Cover

Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	1263854
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
Project/Grant Period:	09/15/2013 - 08/31/2018
Reporting Period:	09/01/2016 - 08/31/2017
Submitting Official (if other than PD\PI):	Donald A Walker Principal Investigator
Submission Date:	08/27/2017
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 — 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 of infrastructure, landscapes and vegetation in the Prudhoe Bay Oilfield. This component is complete. We published two key papers describing the historical trends of infrastructure- and climate related changes in northern Alaska: 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-resolutionaerial photographs, ground studies, and vegetation maps.

2. Ground-level investigation of changes associated with intensive thermokarst along roads. The final progress report for the field work is in progress. 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. In previous reports we described interviews of local people and industry personnel that are being used to determine their perceptions of change, implications to their livelihoods, and assessment of adaptive management for infrastructure in Northern Alaska. Identification of agency personnel interviewees is being organized in collaboration with the Oversight Committee of the North Slope Science Initiative, a federal initiative of all major entities involved in North Slope resource and land management. We interviewed 15 BP Exploration Alaska, Inc. staff and 28 residents of Nuiqsut. 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. Findings of interviews are being compared with findings of environmental change in the academic literature to understand if and where they are differences in perceptions. We are also making an annotated bibliography regarding the topics of cumulative effects and adaptive management. On 5-6 June 2017, eleven members of the Kuukpik Corporation Board met with researchers from the University of Alaska Fairbanks (UAF) in the Decision Theater North in Fairbanks, AK to review findings from over fifteen research projects from in and around the the North Slope. The workshop, jointly sponsored by Alaska

EPSCoR, provided an opportunity for the group to share and discuss the findings of research, local and traditional knowledge, and the implications of a changing North Slope, identify information gaps and research needs/priorities, and explore ways the University of Alaska can better assist in addressing community concerns through future research and collaboration. The workshop addressed the topic of cumulative effects through participants' dialogue on the effects of multiple interacting drivers of change to community wellbeing. One (of several) significant results of the workshop was recognition of the complementary perspectives of science and local knowledge about social-ecological systems (SES) change and the need for more research science to address questions that tracks these impacts from physical, ecological, to human health. A follow up workshop will be held in the community this fall.

4. Arctic Infrastructure Action Group: Rapid Arctic Transitions due to Infrastructure andClimate (RATIC). The RATIC initiative is a 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). An IASC white paper describes five international case studies, conclusions, and recommendations for steps to develop scientific research plans aimed at sustainable infrastructure development (Walker et al. 2015). The primary activities this past year year included: (1) Seven presentation at the 11th International Conference on Permafrost (ICOP 2016), in Potsdam, Germany, 20-24 June (Buchhorn et al. a, b; Frost et al. 2016; Kenevskiy et al. 2016; Liljedahl et al. 2016; Shur et al. 2016; Walker et al. 2016); (2) three papers at the 2016 AGU Fall Meeting (Farquharson et al. 2016; Liljedahl et al. 2016b; Walker et al. 2016b); and (3). A Sustainable Arctic Infrastructure Forum (SAIF) workshop and a RATIC session at the Arctic Science Summit Week 2017, Prague, Czech Republic, 31 March – 7 April. The SAIF workshop was partially sponsored by IASC as a cross-cutting workshop between the Terrestrial, Social and Human, and Cryosphere IASC working groups.The workshop report is attached. Sixteen papers were presented at Session 17.3, Rapid Arctic Trnasitions due Infrastructure and Climate (RATIC) including a reports on the ArcSEES project at Prudhoe Bay (Walker et al. 2017, attached).

Specific Objectives:

Significant Results:

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 theSagavanirktok 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 SAIF workshop at Arctic Science Summit Week 2017 in Prague Czech Republic. 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, the PRB and at the International Conference on Permafrost 2016, and Arctic Science Summit Week 2017 (Walker et al. 2017, attached)

Key outcomes or Other achievements:

1. SAIF Workshop at ASSW 2017

2. ArcSEES presentation at RATIC Session, ASSW 2017

(See other Major Arctivities, Item 4)

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

1. 14 students have been trained in Arctic System Science through the the UAF summer field course.

