2019 Toolik Field Station All Scientists Meeting Poster Abstracts

Portland, Oregon
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Toolik Field Station Mission:

To support research and education that creates a greater understanding of the Arctic and its relationship to the global environment.

Purpose of the All Scientists Meeting:

The goal of the meeting is to share scientific findings, promote collaboration, and gather future science support requirements for services and facilities needed among Toolik researchers and others working in the Arctic.

Meeting website and agenda:

http://toolik.alaska.edu/news/all_scientists_meeting.php

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Notes:

Abstracts are listed in alphabetical order by author. Presenters are demarcated with an asterisk.

Seasonal thaw depth and soil C and N inventories in graminoid tundra in the vicinity of Toolik Field Station, AK

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Northern circumpolar permafrost soils contain vast amounts of organic carbon (1,035±150 Pg C in the top 3 m) that may become vulnerable to microbial decomposition as climate warms and permafrost thaws. Major uncertainties remain regarding the timing and magnitude of the permafrost C feedback to climate change.

Here, we investigated active layer dynamics and soil organic matter properties in moist acidic tussock tundra near Toolik Field Station to understand the vulnerability of soil carbon stocks in this common type of graminoid tundra to climate change. We monitored the timing, magnitude, and variability of active layer thaw and compared our measurements to observations made by the Circumpolar Active Layer Monitoring Network (CALM) and Long-Term Ecological Research (LTER) networks. We also collected soil cores and used elemental and isotopic analyses to quantify the amounts and composition of soil organic matter in the active layer and underlying surface permafrost.

We found that the active layer is fully developed by mid-July. The active layer depth is 46±15 cm (mean±SD), with a range of 20-80 cm, and has not changed significantly during the past 25 years. Moist acidic tussock tundra contains 91 kg C m^{-2} in the top 2 m, of which 82% are present in permafrost. These permafrost organic matter pools fundamentally differ in their properties from those in the active layer. Permafrost organic matter is older (mean age 1,600 to 9,400 yrs BP), less microbially processed, and likely represent yedoma-type deposits (loess).

Our data shows that moist acidic tussock tundra contains large amounts of potentially-vulnerable carbon, specifically in permafrost, that may contribute to the permafrost C-climate feedback as the Arctic continues to warm.

Arctic Lake Water Isotopes Track Climatological Phenomena

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The hydrogen and oxygen isotopes of water (D/H and $^{18}O/^{16}O$) are excellent tracers of the hydrologic cycle. They are commonly employed to study paleoclimatology, moisture sources, groundwater and surface water flowpaths, and ecophysiological processes. At Toolik Field Station (TFS), they can potentially be used as a tracer of both persistent meteorological changes, interannual changes in moisture availability (i.e. precipitation-evaporation), physical limnology, and other aspects of the arctic hydrology.

Here we begin to explore the fundamental patterns and changes in hydrology at TFS using the water isotopes of lakewater samples. We analyzed 712 archived samples from the Arctic Long-Term Ecological Research Program for D/H and $^{18}O/^{16}O$ using a Picarro Cavity Ring-down Spectrometer at the University of Massachusetts Amherst. We compare open versus closed-basin lakes, and epilimnion versus hypolimnion waters from a suite of LTER lake sites over their sampling histories (Toolik Lake, Lake N1, Lake E5, and Lake Fog 2).

Climate sensitivity of *Alnus viridis* ssp. *fruticosa* and its interactions with *Betula nana* and *Salix pulchra*

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Siberian alder, *Alnus viridis* ssp. *fruticosa*, is expanding in arctic Alaska, and may impact the ecosystem by changing nutrient cycling and plant-plant interactions. It is a large woody shrub whose associations with *Frankia* bacteria allow them to fix nitrogen. Due to its N-fixing potential, it is of interest to study the growth and climate sensitivity of Siberian alder in the Arctic, and to learn more about its potential impacts on surrounding species. By examining the growth of other shrub species growing near (~1m) and away (~10m) from Siberian alder, we can investigate the potential mechanisms that might foster facilitative or competitive interactions between alder and the other shrub species. Twenty-five Siberian alders were harvested along with pairs of dwarf birch, *Betula nana*, and diamondleaf willow, *Salix pulchra*; one additional alder was harvested without pairs. Approximately four cross sections were made for each alder either above or below ground on either side of the suspected collar with two cuts along the same stem. From the cross sections, thin sections were made, ring widths measured, and all parts were cross-dated within thin sections, within plants, and across plants. We've found that Siberian alder can be very long lived (143 years old) and appear to be synchronous with June/July monthly air temperatures from Utqiaġvik. In the future we plan to standardize and de-trend the raw alder chronology, relate the growth curve to summer temperatures to Utqiaġvik, and to measure ring widths of the dwarf birch and diamondleaf willow from near and away sites to asses competitive/facilitative mechanisms from year to year.

