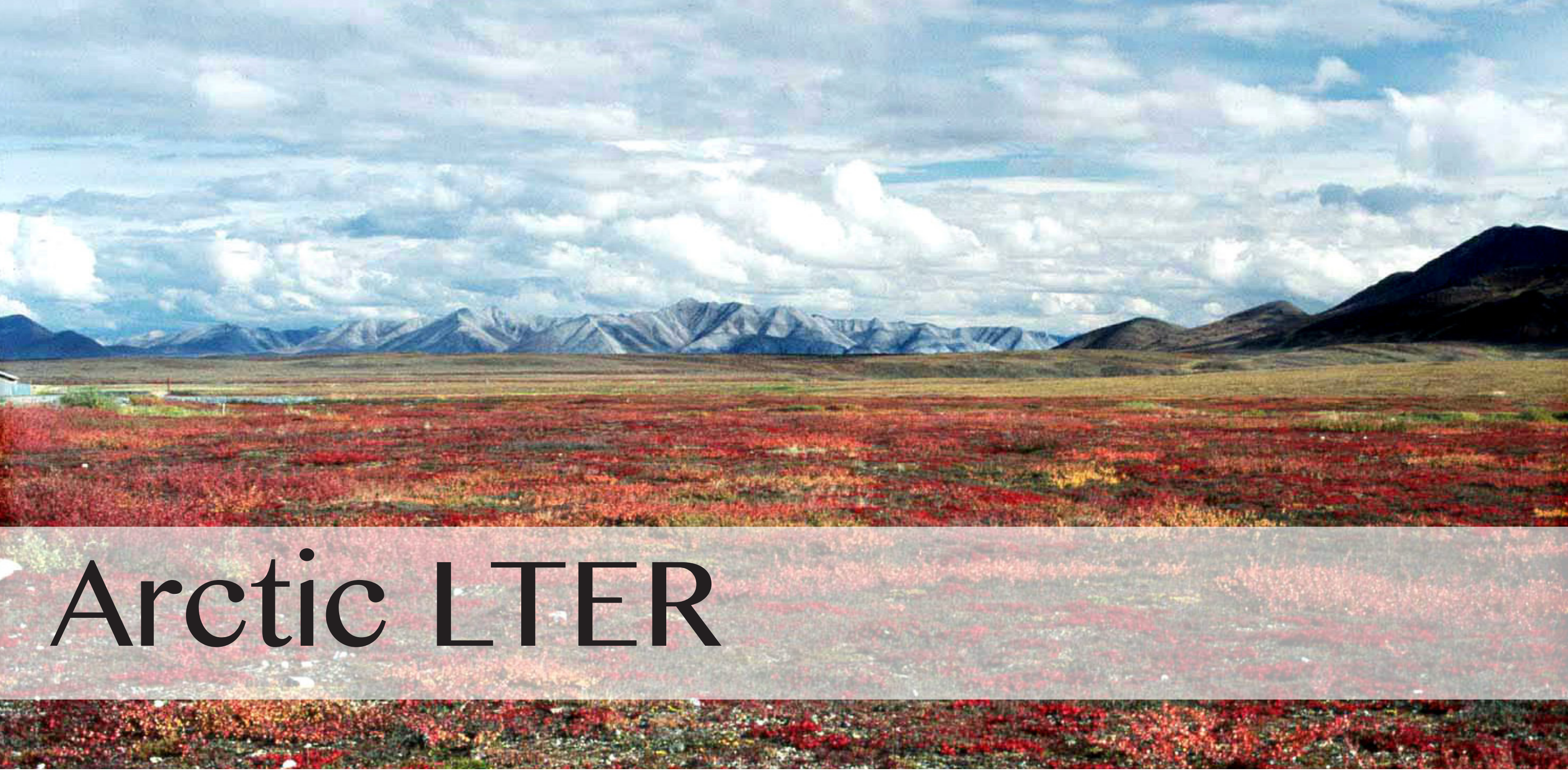


Arctic LTER

Arctic (ARC) LTER uses long term monitoring and manipulations of temperature, nutrient inputs, and community structure to understand how tundra terrestrial, stream, and lake ecosystems respond to climate change and climate-induced disturbances such as wildfire and permafrost thawing. Recent research explores biogeochemical and community openness and connectivity as ways to describe and predict how climate related changes propagate across the landscape.

