Ecological Drought in Alaska

The impacts of climate change on a large, diverse, remote landscape

Alaska Climate Science Center Workshop
September 15–16, 2015
Fairbanks, Alaska

The Department of the Interior Climate Science Centers (CSCs) and their managing organization, the National Climate Change and Wildlife Science Center at the U.S. Geological Survey, have chosen the emerging climate science field of Ecological Drought as a research focus area. This workshop is part of a series of meetings at each of the nation's eight CSCs aimed at collating our existing knowledge of the ecological impacts, resistance, and recovery from drought. The eight CSCs provide a fantastic opportunity to compare the ecological effects of drought, related research activities, and management options at different regions, spatial scales, and biomes.

Climate change threatens the unique values of the Alaskan ecosystem

The stress incurred on ecosystems from prolonged and widespread deficits in naturally available water supplies is termed ecological drought. This stress is evident in many of Alaska's unique ecosystems that are characterized by, and highly dependent on, frozen, liquid, and gaseous forms of water. Increased temperatures, altered timing of seasons, and more extreme events are having drastic consequences on these water resources throughout Alaska. The unique characteristics of Alaska both help, and inhibit assessment and management of these consequences.

Alaska has large, intact landscapes

Defined by vast, diverse, intact landscapes, there is limited outside disturbance on Alaska's ecosystems. Despite the remoteness of much of Alaska, a wealth of interdisciplinary scientific knowledge is growing in the region, aided by improved technologies (e.g. remote sensing). This isolation, however, means limited historical records are available to develop baselines for climate change assessment, to which Alaska is vulnerable. These limited historic records, in combination with a lack of long term funding (required to measure climate change effects), confounds our understanding of how Alaska is changing in response to climate change.

SNAP

Alaska has iconic species and ecosystems

Alaska has vivid and iconic landscapes, ecosystems, and species, that are well known throughout the world. However, a challenge remains in relating equally vivid climate change stories to non-Alaskans due to a physical disconnect to this remote region. Climate change in Alaska has recently gained increased public awareness, funding, and political attention due to the sheer scale of impacts in the region and the natural resources that it has to offer. There still remains the importance of sharing the consequences of climate change in Alaska due to the physical and emotional detachment to this remote region.

USFWS

Alaska is culturally diverse

Alaska has a strong, diverse culture, and sustaining this culture is an important aspect of climate change research and education within the region. Alaska's native people maintain many traditions such as subsistence hunting and fishing, and traditional forms of gathering and growing. This unique cultural identity and knowledge provides first hand observations of change, historical benchmarks, and land ethics. Improved communication between researchers and communities will ensure that research assists in dealing with, and adapting to problems related to climate change, even though resource and infrastructure limitations may make adaptation difficult.

S. Zuray

Climate change in Alaska is real, observable, and profound

The Arctic is among the fastest-warming regions on earth, and because of its cold-adapted features and rapid warming, climate change impacts on Alaska are already pronounced. Earlier spring snowmelt, reduced sea ice, widespread glacier retreat, warmer permafrost, drier landscapes, and more extensive insect outbreaks and fire all have the potential to shift the Alaskan arctic dramatically. These impacts are already measurable.

Alaska is getting warmer earlier in the year

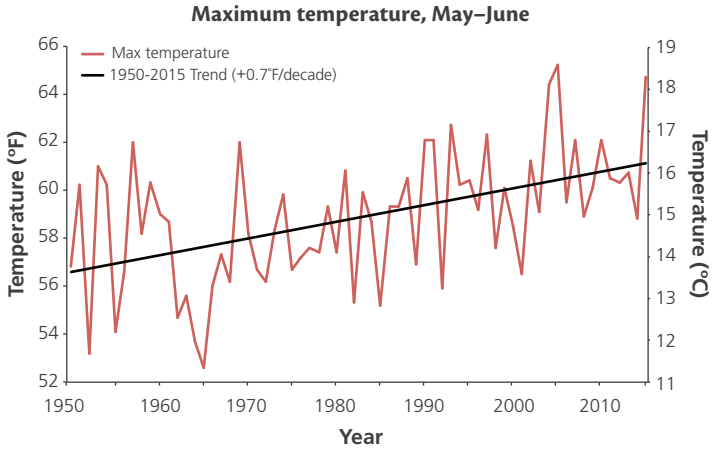
During the past 60 years, the average annual temperature in Alaska has increased by 1.8°C (3.4°F). However, when analyzing the trends seasonally, most of the change has occurred in winter and spring, with the least amount of change in autumn and summer. Earlier warming is likely resulting in more frequent and bigger fires, changes in hydrology and vegetation, and animal migration patterns.