Snowmelt hydrology of the Upper Kuparuk River

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The Fourth National Climate Assessment Report (2018) indicate that Alaska has been warming at a rate two times greater than the global average with the Arctic continuing to be experiencing higher rates of warming. Changes to air temperature, permafrost, and snow cover impact the timing and magnitude of snowmelt runoff. Snowmelt spring floods are the largest hydrologic event of the year in many Arctic Alaska river systems. This poster is focused on hydrology of the Upper Kuparuk River watershed, where several monitoring programs have been operating long enough to generate 20-yr climatic and hydrologic records. Long-term air temperature, precipitation, and streamflow data collected by the University of Alaska Fairbanks at the Water and Environmental Research Center and other agencies were used to provide exploratory statistical analysis. While no statistically significant trends in snow accumulation and snowmelt runoff were identified during 1993-2017, observations highlight large year-to-year variability and include extreme years. The spring of 2015 stands out as the warmest, snowiest year on record in the Upper Kuparuk. Further investigation into spring and summer of 2015 included the application of the Snowmelt Runoff Model (SRM) developed by Martinec. Testing SRM in the Upper Kuparuk provides insights and set of recommendations for improved snowmelt runoff forecasting and hydrologic modeling across Arctic Alaska.

Toolik Field Station GIS: Flying into the Future

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In response to research requests for high resolution spatial and temporal data products, the Toolik Field Station GIS Program has developed and continues to enhance our Unmanned Aerial System (UAS) platforms, sensors, and services. Our dual-camera commercial-grade UAV is capable of flying in temperatures down to -20C, allowing us to fly during cold shoulder seasons and capture images of snow conditions and snow events of interest to researchers and management. Our research-grade multispectral camera can record high-resolution (>3cm/pixel) images in the blue, green, red, red edge, and near-IR wavelengths – improving the data products (e.g. NDVI maps of research areas) we can provide Toolik scientists. Our second camera can record very-high resolution (sub-centimeter/pixel) images in the red, green, blue wavelengths which we can process to create 3D models of research features (e.g. thermo-erosional features, river banks, shrub patches, elevation models) at a level of detail previously available only via expensive and time-consuming LiDAR systems. We are excited at the prospects these new tools and data products offer Toolik researchers.

Arctic Wolverine Ecology Project Overview

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Wolverines (*Gulo gulo*) are a circumboreal, panarctic species for which the Arctic Beringia region is typically considered a stronghold. However, research regarding the ecology and conservation needs of the species in the Arctic tundra biome is sparse. Wildlife Conservation Society has been working with partners to better understand the broad-scale distribution and fine-scale habitat associations of wolverines on Alaska's North Slope since 2014. Here we summarize the completed, current, and future research topics of the project.

Epigenetic adaptation during maturation in Arctic white spruce

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Epigenetic response, especially induced by environmental factors, is recognized as an important component in growth and adaptation across species. The Arctic tree line is the largest transitionary ecotone in the world and a site of well-documented environmental stress due to harsh climatic conditions and rising temperatures. Our two-year study of *Picea glauca* (white spruce) around the Alaska North Slope assessed global epigenetic differences across a latitudinal transect ranging from the northernmost point of spruce existence to more verdant Boreal forest. As conifers serve as ideal models for age associated epigenetic adaptation in plants, since mature leaves are exposed to multiple years of frigid temperatures, wind stress and herbivory, while their embryonic leaves lack such exposure, we also examined methylation disparities between embryonic and mature growth. Our analysis demonstrates that global DNA methylation changes in old growth leaves as a function of latitude, while the same correlation is largely absent in embryonic growth. Additionally, we observed rising annual methylation levels across all new growth. Such trends indicate a potential epigenetic-driven learning mechanism that is more pronounced in mature organisms accustomed to environmental stressors, and rapidly evolving to account for yearly temperature changes.

