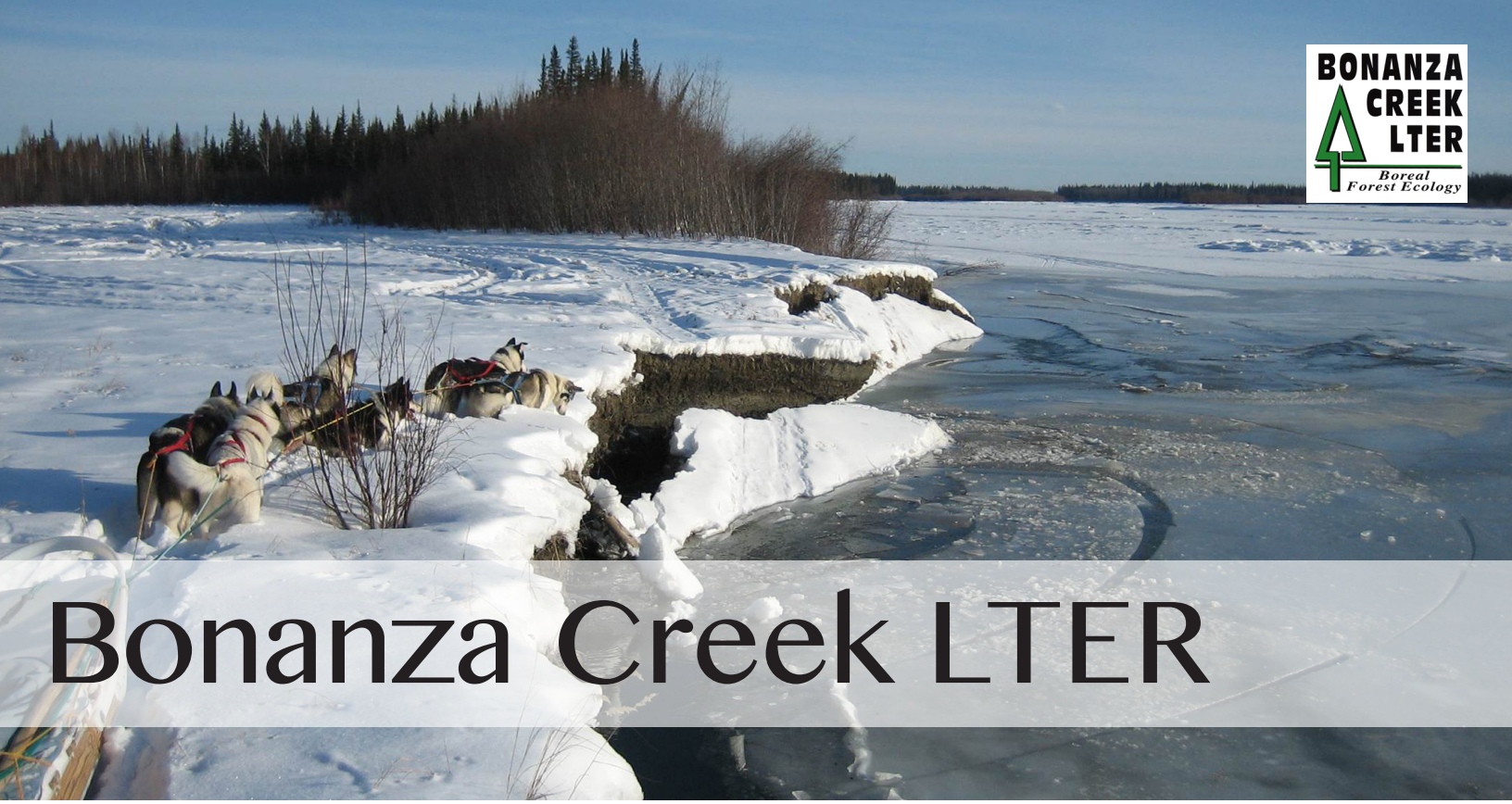
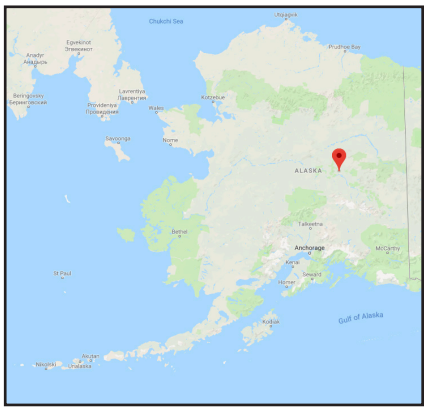


