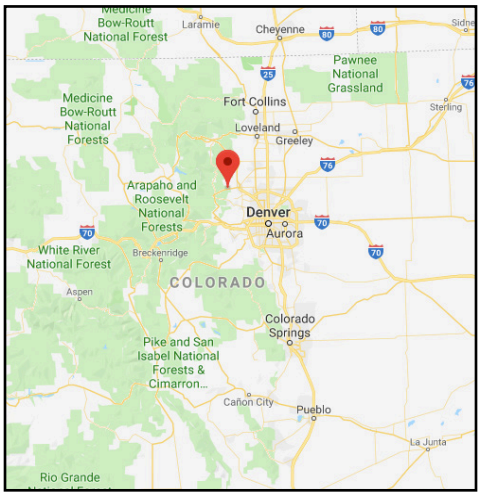
Niwot Ridge LTER

The entire study site of Niwot Ridge LTER (NWT) lies above 3,000 m elevation, approximately 35 km west of Boulder, Colorado. The NWT LTER program is built on a foundation of long term monitoring and experimental research designed to understand ecological dynamics of high elevation, mountain ecosystems, and their responsiveness to climate change. The program's overarching goals are to better understand where and when climate change leads to ecological change, to elucidate the mechanisms driving ecological sensitivity and buffering in this system, and to use this information to enhance forecasting, management, and conservation in mountain areas.



Between 2008-2018: **45** investigators **10** institutions represented **52** graduate students

Tundra

Principal Investigator:

Katharine Suding

University of Colorado, Boulder

Est. 1980

Funding Cycle:

LTER VII

NSF Program:

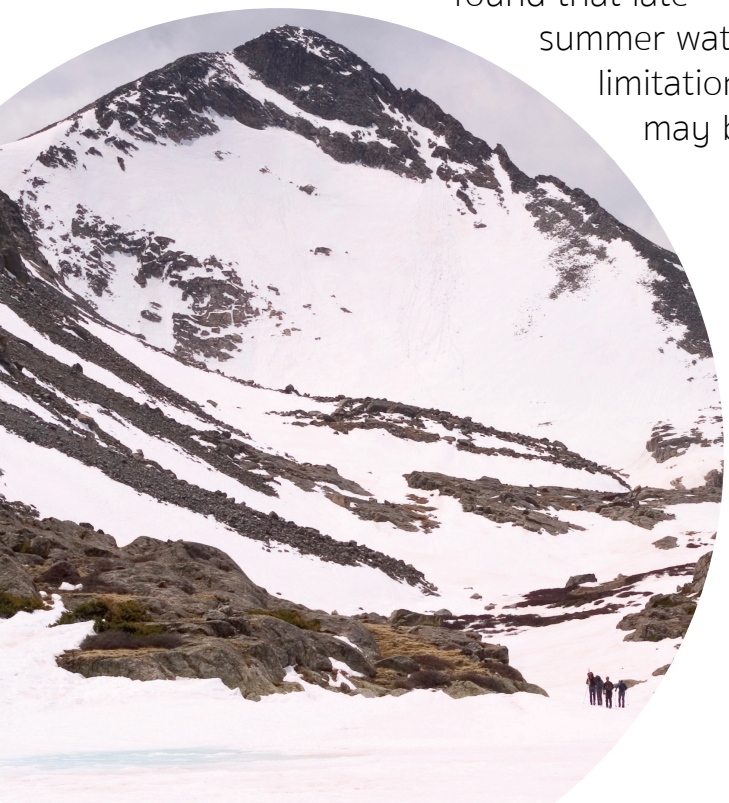
Biological Sciences / Division of Environmental Biology

Key Findings

Permafrost and stored ice are thawing. Longer, warmer summers are associated with permafrost and stored ice thawing. The Arikaree Glacier is losing large volumes of ice and is expected to disappear in the next two decades. Thawing contributes to increased solute export associated with rock glaciers [Product 1] and winter carbon loss associated with tundra solifluction lobes [2].

Snow redistribution and snow melt timing are key to ecological response. Longer, warmer summers increase heterogeneity in catchment snowmelt timing and flushing [3]. As snow melt flows through soils, it accelerates biogeochemical process rates in some areas [4], increasing tundra production. In windblown areas that receive little snow melt, however, the extended period of water limitation driven by these same climate conditions causes a decline in primary production [5].

Little treeline advance, increased tree mortality. Treeline projections often focus on warming. However, NWT LTER researchers found that late summer water limitation may be a primary constraint on treeline expansion [6]. Longer, warmer summers also accelerate tree mortality, reduce tree recruitment, and decrease forest production within the subalpine forest [7].