Seedling recruitment and clonal expansion of willows may contribute to tall shrub thickets in retrogressive thaw slumps (RTS) in the Alaskan Low Arctic

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Thermal erosion of ice-rich permafrost soils (thermokarst) is likely to increase in frequency as the Arctic warms. Retrogressive thaw slumps (RTS) are large depressions of exposed mineral soil on hillslopes caused by permafrost thaw and mass soil wasting. Within a decade of disturbance, RTS in the Toolik Lake area are infilled with tall (≥ 0.5 m) willow shrubs. Thickets may be composed of many individuals through increased seedling recruitment post-disturbance, or of fewer recruits and survivors that expanded clonally following disturbance. We compared eight microsatellite loci of two populations, including ramets (aboveground branches) excavated and used as clonal controls: 141 ramets from a RTS aged within 20-30 years since disturbance, and 82 ramets from undisturbed (control) tundra. Ramets were sampled on the same hillslope in 18 x 18 m grids nested at three spatial scales: ≥ 2 m between ramets (broad), 1 m between ramets (intermediate), and 0.25 m between ramets (fine), to understand RTS effects on willow recruitment and expansion. We identified 121 genotypes, including 10 clones, in the RTS and 66 genotypes and 7 clones in the control, with higher Ht in the RTS than control: 0.626 and 0.524, respectively. Expected clonal diversity and percent distinguishable were higher in the RTS than control: 0.997 and 0.86 versus 0.994 and 0.81, respectively. Spatial analysis found three times more broadly-spaced clones in the RTS than control, at an average distance between ramets of 4.4 (1.9) and 1.2 (0.4) m, respectively. Broadly-spaced clones were located 7-16 m downslope in the RTS versus 4 m apart at the same altitude in the control. Our results suggest 1) seedling recruitment may be higher in RTS-disturbed tundra; 2) conditions for clonal expansion may be better in RTS than undisturbed tundra; and 3) RTS may alter the bud bank by separation and translocation of clonal fragments.

Evaluation of permafrost degradation after the Anaktuvuk River Fire using L-band SAR data

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In the Arctic terrestrial regions, climate warming and surface disturbance will alter ground heat balance and induce permafrost degradation. Thermokarst is the process that deforms original landforms due to the thawing of ice-rich permafrost or the melting of massive ice. Thermokarst development is often observed as ground deferential subsidence in the Arctic region after natural or anthropogenic surface disturbances like wildfires and various land-use changes, which impacts local human life and infrastructure. We investigated thermokarst development triggered by a tundra wildfire in Alaska (Anaktuvuk River Fire in 2002) underlain by ice-rich permafrost using both optical and L-band microwave remote sensing as well as in situ fieldwork measurements and observations. GAMMA software was used to generate interferograms from Lv1.1 data of ALOS-PALSAR and Lv1.1 data of ALOS-2/PALSAR-2 by the differential SAR interferometry (DInSAR) technique. Digital surface models (ArcticDEM) were used to simulate and remove topographic fringe. Assuming ground displacement occurred only vertically, the line of sight change was converted to vertical displacement using the incidence angle. Significantly large amounts of subsidence (up to 6.2 cm/year spatial average) were measured by the DInSAR within burned areas relative to unburned nearby in the first three years after the fire. Post-fire interferograms were decorrelated along fire boundaries where rapid surface roughness changes due to lateral erosion can be expected and clearly separated subsiding burned areas from stable areas of intact environment. Inside the burned areas there are some gradual changes in phase values while there are relatively uniform phase values in unburned areas. Despite the topography of the studied area being flat or showing only gentle slopes, the magnitude of subsidence depended on slope angles. Operation period of ALOS2 covered from 8th to 11th years after the fire. The spatial variation of thermokarst subsidence measured during this period shows a markedly different pattern from the period just after the fire (1st to 3rd years). The distribution shift was thought to be reflected from variations in depths to bedrock, active layer thickness, and relative location to burned areas. Observations from high-resolution optical images and field surveys supported the DInSAR measurements of thermokarst subsidence.

Arctic LTER: The role of biogeochemical and community openness in governing response to climate change and disturbance

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The Arctic is rapidly warming. Responses to warming involve acceleration of processes common to all ecosystems (e.g., plant community changes) and changes to processes unique to the Arctic (e.g., loss of permafrost). Our objectives are to use the concepts of biogeochemical and community "openness" and "connectivity" to understand the responses of Arctic ecosystems to climate change and disturbance. "Biogeochemical openness" relates to ecosystems dependence on external sources of nutrients and organic carbon versus nutrients recycled internally and organic carbon fixed locally by photosynthesis. "Community openness" relates to the effect of organism movement in and out of the ecosystem on community and trophic structure. “Landscape connectivity" describes the nature and strength of interactions among ecosystem components and the resultant propagation of ecological signals across the landscape. Components of the Arctic landscape differ widely in biogeochemical and community openness. We will compare key ecosystems of the Arctic to determine how their degree of openness governs their responses to climate change and acute disturbance such as fire and surface slumping associated with permafrost thaw. We will also determine how the responses to climate change and disturbance are mediated by landscape connectivity and the movement of nutrients, carbon, and organisms across Arctic landscapes, and how that movement is facilitated or impeded by the degree of openness of the ecosystems.