Bonanza Creek LTER

Bonanza Creek (BNZ) LTER is based in Alaska's interior boreal forest, where the climate has warmed more than twice as rapidly as the contiguous U.S. over the past century. Bonanza Creek LTER research shows how climate warming has altered disturbance patterns and their interactions. Changes in fire frequency, size and severity, rate of permafrost thaw, surface hydrology, and insect and pathogen outbreaks are reshaping the Alaskan landscape by influencing biogeochemical cycles, succession, and patch size. Current research seeks to understand consequences for regional feedbacks to the climate system, and to identify social-ecological vulnerabilities, and to explore adaptation opportunities with rural Alaskan communities and land management agencies.



Data Accessibility

Since 1987, BNZ LTER has maintained a comprehensive catalog of data products. Data are submitted to the Environmental Data Initiative (EDI) repository, as well as to NASA, NADP, GenBank, and Ameriflux. A portal available to the streaming climate sensor network allows visitors to access and visualize current and historical measurements.

Between 2008-2018:

91 investigators

11 institutions represented

166 graduate students

Forest

Principal Investigator:

Roger Ruess

Institute of Arctic Biology, University of Alaska, Fairbanks

Est. 1987

Funding Cycle:

LTER VI

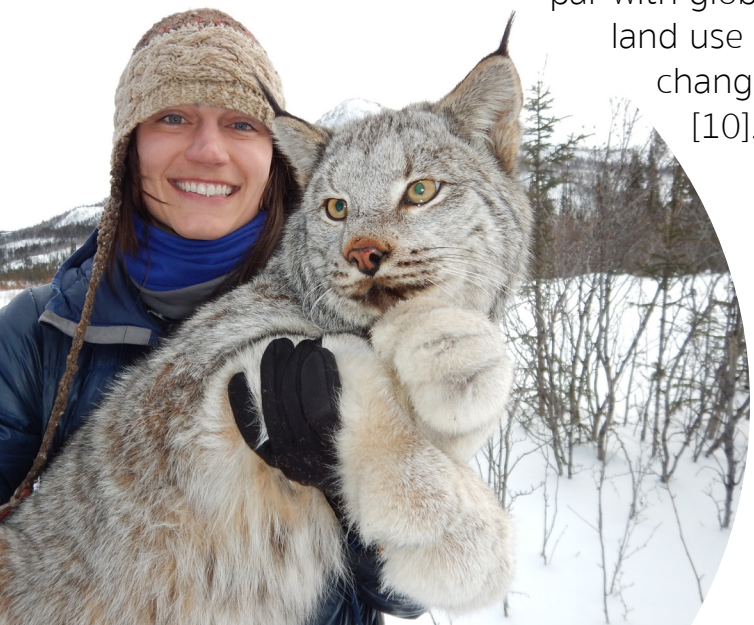
NSF Program:

Biological Sciences / Division of Environmental Biology

Key Findings

Severe fires drive shifts from black spruce to broadleaf dominance. Severe late summer fires consume the soil organic layer, allowing deciduous tree species, such as aspen and birch, to establish at high densities. The fast decomposing litter and rapid evapotranspiration of deciduous trees maintain a thinner, drier organic layer that does not sustain spruce forests or insulate permafrost. This ecosystem state change alters an iconic Alaskan ecosystem by modifying productivity and carbon storage, climate regulation, and other ecosystem services to society. [Products 1, 6]