Alaska is burning more, and more often

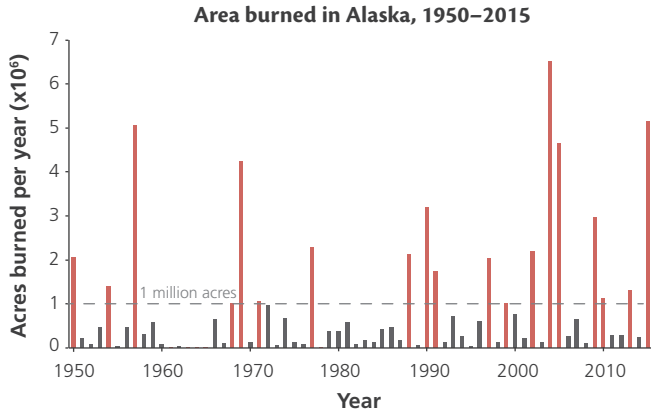
Researchers have found a strong correlation between warm June temperatures and large fire years and as maximum temperatures in May and June continue to rise, so does the threat of large area-burned wildfires. From 1950 to 2000, there were 12 wildfires that burned one million acres or more, and in the past 15 years (2000–2015), there have been seven. A major contributor to the ignition of these fires is lightning strikes from storms.

Alaska is getting less snow

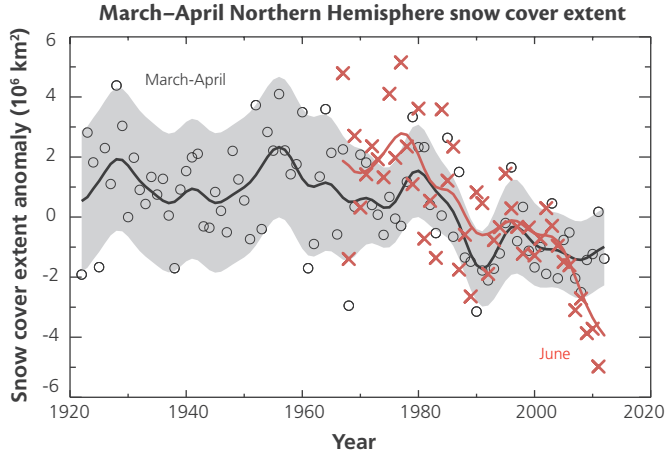
Warming temperatures in Alaska have coincided with changes in the type of precipitation. Higher temperatures result in a shift from snow to rain. As precipitation shifts from snow to rain, snow cover extent decreases. Snow cover is important for water storage and insulation, soil temperatures, energy balance, habitat, and permafrost thickness. Overall precipitation amount has also increased. This is counteracted by increases in evapotranspiration and changes in soil hydrology, resulting in the shrinking of wetlands and drier tundra, which also lead to more fires, and an increase of carbon released into the atmosphere.



May–June maximum temperature in central Alaska. *Researchers have found a strong correlation between warm June temperatures and large fire years. Data from NOAA Alaska Climate Division 3.*