Uphill spread of tundra vegetation. Once limited by a short growing season, vascular plants have colonized almost one fifth of the very high elevation unvegetated talus areas over the last four decades [6]. Diverse and active microbial communities may be key players in these colonization dynamics [8].

Decline of pikas. Pikas are widely considered a sentinel species for detecting ecological effects of climate change. Populations at Niwot Ridge and across the Western U.S. are projected to continue declining, and as a result, pikas have been considered for listing as threatened at the state and federal levels. Research at NWT LTER has shown that pikas in warming sub-surface areas show signs of chronic stress. [9]

Extended summer responses in lakes. Climate driven changes in alpine lakes, such as earlier ice-off and warmer surface water temperatures, are associated with reduced summer streamflow, increased water column thermal stratification, and higher late summer solute (including nitrate) concentrations. [10]

Photo credits: Todd Ackerman (left); NWT LTER (right)

Synthesis

The role of synchrony in ecological stability. This project led by two NWT LTER investigators uses statistical techniques to examine long term, spatially replicated data from both terrestrial and aquatic LTER sites to understand the timescales at which synchrony occurs, identify drivers of synchrony, and integrate the effects of population and community synchrony on ecological stability.

Synthesizing multi-scale observations, manipulations and models of soil organic matter. Will Wieder, a NWT LTER investigator, leads this project combining soil organic matter data across LTER sites, Critical Zone Observatory (CZO) sites, the Detrital Input and Removal Treatments (DIRT) Network, and the Nutrient Network (NutNet). The goal is to evaluate theories of soil organic matter stabilization and understand the impact of experimental manipulations on soil organic matter across a variety of sites.

Partnerships

The Boulder Creek Critical Zone Observatory (CZO) | NEON | NOAA | National Atmospheric Deposition Program (NADP) | AmeriFlux | City of Boulder

Data Accessibility

Long term climate records in the NWT data archive include continuous measurements from stations established in the 1950s. The local data catalog is linked to the Environmental Data Initiative (EDI) repository through the PASTA API. This recently implemented solution improves NWT LTER's ability to version data, track updates, and more rapidly deliver datasets to EDI.

Photo credits: Erika Zambello (top); NWT LTER (right)

Broader Impacts

Graduate seminar in communication. Graduate students learn strategies for avoiding jargon, assessing prior knowledge, and engaging public audiences in meaningful scientific conversations. Students in the seminar share NWT LTER science with public audiences by teaching early elementary school children, developing short online videos, giving lectures to volunteer naturalist groups, leading tours of the research sites, and attending *Meet a Scientist* events at the public library.

Sharing alpine science. New partnerships with Winter Wildlands Snow School, Wild Bear Ecology Center Nature Camp, Nature Kids Lafayette, and the Colorado University Museum of Natural History have allowed NWT LTER researchers to share their science with over 300 students during 2019. The NWT LTER Schoolyard Book, *My Water Comes from the Mountains*, was used for outreach, along with a new curriculum and materials kit, in Boulder Valley School District (~80 fourth grade classrooms) and in 15 other communities around the state.

Engaging city staff and residents. A climate change seminar and a monthly newsletter are used to communicate NWT LTER research and high level findings to City of Boulder staff as a "Monthly Water Quality Update."

Photo credits: William Bowman (above and cover)

Top Products

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2. Knowles, JF et al. 2019. Evidence for non-steady state carbon emissions from snow-scoured alpine tundra. **Nature Communications.** doi: 10.1038/s41467-019-09149-2
3. Jepsen, SM et al. 2012. Interannual variability of snowmelt in the Sierra Nevada and Rocky Mountains, United States: Examples from two alpine watersheds. **Water Resources Research.** doi: 10.1029/2011WR011006
4. Darrouzet-Nardi, A et al. 2011. Hot spots of inorganic nitrogen availability in an alpine-subalpine ecosystem, Colorado Front Range. **Ecosystems.** doi: 10.1007/s10021-011-9450-x
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6. Bueno de Mesquita, CP et al. 2017. Topographic heterogeneity explains patterns of vegetation response to climate change (1972–2008) across a mountain landscape, Niwot Ridge, Colorado. **Arctic, Antarctic and Alpine Research.** doi: 10.1080/15230430.2018.1504492
7. Andrus, RA et al. 2018. Moisture availability limits subalpine tree establishment. **Ecology.** doi: 10.1002/ecy.2134
8. King, AJ et al. 2010. Biogeography and habitat modelling of high-alpine bacteria. **Nature Communications.** doi: 10.1038/ncomms1055
9. Wilkening, JL et al. 2015. Relating sub-surface ice features to physiological stress in a climate sensitive mammal, the American pika (Ochotona princeps). **PLOS one.** doi: 10.1371/journal.pone.0119327
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