Photofate of Tetrabromobisphenol A in Waters Under Natural and Simulated Sunlight

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The discontinued use of polybrominated diphenyl ethers as flame retardants in consumer products has led to its replacement by other brominated compounds, such as tetrabromobiphenol A (TBBPA). TBBPA is extensively used across the globe and its detection in remote regions (e.g. Arctic inhabitants, wildlife, and vegetation) strongly suggests their potential to be globally transported. As such, the widespread presence of TBBPA is of concern since it is an endocrine disruptor. The goal of this project is to evaluate the photofate of TBBPA in sunlit natural waters by investigating the effect of environmental parameters (such as polar-derived dissolved organic matter (DOM) and pH) on the reaction rates, formation of photoproducts, and degradation pathway. Photolysis experiments were performed under natural and simulated sunlight and assayed by ultra performance liquid chromatography-mass spectrometry, which was used to both quantify TBBPA and identify photoproducts. First order half-lives of TBBPA increased with decreasing pH (2.5 min in pH 10.5 water, 3.3 min in pH 8 water, and 26 min in pH 5.5 water), and is likely due to an increase overlap between sunlight irradiance and TBBPA absorption spectra its ionized form. Polar-derived DOM slowed the photoreactivity of TBBPA by 16 to 32%, suggesting that DOM screens the wavelengths responsible for its observed photodegradation. The quality of DOM affected the occurrence and distribution of TBBPA photoproducts.

Characterization of Spatial Heterogeneity of Temperatures in a Tundra River Using Thermal Infrared Imagery

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Spatial heterogeneity in river temperatures provide important thermal refuge habitat for cold-water aquatic taxa in many temperate and tropical rivers. As climate change progresses in the Arctic, it is feasible that the endemic fish populations will seek out similar refuges from increasing river temperatures during dry periods throughout summer months. However, little is known about the occurrence, distribution, and drivers of thermal heterogeneity of Arctic Rivers. In this study we present an analysis of thermal anomalies for a 35 km long reach of the Kuparuk River, Alaska. Using high-resolution thermal Infrared (TIR) imagery from repeat aerial surveys we identified the spatial distribution and magnitude of thermal anomalies under a wide range of flow conditions. We classified these thermal anomalies based on hydro-geomorphic features to develop a conceptual model of the processes that produce thermal heterogeneity in Arctic rivers, and how these processes vary with hydrologic condition. Our preliminary results show that 1) nearly all thermal anomalies were colder than mean river temperatures, 2) thermal anomalies were found to be associated with four major hydro-geomorphic features: tributary and water track mouths, surface transient storage zones, and the downstream side of gravel bars, 3) there were limited differences in the magnitude of thermal anomalies across hydro-geomorphic types, 4) the abundance and magnitude of thermal anomalies were inversely related to river discharge, and 5) the abundance of thermal anomalies in response to changes in discharge varied most for gravel bars and least for tributaries. These findings show that thermal anomalies are abundant under current hydrometeorologic conditions, and highlight the influence of permafrost, landscape connectivity, and groundwater/surface water interactions on producing spatial thermal heterogeneity. Further research is required to determine the sensitivity of currently observed thermal refugia to projected changes in basin characteristics, such as increased depth of permafrost thaw and alterations to hydrologic regimes.

Does vegetation, warming and substrate availability effect decomposability of SOM?

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Soil organic matter (SOM) is formed of dead plants, which together with proceeding decomposition determines the primary characteristics of SOM. Despite SOM characteristics (i.e. nutrient availability and carbon compound composition) determines its decomposability, cold climate and moisture are the primary decomposition limiting factors in Arctic. However, climate warming improves conditions for decomposition and alters vegetation composition, which undoubtedly influences characteristics of “old” SOM previously accumulated after the last glaciation period as well as new slowly forming SOM. These changes might strengthen the role of SOM decomposability when estimating the vulnerability of carbon (C) stored in arctic soils. This study aims to pinpoint the effects of long-term warming and increased amount of decomposition limiting substrates (nitrogen, N, and phosphorus, P) on SOM characteristics and decomposability. The differences in SOM characteristics under common vegetation types are also untangled to estimate the effect of vegetation on SOM decomposability. With the results from this study we hope to have a good start in answering to the following questions: 1) Does vegetation, warming and substrate availability effect characteristics of existing SOM? 2) Does decomposability of SOM vary and is it affected differently by warming and substrate availability between common vegetation types (tundra vs. shrub)? 3) Can chemical characteristics be used to explain vulnerability of SOM carbon in a changing arctic climate?