2. A post-doctoral student, Dr. Marcel Buchhorn, was recruited trained, and worked for the project during the first two years, making major contributions to remote sensing aspects of the project. He recently accepted a top job with VITOS in Belgium.

3. Funds from the ArcSEES project were used to help involve Arctic Polar Early Career Scientists to the RATIC meetings at 11th International Conference on Permafrost in Potsdam, and Arctic Science Summit Week in Postsdam.

4. A young visiting scientist from the Slovak Republic, Dr. Jozef Sibik, and his graduate student, Silvia Chasnikova, received training in our methods of data collection and analysis methods, and background in projectsincluding our ArcSEES project.

5. Ph.D. candidate Tracie Curry is completing a thesis on adamptive management of cumulative effects of oil field development.

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

AGC publication series: We expanded the AGC publication series that provides web and hard copy data reportsfrom the project. The publications are listed with the publications.

Special Session and Workshop at the the Arctic Science Summit Week 2017 in Prague Czech Republic.The Sustainable Arctic Infrastructure Forum (SAIF) was an IASC cross-cutting workshop involving principally the Terrestrial, Social and Human, and Cryosphere working groups. Co-applicants the IASC Rapid Arctic Transitions due to Infrastructure and Climate (RATIC) initiative. The forum occurred 3 April, during Arctic Science Summit Week 2017, in Prague, Czech Republic. The forum was attended by 38 participants, and consisted of a series of introductory talks and a keynote student presentation, breakout sessions to address scientific and policy issues related to major types of infrastructure. The major task of SAIF was to address the cumulative effects of four major types of infrastructure systems: indigenous infrastructure (e.g., camps, trails, corrals, migration corridors, etc.); onshore oil & gas fields (networks of roads, drilling and facility pads, pipelines, etc.); remote communities (village infrastructure); and urban infrastructure (cities). Plans for publication of the results from the forum are to summarize the results from the breakout groups, identify the science questions and policy issues that were common to all types of infrastructure and those that were unique to one or two types, and develop a strategy for addressing the questions and issues based on the tools, approaches and institutions identified by each breakout group. “Corridors” and “nodes” emerged as an organizing framework for developing research themes to address various types of infrastructure. A “Prague Sustainable Infrastructure Scientific Research Agenda” identified the following tasks to be completed by RATIC in the next five years: (1) Promote the topic of “sustainable infrastructure development” as a key IASC research theme; (2) involve scientists, local communities, governments, industry and the general public in this research; (3) publish a synthesis of sustainable Arctic infrastructure research findings in peer-reviewed scientific journals and more publicly accessible platforms; (4) pursue funding to continue the RATIC initiative; and (5) develop a strategic plan to accomplish these goals by December 2017.

Kuukpik-UAF workshop, 5-6 Jun, Fairbanks:

Walker, D. A. (2017). Cumulative effects of arctic oil development: planning for a sustainable future. Presented at the Kuukpik UAF Workshop, UAF, 5-6 June.

Public lectures:

Walker, D. A. (2017). Vegetation of the European Arctic Transect (EAT) Yamal Peninsula and Franz Jozef Land, Russia. Presented to the Slovak Academy of Sciences, Institute of Botany, Bratislava, Slovak Republic, 12 April, 2017.

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

1. Finish the last data report regarding field work at the Prudhoe Bay ArcSEES research sites. The report will include temperature data from i-buttons places in different habitats and distances from the road, snow surveys, and active layer measurements collected in 2015 and 2016.

2. Complete several papers currently in progress including a synthesis paper on the status of cumulative impact research in the Arctic.