Key Findings

Ecosystem enrichment in terrestrial and aquatic systems. Warming will increase nutrient cycling in soils, increasing its fertility and nutrient supplies to streams and lakes. Data from long term fertilization studies at ARC LTER are used to model tundra responses to climate change and disturbance. Long term phosphate fertilization has altered the Kuparuk River's structure and function, but lake response to fertilization is complicated by lake morphometry – benthic and planktonic communities exhibit different responses in deep versus shallow lakes.

Between 2008-2018:

33 investigators

21 institutions represented

20 graduate students

Tundra

Principal Investigator:

Edward B. Rastetter

The Marine Biological Laboratory

Est. 1987

Funding Cycle:

LTER VI

NSF Programs:

Biological Sciences / Division of Environmental Biology

Geoscience / Office of Polar Programs

Diversity of species interactions in a changing Arctic. Microbial communities decreased from soil, to streams, to lakes. About half of the common lake bacteria detected were rare species in soils and headwater streams [Product 3]. Initial inoculation from soils was followed by species sorting downslope. With warming, microbial trophic structure has become more homogenous across soil horizons, and plant biomass and woody plant dominance has increased [10]. Arctic LTER researchers have found that, in lakes, warming caused fish populations to cycle between large and small individuals. Models predicted faster growth, which would require more food, increased reproduction, and decreased generation time [1].

Wildfire and thermokarst: impacts and recovery. In 2007, a massive tundra fire released ~2 Pg of carbon into the atmosphere [8]. Climate-driven fire may accelerate warming, potentially offsetting the effects of arctic greening. Long term effects of wildfire on tundra were assessed and incorporated into a model simulating recovery from fire and the loss of ~66 Gg of nitrogen. Tundra darkening caused by fire likely increases thermokarst activity, increasing long term nutrient delivery to streams, and enhancing the biogeochemical connectivity between terrestrial and aquatic ecosystems. The magnitude of this effect is comparable to the ARC LTER fertilization experiments on the Kuparuk River.

Transport and transformation of DOC in aquatic systems. Dissolved organic carbon (DOC) released from thawing permafrost soil can be respired by microbes almost twice as fast if the DOC is first exposed to UV light [2]. Arctic LTER long term data indicate that direct photochemical degradation of DOC from land is the dominant mechanism of DOC oxidation in streams and lakes.

Indirect indicators of rapid warming in the Arctic. Although air temperature at Toolik Lake is too variable for a warming trend to be statistically significant, several long term measures indicate warming [5]. After 40 years, satellite data indicate “greening,” but plot re-harvesting in 2018 does not indicate an increase in shrub abundance. Alkalinity in Toolik Lake has doubled over 40 years, indicating deeper thaw, which allows water to flow through from deeper, more carbonate-rich soil layers. Stream water alkalinity, base cation concentrations, nitrate, and DOC have all increased in ways consistent with permafrost thaw [6]. Dissolved phosphorus has decreased in the Kuparuk River, contrary to expectations.