Plot level measurements of NDVI show warming increases the length of the green season at tundra communities in northern Alaska

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A warming Arctic has been associated with increases in aboveground plant biomass, specifically shrubs, and changes in vegetation cover. However, the magnitude and direction of changes in NDVI has not been consistent across different tundra types. Here we examine the responsiveness of plot-level NDVI to experimental warming at eight sites in northern Alaska, USA. Dry and wet or moist communities were monitored for canopy surface temperatures and NDVI in control and experimentally-warmed plots at near-daily frequencies during the summer of 2017 to assess the impact of the warming treatment on the magnitude and timing of greening. Experimental warming increased canopy-level surface temperatures across all sites (+0.47 to +3.14˚C), with the strongest warming effect occurring during June and July and for the southernmost sites. Greenup was accelerated by warming at six sites, and autumn senescence was delayed at five sites. Warming increased the magnitude of peak NDVI values at five sites, decreased it at one site, and two sites did not change. Warming resulted in earlier peak NDVI at three sites and no significant change in the others. Shrub and graminoid cover was positively correlated with the magnitude of peak NDVI (r=0.37 to 0.60) while cryptogam influence was mixed. Thus the magnitude and timing of peak NDVI showed considerable variability across sites. Experimental warming extended the duration of the summer green season at most sites due to accelerated greening in the spring and delayed senescence in the autumn. We show that in a warmer Arctic (as simulated in our experiment) the timing and total period of carbon gain may change. These changes will impact net primary productivity and trophic interactions; therefore, we encourage a broad adoption of these methods aimed at linking remote sensing with plot level changes occurring across the Arctic.

Living a double life: Communication dynamics on and off the station

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Remote field stations pose unique situations for both staff and researchers often being isolated, confined and extreme environment for weeks to months on end. Generally, remote field stations are far removed from society and people struggle to communicate with those outside of the field camp. The present study sought to uncover the lived experiences of both staff and researchers at Toolik Field Station to understand how remote field station life impacts communication on and off the station. Through 20 interviews of a variety of field camp members, the researcher's findings suggest that much like military members returning home from deployment, the extended period away from family and friends can impact people's ability to reintegrate into everyday life. This study further explored the impact of remote field station life on people's perceived personal gains and how communication was impacted through the use of shifts during a peak summer research season. Finally, the researcher present potential strategies for improving the reintegration coping strategies among staff and scientists.

Who has access: Mapping the impact of Toolik Field Station job postings

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Diversity is a driving force in many companies to expand their job search pool and potential for attracting a variety of talented candidates. Currently, there is a lack of diversity within the sciences and especially within remote field stations impacting the current culture and climate. Many field stations are questioning how to increase diversity among staff, researchers and research projects in order to increase their organizational diversity. The present study used network analysis theory to map Toolik Field Station as an organization to better understand the reach of their current job posting system. Findings suggest that Toolik Field station is utilizing different platforms than other Arctic remote field stations and missing some of the strong communication hubs that interest target populations. Furthermore, findings suggest that there are a few strong ties that connect the remote field station community not being utilized by Toolik. Overall, there is a lack of cohesion in recruitment methods online for remote field stations that may be impacting their access to target and potential populations.

Belowground responses to 20 years of plant species removal in moist acidic tundra

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Plant species possess unique traits (e.g., tissue quality, rooting depth, and relationships with microbes) that drive ecosystem functions such as carbon and nutrient cycling. Anthropogenic climate change has triggered plant diversity loss and profound community composition changes. Given the control of plant species on ecosystems, understanding interactions within plant communities is critical for determining resiliency after disturbance and predicting ecosystem functions under future climate conditions. The purpose of this study was to better understand the effects of plant species and functional types by quantifying belowground responses to long-term species removal. We measured coarse and fine root biomass and distribution as well as root nitrogen concentration from soil samples collected in plots from five species removal treatments: control, *Ledum palustre* removal, *Betula nana* removal, all deciduous species removal, and all canopy removal. Following 20 years of manipulation, there were no detectable effects of plant species removal on root biomass, distribution, or nitrogen concentration. Similar results were observed in aboveground biomass across treatments, indicating that overall plant biomass recovered following species removal. Although biomass was compensated, there were shifts in community composition in response to removal treatments, and species were not necessarily replaced by others in the same functional groups. Shifts in the dominant plant community could result in changes to ecosystem function over longer time scales by altering traits, such as mycorrhizal root colonization, that affect nutrient cycling and other processes.

NEON Aquatics at Toolik Field Station

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The National Ecological Observatory Network (NEON) operates two aquatic field sites out of Toolik Field Station; Toolik Lake and Oksrukuyik Creek. Field work began in 2016, with sites fully commissioned by the Observatory in 2017, and final transition to operations in 2018. The aquatic measurement suite consists of chemical and physical measurements of surface and shallow ground water, diversity and distribution of aquatic microbes, algae, aquatic plants, invertebrates, and fish. Annually, NEON generates over 2,200 individual samples from our two arctic sites that are shipped to external facilities for analysis, or to the NEON Biorespository at the University of Arizona. Our research enables submeter-scale observations of the physical, chemical, and biological structure of streams and lakes at 34 sites across the United States, and our two arctic field sites were selected to complement the rich history of research in the region through the Arctic LTER.