3. Conduct a field course entitled Arctic Environmental Change in Jun 2017.

Supporting Files

Filename	Description	Uploaded By	Uploaded On
SAIF_Workshop Report to the IASC Secretariat_20170428sw.pdf	SAIF workshop Report, ASSW 2017	Donald Walker	08/09/2017
8_Session 17.3_Walker_RATIC_talk_20170809(compressed)-ilovepdf-compressed.pdf	Walker et al. 2017, presentation at ASSW Summit Week 2017	Donald Walker	08/09/2017

Products

Books

Book Chapters

Berman, M., Kofinas, G., and BurnSilver, S. (2017). Measuring Community Adaptive and Transformative Capacity in the Arctic Context. *Northern Sustainabilities, Understanding and Addressing Change in the Circumpolar World* Gail Fondahl and Gary Wilson. Springer. Heidelberg. 59. Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes

BurnSilver, S.B., R. Boone, G. Kofinas, and T. Brinkman (2017). Tradeoffs in the mixed economies of village Alaska: Hunting, working and sharing in the context of change. *The Give and Take of Sustainability: Archaeological and Anthropological Perspectives* New Direct. M. Hegemony. Cambridge University Press. Cambridge. . Status = AWAITING_PUBLICATION; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes

Inventions

Journals or Juried Conference Papers

Baggio, J. A., S. B. BurnSilver, A. Arenas, J. S. Magdanz, G. P. Kofinas and M. De Domenico (2016). Multiplex social ecological network analysis reveals how social changes affect community robustness more than resource depletion. *Proceedings of the National Academy of Sciences*. 113 (1), 121. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1073/pnas.1604401113

Bhatt, U. S., Walker, D. A., Raynolds, M. K., Bieniek, P. A., Epstein, H. E., Comiso, J. C., et al. (2017). Changing seasonality of panarctic tundra vegetation in relationship to climatic variables. *Environmental Research Letters*. 12 (5), 055003. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: http://doi.org/10.1088/1748-9326/aa6b0b

Bieniek, P. A., Bhatt, U. S., Walker, D. A., Raynolds, M. K., Comiso, J. C., Epstein, H. E., et al. (2015). Climate Drivers Linked to Changing Seasonality of Alaska Coastal Tundra Vegetation Productivity. *Earth Interactions*. 19 1. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: http://doi.org/10.1175/EI-D-15-0013.1

Brinkman, T. J., W. D. Hansen, F. S. Chapin, G. Kofinas, S. BurnSilver and T. S. Rupp (2016). Arctic communities perceive climate impacts on access as a critical challenge to availability of subsistence resources. *Climatic Change*. 139 (3), 413. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; OTHER: https://link.springer.com/article/10.1007/s10584-016-1819-6

BurnSilver, S., Magdanz, J., Stotts, R., Berman, M., and Kofinas, G. (2016). Economies Persistent or Transitional? Evidence Using Social Networks from Arctic Alaska. *American Anthropologist*. 118 (1), 121. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: DOI: 10.1111/aman.12447

Farquharson, L. M., Romanovsky, V. E., W, C., & Walker, D. A. (2016). Widespread and rapid thermokarst development in a region of very cold continuous permafrost in the Canadian High Arctic. *AGU Fall Meeting , San Francisco, 12-16 Dec*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; OTHER: Abstract GC33G–06

Frost, G. V., Christopherson, T. C., Liljedahl, A. K., Macander, M. J., Walker, D. A., & Wells, A. F. (2016). Regional patterns and asynchronous onset of ice-wedge degradation in Arctic Alaska.. *11th International Conference on Permafrost, Potsdam, Germany.*. 32. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Frost, G. V., Epstein, H. E., Walker, D. A., & Matyshak, G. (2016). Changes to Permafrost active-layer temperature after tall shrub expansion in low arctic tundra.. *11th International Conference on Permafrost Book of Abstracts, Potsdam, Germany*. 410. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Frost, G. V., Epstein, H. E., Walker, D. A., Matyshak, G., & Ermokhina, K. (2017). Seasonal and long-term changes to active-layer temperatures after tall shrubland expansion and succession in arctic tundra. *Ecosystems*. 16 1296. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: http://doi.org/10.1007/s10021-017-0165-5

Gilbert, G.L., Kanevskiy, M., and Murton, J.B. (2016). Recent advances (2008–2015) in the study of ground ice and cryostratigraphy. *Permafrost and Periglacial Processes*. 27 (4), 377. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: DOI: 10.1002/ppp.1912