Synthesis

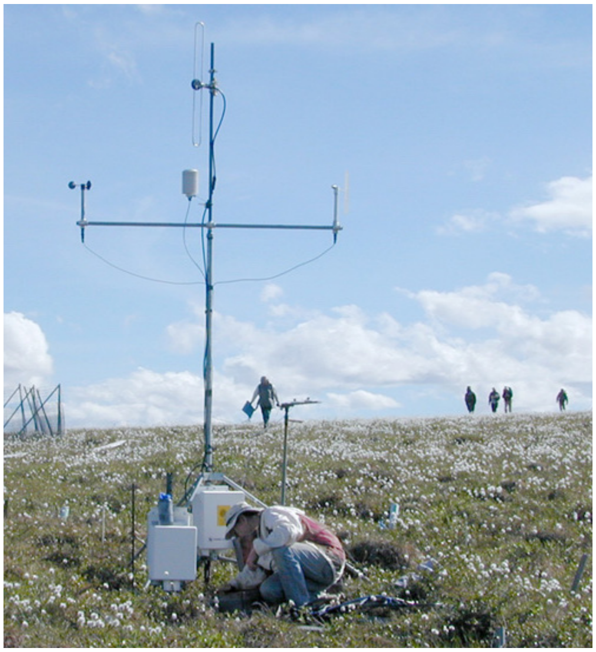
An Arctic model of carbon metabolism. As part of the International Tundra Experiment (ITEX), ARC LTER scientists helped identify a convergence in ecosystem carbon metabolism among all major vegetation types in Arctic and subarctic tundra in Alaska, Greenland, Svalbard, and Sweden [9]. A single regression model predicts net ecosystem metabolism (NEP) as a function of leaf area, air temperature, and light. As the Arctic warms, biomass increases, and vegetation patterns shift — NEP can still be predicted based on these three easily quantified variables.

Forty-five years of tundra research. Research at Toolik Station began in 1975; a new book synthesizes research and results up to present day, emphasizing the importance of long term data measurements and curation through LTER [5]. The volume includes chapters on past and predicted future climate, a synthesis of paleoenvironmental change in the ARC LTER region, and the ITEX collaboration.

Modeling nutrients and disturbance. The multiple element limitation (MBL MEL) model has been used to compare model predictions to five years of eddy covariance data from fire recovery with the aim of projecting long term tundra recovery from fire, and to spatially predict C, N, and P budgets for Northern Alaska. Arctic LTER researchers are identifying patterns of variation in response to climate and disturbance by applying the model to 8 LTER sites (ARC, AND, BNZ, HBR, KBS, KNZ, HFR, & NWT), an Amazonian tropical forest, and a pine plantation in the southeastern U.S.

Partnerships

Toolik Field Station, Institute of Arctic Biology, University of Alaska, Fairbanks | Marine Biological Laboratory | University of Michigan | Townson University | University of Vermont | Utah State University | NASA



Data Accessibility

The Arctic LTER data archive includes datasets from the Toolik Lake site and collaborating projects back to 1975. Datasets are updated and added after documentation and quality checking (usually within 2 years). They are then posted to the Arctic LTER website and to the Environmental Data Initiative (EDI) data portal where they are available and licensed under a Creative Commons License. Data from projects supported by the NSF Office of Polar Programs (OPP) are uploaded to the Arctic Data Center upon PI request.

Broader Impacts

Sharing priceless experiments. Arctic LTER actively encourages other researchers, their students, and postdocs to conduct complementary studies using ARC LTER field sites, experiments, and data.

Polar journalists. Arctic LTER has hosted approximately 20 journalists through the Logan Science Journalism Program at the Marine Biological Laboratory.

Engaging communities and resource managers. Researchers from ARC LTER regularly offer talks and short courses for Alaskan Native communities at Anaktuvuk Pass, Kaktovik, and Barrow. They also provide briefings to the U.S. Bureau of Land Management, Arctic National Wildlife Refuge, Alaska Division of Natural Resources, Alaska Fish and Game, and North Slope Borough.

Plugging into an Arctic network. Two NSF REU students per year — and many other graduate and post-baccalaureate students — gain invaluable field work experience at ARC LTER.

K-12 education. Arctic LTER has hosted over 35 K-12 teachers and PolarTREC teachers who work directly with site scientists. The LTER schoolyard program engages K-12 students in Barrow, AK and works with the Environmental Literacy Program at Colorado State University.

Top Products

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Photo credits: John Hobbie (top); ARC LTER & U.S. LTER (all others)