Partitioning of emerging contaminants to Arctic dissolved organic matter

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Anthropogenic organic pollutants have been commonly detected in the Arctic, and include new classes of brominated flame retardants (BFRs) and current use pesticides (CUPs). In this study, we focus on the environmental fate of chlorpyrifos (CUP) and tetrabromobisphenol A (TBBPA), which is a flame retardant). These chemicals are produced and used at lower latitudes and transported to higher latitudes through global distillation processes. These two chemicals have been detected in various environmental compartments in the Arctic where they are neither used or manufactured. These chemicals have been found in the indigenous Alaskan Yupik communities at relatively high concentrations, and we believe that the exposure pathway is through bioaccumulation up the food chain. One process that can limit exposure and bioaccumulation of these compounds is through their interactions with Arctic dissolved organic matter (DOM). We hypothesize that the presence of DOM in Arctic surface waters at sufficiently high enough concentrations (> 10 mg/L) will bind these chemicals making them less bioavailable. Solubility enhancement studies for chlorpyrifos and TBBPA were conducted with various types of Arctic DOM (Imnavait Creek and a tundra seep adjacent the Sagavanirktok River). The DOM concentrations ranged from 5 mg/L to 90 mg/L with two controls at 0 mg/L and the compounds were analyzed by liquid chromatography. Our measured solubility values for TBBPA and chlorpyrifos were in excellent agreement with reported those reported in the literature (0.3 and 9 µM respectively). Surprisingly, we observed loss of TBBPA in the presence of DOM, which was unexpected. Solubility enhancement experiments of chlorpyrifos are ongoing.

Predictability of variable arctic soil hydraulic and thermal properties, and implications of such variability on future thaw

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Global climate change is driving rapid increases in arctic temperatures and the thawing of shallow permafrost. The amount of anticipated permafrost thaw has uncertainty because of the limited observations of hydraulic and thermal properties of arctic soils. This is especially true in the ‘organic mat’ that tends to overlie continuous permafrost in the arctic. However, few studies consider how the depth-variability of hydraulic and thermal properties observed in the organic mat could affect how the arctic active layer thaws and laterally transmits groundwater. Here we present high-spatial-density measurements of organic mat hydraulic and thermal properties, as well as model simulations of groundwater flow and freeze-thaw informed by these measurements. Our measurements of water retention, thermal conductivity, organic matter content, porosity, and permeability across multiple watersheds with continuous permafrost illustrate that soil hydraulic and thermal properties vary predictably due to spatial factors such as depth, glacial age, location along a topographic transect, and microtopographic relief. Furthermore, simulations of freeze-thaw and groundwater flow indicate that the observed variability can exert a strong control on active layer thaw and groundwater fluxes. These findings can be used to inform landscape-scale Land Surface Models designed to predict changes in heat, water, and carbon fluxes in arctic watersheds due to increased thaw.

The National Ecological Observatory Network's Flora Data Collection at Toolik Field Station

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Each year Neon performs several flora-related protocols at Toolik Field Station. These protocols include measurements of diversity, biomass, and primary productivity. Neon's Plant Phenology measurements record the seasonal progression of critical biological processes and the timing of ecological events of three species in Toolik throughout the growing season. Separately, our Startdot Netcam mounted to Neon's flux tower captures RGB and IR images every 15 minutes. The Plant Diversity protocol targets data that can be used to understand changes in composition, distribution, and abundance of native and non-native plant species over time. Neon also collects and curates foliar material for analysis of plant genetic diversity over space and time as part of this protocol. Leaf Area Index (LAI) is a useful proxy variable for numerous other variables of ecological interest including plant biomass, plant productivity, forage quality, carbon balance, ecosystem energy flux, plant density, and the heterogeneity of plant cover. The Herbaceous Biomass protocol is used to measure above-ground plant productivity, which dominates the total net primary productivity (NPP) of the tundra. Neon provides open data for each of these protocols to contribute to the understanding of changing ecosystems.

Apportioning seasonality of soil respiration sources: A passive, quasi-continuous $^{14}CO_2$ sampler

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Today, the Arctic is warming and degradation of permafrost may subject permafrost carbon (C) to microbial mineralization and fluxes to the atmosphere (Schuur, 2015).

