowledgement of Federal Support = No

Websites or Other Internet Sites

Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked

Name	Most Senior Project Role	Nearest Person Month Worked
Walker, Donald	PD/PI	4
Kofinas, Gary	Co PD/PI	1
Shur, Yuri	Co PD/PI	1
Buchhorn, Marcel	Postdoctoral (scholar, fellow or other postdoctoral position)	3
Raynolds, Martha	Postdoctoral (scholar, fellow or other postdoctoral position)	3
Matyshak, George	Other Professional	1
Peirce, Jana	Other Professional	2
Wirth, Lisa	Other Professional	2

Full details of individuals who have worked on the project:

Donald A Walker
Email: ffdaw@uaf.edu
Most Senior Project Role: PD/PI
Nearest Person Month Worked: 4

Contribution to the Project: Project management, Field research, author several papers and conference presentations

Funding Support: UAF Salary 1 month

International Collaboration: Yes, Russian Federation
International Travel: Yes, Germany - 0 years, 0 months, 7 days; Canada - 0 years, 0 months, 5 days; Japan - 0 years, 0 months, 7 days

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, coordinate human dimension component, supervise graduate student

Funding Support: Partial UAF support

International Collaboration: Yes, Finland
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, field research, project direction, paper writing, conference participation

Funding Support: Partial UAF support

International Collaboration: No
International Travel: Yes, Germany - 0 years, 0 months, 7 days

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Marcel Buchhorn
Email: mbuchhorn@alaska.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 3

Contribution to the Project: Post-doc, field work, GIS/remote sensing lab manager, building new facility

Funding Support: This project plus NASA LCLUC Grant, and PreABoVE

International Collaboration: Yes, Germany
International Travel: No

Martha K Raynolds
Email: mkraynolds@alaska.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 3

Contribution to the Project: Field research, mapping, writing publications

Funding Support: This project

International Collaboration: No
International Travel: No

George Matyshak
Email: matyshak@gmail.com
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: Soils descriptions and analysis at field sites

Funding Support: travel support from this grant

International Collaboration: Yes, Russian Federation
International Travel: Yes, Canada - 0 years, 0 months, 7 days; Germany - 0 years, 0 months, 7 days

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Jana L. Peirce
Email: jlpeirce@alaska.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 2

Contribution to the Project: Writing and editing reports, field work, data analysis

Funding Support: this grant

International Collaboration: No
International Travel: No

Lisa Wirth
Email: lisa@gina.alaska.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 2

Contribution to the Project: Mapping, GIS, web site, field work

Funding Support: This project, NASA PreABoVE project

International Collaboration: No
International Travel: No

What other organizations have been involved as partners?

Name	Type of Partner Organization	Location
Earth Cryosphere Institute	Other Organizations (foreign or domestic)	Tyumen, Russia
University of Eastern Finland	Academic Institution	Finland

Full details of organizations that have been involved as partners:

Earth Cryosphere Institute

Organization Type: Other Organizations (foreign or domestic)
Organization Location: Tyumen, Russia

Partner's Contribution to the Project:
Financial support
In-Kind Support
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution: Helping with RATIC workshop and Russian case study

University of Eastern Finland

Organization Type: Academic Institution
Organization Location: Finland

Partner's Contribution to the Project:
Financial support
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution: Helping with the RATIC workshop and Russian case study

What other collaborators or contacts have been involved?
Nothing to report

Impacts

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

New type of thermokarst described by Shur et al. provides major insight into how massive thermokarst erosion can occur in association with flooding events. Also how aufeis can be promoted by seismic actvities in deltas of rivers.

What is the impact on other disciplines?

The RATIC is a strong cross-disciplinary initiative with major international collaborators in the social sciences, permafrost science, engineering, and education.

What is the impact on the development of human resources?

We are training numerous students during the summer field courses, and through exchanges with researchers in Russia, Slovak Republic, Germany. One Ph.D. Student (Tracie Curry) is funded by the project and developing innovative approaches to convey the results of the project to a broad range of user groups. One Post-Doc has been trained and recently accepted a top research position with TIVO in Belgium.

What is the impact on physical resources that form infrastructure?

Funding from this ArcSEES project helped us make major modernization of the GIS and remote sensing facilitiles.

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

What is the impact on information resources that form infrastructure?

Support from this project help us hire Jana Peirce, who has made many major contributions in helping to write, edit, and publish data reports, and communicate the results of the project to wide group of interested parties, and in developing the project web sites.

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

What is the impact on society beyond science and technology?

The project has made a major contribution in helping direct more scientific attention to the issues related to development and infrastructure in the Arctic, pariticularly the interactions between climate change and infrastructure.

Changes/Problems

Changes in approach and reason for change
Nothing to report.

Actual or Anticipated problems or delays and actions or plans to resolve them
Nothing to report.

Changes that have a significant impact on expenditures
Nothing to report.

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.
Nothing to report.