September 2021

Background

- The Hubbard Brook Experimental Forest was established in 1955 by the U.S. Forest Service.
- Acid rain was first discovered in North America at Hubbard Brook.
- The acid rain discovery led to the 1990 Clean Air Act Amendments that protect our air and water quality.
- Hubbard Brook has been a world-leader in ecosystem science and a resource for environmental decision-making for more than six decades.
- Long-term ecosystem studies like Hubbard Brook are pulse-points for environmental health in the U.S.

Climate Change Indicators

Based on **more than 50 years of continuous ecosystem monitoring,** this is what we know about climate change at Hubbard Brook.

- **The air is warming.** Average annual air temperature has increased by 2.6ºF over the study period.
- **Winters are the fastest-warming season.** Average annual winter air temperature has increased by 3.5ºF.
- **We receive more precipitation**. Annual precipitation has increased by 13 inches, and summer precipitation is increasing the most.
- **More precipitation is falling in heavy bursts.** We have 7.5 more days per year with heavy rainfall (i.e., ¾ of an inch or more in a day).
- **Rain is more frequent in winter.**
- **Stream flows are increasingly variable.** Climate change is causing higher and more variable stream flows.
- **We have fewer cold days.** There are 10 fewer days per year when the maximum air temperature is below 32ºF.
- **Snowpack is decreasing.** Average annual snow depth has decreased by 11 inches. Duration of snowpack has decreased by 24 days—nearly one more month per year without snow on the ground.
- **Lake ice is disappearing.** The number of days per year with lake-ice cover has declined by 25—nearly one more ice-free month per year.
- **Seasons are changing.** Spring leaf-out is occurring earlier. Leaf-fall is occurring later.

Connections to Our Economy, Health, and Culture

- **We are losing snow-making opportunities, particularly in the early ski season.** In the White Mountains, eight days of snow-making opportunity have been lost over the last 50 years. Seven of these days occur before the holidays, representing a 20% reduction in snow-making conditions during the early ski season, a crucial period in a winter recreation economy.
- **Smaller ski operations without large-scale snow-making infrastructure have disappeared.** Ski operations that make snow must use more water over shorter periods to establish and maintain snowpack. This requires additional investments in equipment and access to substantial water reserves.
- **The snowmobiling industry is struggling with the loss of snowpack and lake ice.**
- **There are fewer opportunities for timber harvesting on snowpack.** Snowpack protects against soil disturbance and erosion during harvesting.
- Without insulating snowpack, **maple tree roots are damaged by more frequent soil freezing.** This has a negative effect on forest growth and carbon sequestration.

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- **Changing winter conditions may lead to lower maple yield and shorter sugaring seasons.**
- **Intense weather events and rain on snow cause high runoff.** This increases the risk of flooding and contributes to the pollution of downstream water supplies.
- **A warming climate is allowing the northward advance of the hemlock woolly adelgid,** an invasive insect from Asia that is now within 30 miles of Hubbard Brook. This insect kills eastern hemlock, one of our longest-lived tree species, typically abundant along stream corridors.
- **Some ticks, mosquitos, and invasive insect pests that were previously suppressed by cold temperatures may increase.** If ticks and mosquitoes expand their ranges and become more abundant, people will be at increased risk of Lyme disease and other illnesses, including eastern equine encephalitis.

Science for Solutions

- In the aftermath of acid rain, the addition of calcium reversed forest decline at Hubbard Brook and boosted carbon sequestration.
- Hubbard Brook research can inform forest management to enhance sequestration of carbon as a natural solution to climate change, including how to identify and carefully manage sensitive forest hot spots that are at increased risk of releasing carbon, nitrogen, and other pollutants during heavy precipitation events.
- Hubbard Brook is eager to share cutting-edge approaches for understanding the landscape, including the use of LiDAR satellite images that reveal detailed forest and soil characteristics. This enables sophisticated and precise matchmaking between trees and soil, to promote forest health and enhance carbon capture.
- Hubbard Brook science can inform forest management for water quality and flood prevention (e.g., stream flow, erosion, and nutrient export in response to a variety of tree harvesting approaches).
- Hubbard Brook scientists collaborate with snowmakers to pinpoint when and how much water they need to produce adequate snow in a changing climate.
- Strong relationships among scientists, lawmakers, and leaders from the ski, snowmobiling, maple, and timber industries can support adaptation to climate change.

Need for Further Study

Our environment will continue to be affected by changing air temperatures, precipitation patterns, stream flows, snowpack, lake ice, and the distribution and abundance of pests. Long-term research is needed to understand, respond to, and prepare for these changes.

Given our forest-based economy and culture, world-class science, and strong relationships between forest researchers and managers, New Hampshire has the potential to set a national standard for nature-based solutions. We are well-positioned to combine our rugged and rural lifestyle with the latest science and technology to fight climate change while building a green economy around healthy, working forests.

HUBBARD BROOK RESEARCH FOUNDATION

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