Loss of permafrost C can be quantified in situ by measuring the radiocarbon (^{14}C) content of soil and ecosystem respiration, because permafrost C is older (depleted in ^{14}C) than current plant products and soil C cycling operates on timescales of years to centuries. Fast-cycling C will have a ^{14}C signature like the atmosphere, while slow-cycling C (i.e. previously frozen, mineral bound, highly decomposed, or otherwise recalcitrant) will have undergone significant radioactive decay.

The net surface isotopic flux over a short period of time can be measured with traditional chamber techniques and combined with incubation experiments and bulk soil analysis to constrain end members of ecosystem respiration. However, this approach fails to resolve proportional contributions by depth, and is not feasible in the winter. By sampling continuously at different depths throughout the year, we aim to address:

1) Which soil C pools are being consumed by microorganisms during the winter;
2) What proportion of the carbon originates from microorganisms decomposing organic matter (as opposed to from the roots of plants that are fixing C from the atmosphere) during the summer.

Post-fire response to nutrient addition

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Characterized by low-temperatures and severe nutrient limitation, the arctic responds readily to environmental changes such as warming. Thus, climate change has the potential to influence important ecosystem processes such as nutrient cycling and wildfire activity in these regions. Predicted annual temperature increases are expected to stimulate nutrient cycling through accelerated plant-soil interactions and increase wildfire activity through a warmer, drier regional climate. However, the role wildfire plays in arctic nutrient cycling is unclear. It is believed that wildfire will increase nutrient availability shortly following such events so one might expect post-wildfire tundra to be less nutrient limited. However, given the severe nutrient limitation of arctic tundra, we hypothesize that burned tundra will still respond to nutrient addition. In this study, nitrogen and phosphorus were added to severely burned and unburned arctic tundra for 3 years to capture vegetation response. Nutrient addition of the severely burned site occurred during the ninth, tenth and eleventh year of post-fire recovery at the Anaktuvuk River burn scar in northern Alaska. The addition of nitrogen, phosphorus and nitrogen plus phosphorus resulted in varying degrees of species composition, canopy structure, and ANPP in both tundra types. Yet, the response was generally stronger in burned tundra, suggesting a nutrient limited environment even after fire. As such, both wildfire occurrence and wildfire history have the potential to impact tundra ecosystem behavior in novel ways that are only beginning to be understood.

Unraveling the relationship between *Eriophorum vaginatum L.* flowers, *Pseudopachychaeta ruficeps* (Chloropidae) and an unknown wasp in the Alaskan tundra through an exclusion experiment

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Eriophorum vaginatum L. (Cottongrass) is a tussock forming sedge that dominates the moist arctic tundra. Flowers are wind pollinated/dispersed and form cotton bristles to aid in dispersal once mature. *Pseudopachychaeta ruficeps* (Zetterstedt,1838) (a fly in the Chloropidae family) and an unknown wasp have been found in the flower head, however, little is known about the natural history of the flies and wasps or whether they affect seed production. To determine whether fly larva are already present on the flower prior to snow melt, three 100m x 2m transect grids were laid out at Toolik Field Station and at Sagwon. Every 2m along the transect, the nearest tussock had up to 15 exclusion bags fastened over each inflorescence until 150 were bagged per transect. In all, 900 exclusion bags were set out after snow melt in early June. After three weeks, one transect of bagged flowers and 150 control flowers from the same transect grid was harvested each week and sealed in individual coin envelopes. Flowers were dissected in search of insects present (at any life stage) and viable seeds were counted.

There was no significant difference in seed production between the bagged and control flowers suggesting that the organza bag allowed pollen to penetrate without issue. We found a fly in 56% of the control flowers and a wasp in 16% of control flowers. However, there was a significant difference ($p < 0.05$) in the presence of wasps, being observed in 0.16 wasps/flower of the control samples, but only 0.03 wasps/flower in the bagged samples. Also, 1.06 flies/flower in the bagged samples were found compared to 0.56 flies/flower in controls, indicating that they were present from the time of bagging shortly after snow melt. These findings lead us to believe that the flies lay their eggs in the late summer to develop the following spring whereas the wasps emerge during the spring. There is some evidence to suggest these wasps are parasitoids, possibly on the flies, which warrants further investigation.