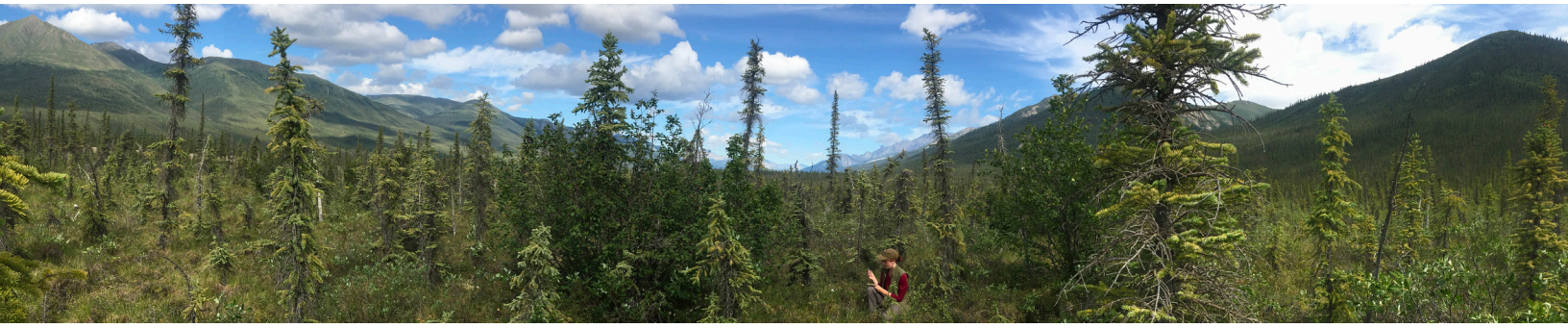
Thawing permafrost and more frequent wildfires are likely to amplify climate warming to the same extent as land use change worldwide. Measurements across latitudinal gradients, field experiments, and laboratory incubations all point to significant releases of CO_2 and CH_4 from soils that have been frozen or waterlogged since the last ice age. Over decadal time scales, this carbon release could overwhelm increased plant carbon uptake. In a warmer world, the boreal forest could be transformed into a major carbon emitter, putting the forest on par with global land use change [10].



A longer snow free season is likely to increase energy absorbed by land surface and speed up warming. Models that assess climate feedbacks over the next centry have simulated decreases in albedo due to a shorter snow season, wider extents of deciduous forest due to altered fire regimes, and changes in climate and atmospheric CO_2 and CH_4 emissions. The strongest climate feedback was positive, derived from lengthening the growing season (reducing the snow-albedo feedback). Increases in young, faster-growing deciduous forests and a net increase in carbon uptake by terrestrial ecosystems only partially counterbalanced this change [3].

Browsing by large herbivores influenced vegetation development and ecosystem function. Browsing by moose and snowshoe hares affects plant species composition, growth, population dynamics, nutrient cycling, and ecosystem function at both stand and landscape scales, causing effects that can persist for decades. Both species selectively consume willows, leading to the dominance of alder, an important nitrogen-fixing species that is chemically defended against herbivory. Snowshoe hare abundance varies nearly as much on an intra-annual basis as it does across a decadal population cycle, underscoring the complex interaction of biophysical factors. This in turn influences predation intensity and the population abundance of lynx, which is largely controlled by emigration and immigration [4, 7].

Partnerships with local communities facilitate knowledge exchange. Local residents observe that warming has changed the timing of freeze up, affected river ice thickness and melt, and has reduced winter travel safety and access to local ecosystem services. Wildfire reduces access to the land, threatens cultural and historic sites, and reduces wildlife densities for one to several decades (e.g. moose and caribou, respectively). Sources of resilience range from oral traditions and cooperative harvesting strategies to new technologies and network sharing [2].



Synthesis

Forest regime change framework. Researchers at BNZ LTER led the development of a novel framework to articulate how changing disturbance regimes impact recovery and resilience of forest ecosystems. Two types of ecological memory (legacies) can support recovery, but may become misaligned with present conditions when disturbance regimes change, creating "resilience debt." Information legacies include species adaptations and the pool of genetic information. Examples of material legacies include seed banks and soil carbon stores. Information from multiple diverse forest ecosystems indicates that they are most vulnerable to regime shifts when disturbance and climate change erode ecological memory. [Product 6]

Assessment of land carbon dynamics in Alaska. Bonanza Creek LTER helped design and execute the USGS assessment of carbon dynamics in Alaska, providing relevant information for climate policy and carbon management. The assessment provided information on: 1) feedbacks between ecosystem structure/function and fire regime 2) the fate of deep carbon in permafrost and soils, and 3) the mass balance of carbon in and across uplands, wetlands, and surface waters in Alaska with a nominal 1 km^2 resolution. [8]