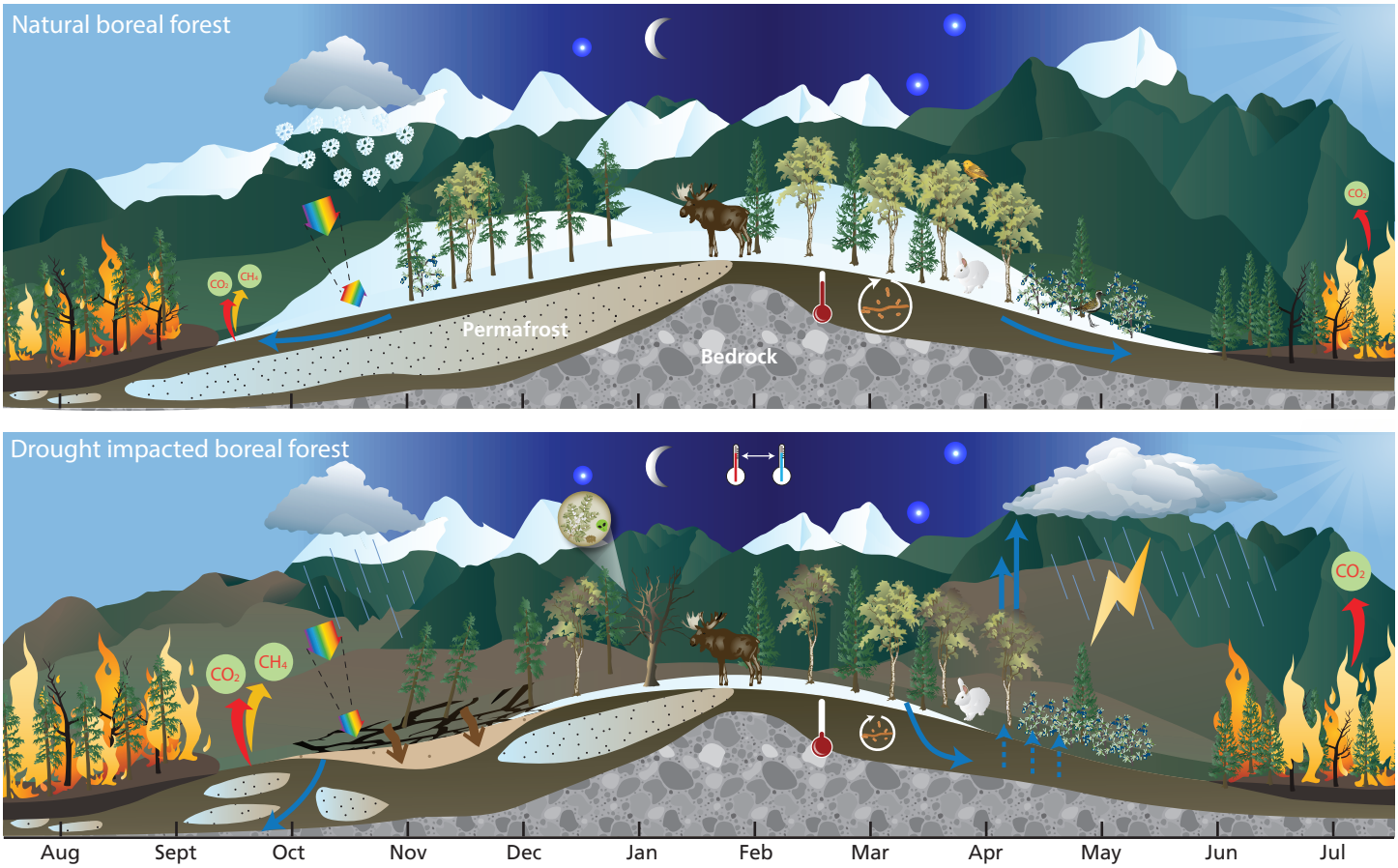
Area burned in Alaska 1950–2000. *Data from Gabriel and Tande, 1983; Todd and Jewkes, 2006; Alaska DNR Division of Forestry; AFS Annual Summaries.*



Northern hemisphere snow cover extent (SCE) from March to April *in situ data (black line) and June SCE (red crosses, from satellite data alone). The gray area indicates the 95% confidence level. Source: IPCC 2013, data from Brown and Robinson 2011.*

Alaska is warming twice as fast as the rest of the United States

As Alaska continues to warm and the impacts of climate change are more widespread, the threat of ecological drought has the potential to result in major social and ecological impacts. The boreal forest regions of Alaska are particularly susceptible to changes due to climate change and ecological drought. As temperatures increase, the thawing of permafrost leads to increased greenhouse gas emissions, land subsidence, and changes in hydrology—all with major consequences to the Alaskan landscape. Reduced snowpack caused by changes in precipitation are resulting in changes in phenology, as well as influencing soil temperatures and processes. Together, changes in permafrost and snowpack are leading to hydrological changes, which can result in increased wildfire activity throughout the boreal forest.



Climate

- Shift in precipitation from snow to rain.
- Transpiration increases cloud cover.
- Increased frequency of lightning strikes from earlier summer storms.

Fire

- Spring and summer water availability can lead to dramatic changes in wildfire occurrence.
- Wildfire improves habitat for berries, mushrooms, and moose.
- Wildfires release carbon into the atmosphere that is typically stored.
- Drought and wildfires contribute to the success of invading forest pest species.