Nutritional Landscapes: Observations, Experiments, and Models Yield Insights to the Arctic Caribou System in Alaska

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Terrestrial Arctic systems are the result of complex interactions between climate, vegetation, herbivores, and humans that must be studied together to fully understand their functional traits today and in the future. While low temperatures and short-growing seasons limit plant growth, enough plant biomass exists to support herds of migratory caribou, which Native Alaskans depend on for their livelihood. Any changes in the base of the food web (vegetation and soils) have cascading consequences for primary (herbivores) and secondary (humans) consumers and their interactions. Today, the Arctic system is in the midst of transformational climate change resulting in new vegetation assemblages, changes in the nutritive value of plant tissues, and ultimately the diets of migratory caribou and the humans that depend on them. This project examines the nutritional landscape of the Central Arctic Caribou Herd as a unifying concept in Arctic System Ecology. This project describes the nutritional landscape as “caribou available protein” (CAP) and “caribou available energy” (CAE), integrative forage quantity (kg m^{-2}) measures that reflect biomass, species composition, plant C and N content, digestibility, and secondary compounds. Understanding the drivers of spatial and temporal patterns in the amounts of CAP & CAE across the tundra (field sampling, remote sensing, hierarchical modeling); caribou use of this nutritional landscape (collared animal location data and movement modeling); how the amounts of CAP and CAE (kg m^{-2}) will differ in the future under a suite of likely climate scenarios (forecasting) using our long-term experiments, and the interactions between caribou, infrastructure and Native communities are the core themes addressed in this program.

The intellectual merit of this project is the merging of five elements to understand Arctic System function and response to climate change: (1) A landscape-scale assessment of plant species, soil and plant C and N, digestibility, and secondary compounds that will be used to calculate the amounts (kg m^{-2}) of CAP and CAE; (2) analysis of how closely caribou foraging is tied to the nutritional landscape throughout the year; (3) analysis of samples from an existing long-term winter x summer climate change experiment to provide data on how CAP and CAE will differ in the future; (4) prediction of future nutritional landscapes and caribou foraging interactions; and (5) observations of Native hunter harvesting and attributes of the system that determine their spatial and temporal patterns. These project components allow the program to create an integrative understanding of

how an important herbivore such as caribou interacts with a landscape that is rapidly changing. This research is of great merit because it: (1) examines the Arctic System from primary production to secondary consumers and the influence of climate change across multiple trophic levels; (2) applies broadly by examining the most abundant large herbivore and its food sources, both of which are distributed throughout the Arctic; and (3) integrates experimental, observational, and modeling approaches to understanding ecological systems and climate change. The integration of observation, experimental data, and modeling to describe current and forecast future nutritional landscapes will provide a mechanistic understanding of Arctic System function and transform understanding of climate-vegetation-caribou-subsistence hunter interactions.

The broader impacts of this study involve residents of the North Slope community of Nuiqsut, the worldwide caribou community, and students at multiple stages of education. The project will imbed a member with hunters in Nuiqsut, and develop an educational/scientific documentary on caribou-Native Alaskan life cycle for high school students. This facet of the program leverages EPSCoR funding for Alaska. We anticipate employing village students and UAA undergraduates affiliated with the Alaska Native Science and Engineering Program (ANSEP) to assist with experimental work at Toolik Lake and vegetation collection. This research is significant to ecologists from the Circumarctic Rangifer Monitoring and Assessment Network (CARMA), who will use our data to consider how a suite of climate change scenarios affect herd fecundity and population dynamics. CARMA cooperators are dedicated to caribou conservation and sustainable management in the US, Canada, and Scandinavia.

NEON Assignable Assets Program - Putting NEON Assets to Use for the Research Community

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The National Ecological Observatory Network (NEON) is a long-term ecological observatory focused on collecting and providing open, continental-scale data that characterize and quantify complex and rapidly changing ecological patterns and processes. As part of the broader Observatory design, specific components of the Observatory are available to funded researchers for Principal Investigator-driven studies as part of NEON's Assignable Asset Program. The available Assignable Assets include the Mobile Deployment Platform (MDP), the Sensor Infrastructure (SI), sampling locations or biological samples as part of the Observational Sampling Infrastructure (OSI), and the remote sensing capabilities of the Airborne Observation Platform (AOP). In addition to the infrastructure assets, NEON has deployable field sampling teams near NEON sites to support specimen collection and observations for specific research needs. Researchers can also gain access to the growing collection of plant and animal specimens and soil and water samples that NEON staff have gathered and stored in the NEON Bioarchive for study and analyses.

Mobile Deployment Platform (MDP): NEON offers a suite of these self-contained, mobile arrays of sensors, power systems, and data logging capabilities for capturing atmospheric, soil, and aquatic-based measurements.

Sensor Infrastructure (SI): Includes infrastructure (i.e., towers, power, and communications) for physical instrument systems or arrays for collecting environmental data from automated sensor suites.

Observational Sampling Infrastructure (OSI): Allows researchers access to NEON sampling locations or to biological samples at NEON sites before samples are archived.

Airborne Observation Platform (AOP): Provides a suite of remote sensing instruments mounted into a Twin Otter aircraft for collecting airborne-based data at nearly any site of interest in the U.S.