Heim, B., Bartsch, A., Beamish, A., Stettner, S., Buchhorn, M., Duguay, C., …Walker, D.A. ...et al. (2016). User and expert-supported validation and evaluation experiments for high latitude permafrost landscapes: ESA DUE PERMAFROST (2009-2012) and ongoing EnMAP, PAGE21, and HGF-EDA programs.. *11th International Conference on Permafrost Book of Abstracts, Potsdam, Germany*. 904. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Kanevskiy, M., Shur, Y., Jorgenson, T., Brown, D. R. N., Moskalenko, N. G., Brown, J., et al. (2017). Degradation and stabilization of ice wedges: Implications for assessing risk of thermokarst in northern Alaska.. *Geomorphology*. 253 . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

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.. *11th International Conference on Permafrost Book of Abstracts, Potsdam, Germany.*. 999. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Lapointe Elmrabti, L., Talbot, J., Fortier, D., Fréchette, B., Strauss, J., Kanevskiy M., and Shur, Y. (2017). Middle to late Wisconsinan climate and ecological changes in northern Alaska: Evidences from the Itkillik River Yedoma. *Palaeogeography, Palaeoclimatology, Palaeoecology*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: doi: 10.1016/j.palaeo.2017.08.006

Liljedahl, A. K., Boike, J., Daanen, R. P., Fedorov, A. N., Frost, G. V., Grosse, G., .,…Walker, D.A.,...et al. (2016). Recent circum-Arctic ice-wedge degradation and its hydrological impacts. *AGU Fall Meeting , San Francisco, 12-16 Dec*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; OTHER: Abstract GC33G–08

Liljedahl, A. K., Boike, J., Daanen, R. P., Fedorov, A. N., Frost, G. V., Grosse, G.,…Walker, D.A.,... et al. (2016). Recent circum-Arctic ice-wedge degradation and its hydrological impacts. *11th International Conference on Permafrost Book of Abstracts, Potsdam.*. 917. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Romanovsky, V., Nicolsky, D., Cable, W., Kholodov, A., Farquharson, L., Panda, S,…Walker, D.A., et al. (2017). Measured and modeled changes in permafrost along North American Arctic Transect. *Arctic Science Summit Week, Prague, 31 Mar-07 Apr.*. 141. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; OTHER: O-100

Trochim, E.D., Schnabel, W.E., Kanevskiy, M., Munk, J., Shur, Y. (2016). Geophysical and cryostratigraphic investigations for road design in northern Alaska. *Cold Regions Science and Technology*. 131 24. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: doi: 10.1016/j.coldregions.2016.08.004

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*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: http://doi:10.1088/1748-9326/11/5/055005

Walker, D. A., Kanevskiy, M., Shur, Y., Raynolds, M. K., & Buchhorn, M. (2016). Cumulative effects of climate change and ice-wedge degradation on infrastructure and ecosystems in the Prudhoe Bay oilfield, Alaska. *AGU Fall Meeting, San Francisco, 12-16 Dec*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; OTHER: Abstract GC33G–01

Walker, D. A., Kanevskiy, M., Shur, Y., Raynolds, M., Buchhorn, M., & Matyshak, G. (2017). Rapid transitions caused by infrastructure and climate, Prudhoe Bay Oilfield, Alaska,. *Arctic Science Summit Week, Prague, 31 Mar-07 Apr*. 171. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; OTHER: O 115

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. *11th International Conference on Permafrost Book of Abstracts, Potsdam, Germany.*. 1234. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Licenses

Other Conference Presentations / Papers

Walker, D.A., Kanevskiy M., Shur, Y., Raynolds, M.K., Buchhorn, M (2016). *Cumulative effects of climate change and ice-wedge degradation on infrastructure and ecosystems in the Prudhoe Bay oilfield, Alaska*. American Geophysical Union Fall Meeting. San Francisco. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Walker, D. A., Peirce, J., Kumpula, T., Leibman, M. O., Matyshak, G., Streletskiy, D., et al. (29 authors) (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*. 11th International Conference on Permafrost. Potsdam, Germany. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Other Products

Data and Research Materials (e.g. Cell lines, DNA probes, Animal models).