The Permafrost Carbon Network (PCN). Led by BNZ LTER scientists, the PCN links biological carbon cycle research to well developed networks in the physical sciences focused on the thermal state of permafrost. Partly supported by an NSF Research Coordination Network grant, the PCN produces new convergent knowledge to quantify how permafrost carbon drives climate change. [9]

Developing and applying social-ecological systems models. A community-based approach has led to a cross site comparison of the factors that mediate sensitivity to climate change, impacts on ecosystems and societies, and feedbacks from adaptive actions. This research has demonstrated that estimates of the future availability of ecosystems services are misleading if ecological factors are assessed in isolation. For example, in fishing, much of the variation in harvest effort is explained by fuel costs and policy rigidity, rather than fish stocks.

Broader Impacts

Citizen Science. Three BNZ LTER citizen science projects investigate the effects of longer growing seasons on boreal plant species, engaging over 1,800 volunteers of all ages. Together with Alaska GLOBE and dozens of international and train-the-trainer workshops, the impact of the program has grown to over 20,000 K-12 students.

Designing for diverse inclusion in research and education. Programs engage BNZ LTER scientists, teachers, youth, and indigenous knowledge holders in co-designing curricula. Features include cultural responsiveness, youth focused ecology research, access to subsistence food resources, and research on ecological change.

Integrating science education and social services. The Fostering Science program, started in 2017, brings scientists and youth in the care of the state together for a week long "science adventure camp." The program melds outdoor and science education with socio-emotional components designed to increase confidence, self efficacy, and resilience, and to cultivate interest in STEM careers.

Arts-humanities-science integration. In a Time of Change (ITOC), BNZ LTER's place based arts-humanities-science program, has led to original public exhibits and performances. Themes include climate change, wildfire, predator control, and microbial worlds. Since 2008, ITOC events have involved dozens of artists and reached thousands of people.

Partnerships

U.S. Forest Service Pacific Northwest Research Station | University of Alaska, Fairbanks (UAF) | NEON

Top Products

1. Alexander, HD and MC Mack. 2016. A canopy shift in interior Alaskan boreal forests: consequences for above and belowground carbon and nitrogen pools during post-fire succession. **Ecosystems.** doi: 10.1007/s10021-015-9920-7
2. Brinkman, TJ et al. 2016. Arctic communities perceive climate impacts on access as a critical challenge to availability of subsistence resources. **Climatic Change.** doi: 10.1007/s10584-016-1819-6
3. Euskirchen, ES et al. 2016. Consequences of changes in vegetation and snow cover for climate feedbacks in Alaska and northwest Canada. **Environmental Research Letters.** doi: 10.1088/1748-9326/11/10/105003
4. Feierabend, D, and K Kielland. 2015. Seasonal effects of habitat on sources and rates of snowshoe hare predation in Alaskan boreal forests. **PLoS ONE.** doi: 10.1371/journal.pone.0143543
5. Johnstone, JF et al. 2016. Changing disturbance regimes, ecological memory, and forest resilience. **Frontiers in Ecology and the Environment.** doi: 10.1002/fee.1311
6. Johnstone, JF et al. 2010. Changes in fire regime break the legacy lock on successional trajectories in the Alaskan boreal forest. **Global Change Biology.** doi: 10.1111/j.1365-2486.2009.02051.x
7. Kielland, K et al. 2010. Demography of snowshoe hares in relation to regional climate variability during a 10-year population cycle in interior Alaska. **Canadian Journal of Forest Research.** doi: 10.1371/journal.pone.0143543
8. McGuire, AD et al.. 2018a. Assessing historical and projected carbon balance of Alaska: A synthesis of results and policy/management implications. **Ecological Applications.** doi: 10.1002/eap.1768
9. McGuire, AD et al. 2018b. Dependence of the evolution of carbon dynamics in the northern permafrost region on the trajectory of climate change. **PNAS.** doi: 10.1073/pnas.1719903115
10. Schuur, EA et al. 2015. Climate change and the permafrost carbon feedback. **Nature.** doi: 10.1038/nature14338

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