Cryosphere

- Degraded permafrost allows for the absorption of water into the soil.
- Degraded permafrost allows for increased water uptake by trees, leading to higher transpiration and increased cloud cover.
- Snow cover regulates diurnal temperature swings.
- Warming and thawing of permafrost soils increases the release of carbon dioxide and methane into the atmosphere through increased decomposition.
- Thawing permafrost results in land subsidence, which can impact erosion and sedimentation, and lead to issues with infrastructure.

Ecosystem

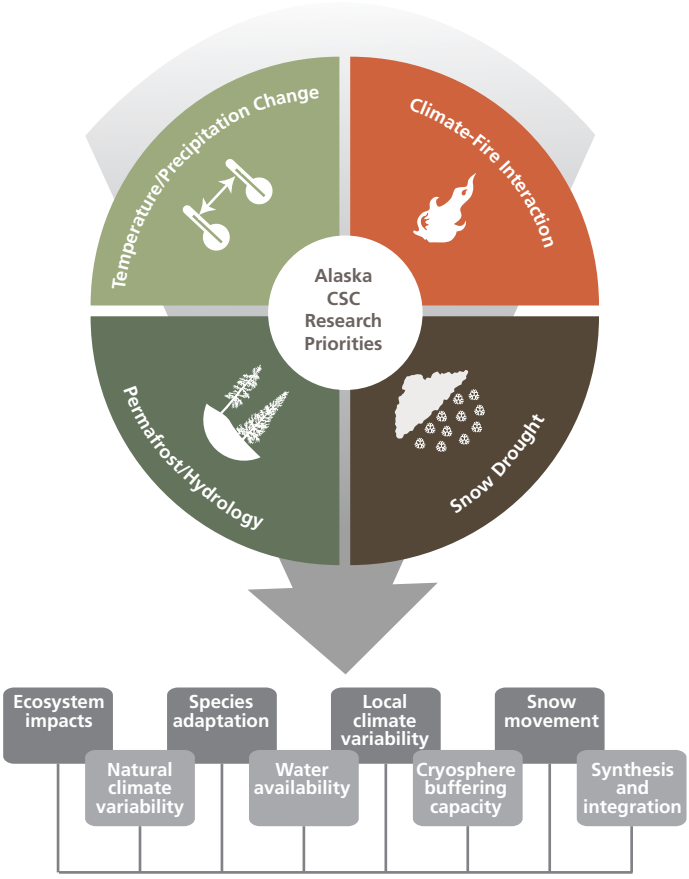
- The timing and length of snow season can have major impacts on the life histories of Alaskan flora and fauna.
- Snow season length influences growing season length, which can lead to changes in plant species ranges, and changes in phenology.
- Changes in timing of snowmelt and freeze-up can influence migratory bird species, and habitat availability.
- Soil temperatures influence decomposition and microbial activity.
- Expansion of tall trees and shrubs into the tundra makes surface darker and rougher, increasing absorption of the sun's energy.

Conceptual diagram illustrating the impacts and changes to the boreal forest due to climate change and ecological drought.

Planning for ecological drought in Alaska

For most people in Alaska, drought and its impacts on ecosystems and habitats—what we are calling "ecological drought"—has never been a major part of their lives. Yet, some parts of Alaska's interior receive very little precipitation compared to most of the contiguous United States (e.g., on par with Tucson, Arizona), and summer temperatures can reach into the 30s Celsius (90s Fahrenheit). In other parts of the state, cool and wet are certainly defining features of the local climate, but many of the species that populate these ecosystems would have limited capacity for dealing with dry times if they did occur. So, the question then becomes what will happen in a warmer world where we will undoubtedly experience increased evaporation, changes in snow cover, and altered water demands in Alaska? Moreover, how would land and resources managers in a region with little to no historical reference for coping with ecological drought respond and adapt to these conditions? As the signs of ecological drought continue to grow within the Alaska Climate Science Center region, one of the critical next steps is the synthesis and integration of research to enhance communication of what we currently know, and what we need to know better. The workshop that you see described here is a critical first step in summarizing the state of our knowledge regarding ecological drought in Alaska, and the results of this effort will provide a foundation for integrated drought, ecosystems, and climate-impacts research led by the Alaska Climate Science Center and its partners.

– Stephen Gray, Director, Alaska Climate Science Center



Research priorities in the four major categories of ongoing ecological drought research at the Alaska Climate Science Center.

For more information regarding ongoing research and activities at the Alaska Climate Science Center, visit csc.alaska.edu

Participants at the Alaska Climate Science Center workshop held in Fairbanks, Alaska in September 2015.

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