DATA REPORT: Walker, D. A., Buchhorn, M., Kanevskiy, M., Raynolds, M. K., Shur, Y. L., & Wirth, L. M. (2016). *Airport study site, Prudhoe Bay, Alaska, Summer 2015: Road effects data report*. Fairbanks, AK: Alaska Geobotany Center. AGC 16-01, 74 pp.

Published as hard copy, and available online at

http://www.geobotany.uaf.edu/library/pubs/WalkerDA2016_agc16-01_datarpt.pdf

Other Publications

Kofinas, Gary, Sarah Abdelrahim, Marcus Carson, F. Stuart Chapin III, Joel Clement, Nancy Fresco, Anne Gunn, Garry Peterson, Andrey N. Petrov, Allyson Quinlan, Martin Sommerkorn, Alice Veazey (2016). *Building resilience in the Arctic: From theory to practice*. Building resilience in the Arctic: From theory to practice. Section in Arctic Resilience Report. M. Carson and G. Peterson (eds). Arctic Council. Stockholm Environment Institute and Stockholm Resilience Centre, Stockholm. http://www.arctic-council.org/arr.. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Patent Applications

Technologies or Techniques

Thesis/Dissertations

Websites or Other Internet Sites

ArcSEES: Cumulative Effects of Arctic Oil Development — planning and designing for sustainability
http://www.geobotany.uaf.edu/arcsees/

Project website includes description of the project, publications, data reports,

Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Walker, Donald	PD/PI	3
Kofinas, Gary	Co PD/PI	1
Shur, Yuri	Co PD/PI	1
Buchhorn, Marcel	Postdoctoral (scholar, fellow or other postdoctoral position)	0
Raynolds, Martha	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Matyshak, George	Other Professional	1

Name	Most Senior Project Role	Nearest Person Month Worked
Peirce, Jana	Other Professional	3
Wirth, Lisa	Other Professional	0
Curry, Tracie	Graduate Student (research assistant)	9

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: 3

Contribution to the Project: PI, project coordination, organized workshops and sessions

Funding Support: NASA LCLUC program

International Collaboration: No
International Travel: Yes, Czech Republic - 0 years, 0 months, 14 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, human dimensions components, organized Kuukpik-UAF workshop, contributed to publications

Funding Support: NSF EPSCoR to UAF

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, Leads the permafrost research component, presented papers at EICOP, author on several others

Funding Support: other NSF grants to Torre Jorgensen

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

Marcel Buchhorn
Email: mbuchhorn@alaska.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 0

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: 1

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, Czech Republic - 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: 3

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

Funding Support: this grant

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

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Lisa Wirth
Email: lisa@gina.alaska.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 0

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

Funding Support: This project, NASA PreABoVE project

International Collaboration: No
International Travel: No

Tracie Curry
Email: tncurry3@alaska.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 9

Contribution to the Project: Ph.D. thesis

Funding Support: This project

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

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?

Three data reports regarding the field work at Prudhoe Bay, provide a large baseline database for future monitoring of roadside impacts at two key field sites.

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

What is the impact on the development of human resources?

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.

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?

Involvement of local native communities in climate-change investigations: Finding indicate that the residents of Nuiqsut are witnessing many changes in the North Slope Landscape. The reported that there are changes in erosion (89%) and gravel bars (85%) including increased erosion (60%), but many people are noticing other unclassified erosion events (32%) and river changes (45%). They reported that moose numbers have deceased (74%), but reported trends in caribou abundance were mixed. There was stronger agreement that summer temperatures have changed than winter, 85% versus 76%, respectively. However, there is stronger consensus that temperatures during winter have increased (winter = 79%) and there are fewer extreme cold days (68%) than warmer temperatures in summer (55%). We did not ask about how the number of hot days in summer have changed. Residents agree that fall is later (70%) while spring is earlier (88%), but fewer people agreed that break-up was earlier (60%). An equal percent of people observed changes in permafrost (74%) and lakes (73%) but exactly how these are changing is more uncertain. The issue that has the least support for is changes in vegetation (58%), especially for willows (39%). But if changes are observed willows are larger (83%) and found in new spots (67%).

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.