Drying in Denali

"Are these lakes really drying and disappearing?"

Amy Larsen
United States National Park Service

by Laura Naranjo

Alaska's wetlands, dotted by thousands of small, shallow lakes, have existed for about 8,000 years. But now, this vibrant summer habitat is drying up. Ecologist Amy Larsen said, "We'd been hearing stories from native elders, community members, and bush pilots that lakes were drying up." She wondered what had changed. "Are we just in some kind of hydrologic low, and we haven't had a big recharge that fills the lakes up over time? Or are these lakes really drying and disappearing?" Larsen asked.

Wetlands occupy almost half of Alaska, including much of the state's public lands. These wetlands abound in life during the summer. Moose forage in the swamps for tender willow shoots. Beaver and muskrat build lodges in shallow ponds, and birds nest in lakeside sedges. Plants reproduce and animals raise their young during the short summer months before winter refreezes Alaska's landscape. Larsen was concerned about what would happen to the state's wildlife and plants if lake levels continued to dwindle.

Larsen, an aquatic ecologist with the United States National Park Service in Alaska, began studying wetlands in Denali National Park and Preserve. Because Alaska's short summer season limits fieldwork to June, July, and August, Larsen and her team could only gather data from a few lakes each year. So Larsen teamed up with University of Alaska remote sensing specialist

When most people think of Alaska, they imagine glacier-capped mountains such as Mount McKinley, the peak in this photograph. But shallow lake wetlands occupy nearly half of Alaska's landmass, providing critical habitat for moose, muskrats, beaver, and waterfowl. (Courtesy T. O'Dea)

Dave Verbyla. Larsen and Verbyla combined remote sensing's broad view of the wetlands with observations of individual lakes. They hoped to discover why lakes were shrinking and assess the survival prospects for these rich ecosystems.

Defining the drying

Verbyla had just completed a study using satellite images and aerial photographs, which revealed that many of Alaska's shallow lakes had shrunk or disappeared in the last fifty years. His findings mirrored records indicating that temperatures in interior Alaska, where the park is located, had risen nearly two degrees Celsius (four degrees Fahrenheit) over the same time period. During the same time, however, precipitation had remained the same. So why was water disappearing from lakes? Were rising temperatures increasing evaporation? Was warmer weather thawing the frozen soils that exist under much of Alaska's interior, and if so, why would that affect water levels?

It was hard to tell, because there was little field data to complement temperature records, and the historical satellite and aerial images of the lakes that Verbyla used had been taken only sporadically. Larsen said, "The information we had was very patchy."

During the 2006 pilot year for their study, the researchers focused on shallow lakes in Minchumina Basin, in the northwestern corner of the park. The basin provided a representative sample of the state's wetlands. To measure lake surface area, Verbyla used Synthetic Aperture Radar (SAR) data from the Canadian Space Agency RADARSAT-1 satellite, available from the Alaska Satellite Facility SAR Data Center. Verbyla said, "From April through October, about every ten days or so, we had a RADARSAT-1 pass of Minchumina Basin ." Satellite imagery provided a large-scale view of the wetlands and allowed the researchers to track lake changes over the course of the study.

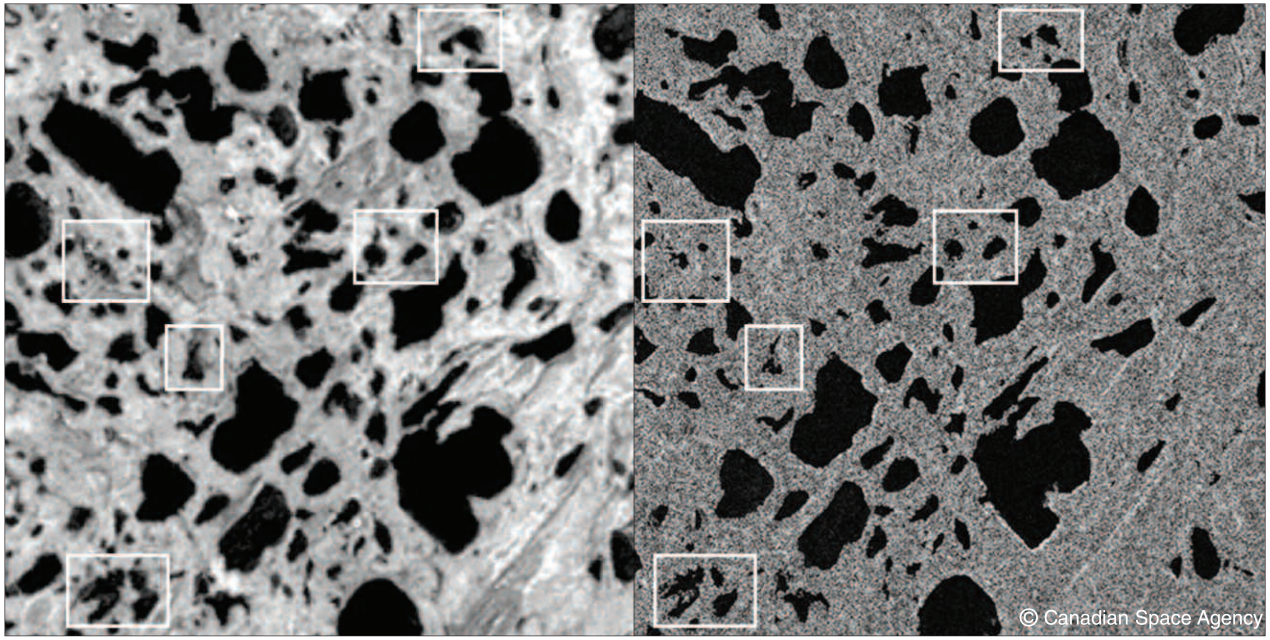
Thousands of small lakes dot Alaska's interior wetlands. Over the past fifty years, many of these shallow lakes have been drying up, reducing habitat for the state's wildlife populations. (Courtesy United States National Park Service)

Over the same time period, Larsen and her team visited thirty lakes in the basin to obtain details about changes in lake habitat. She sampled water quality and surveyed plant life in and around the lakes, because changes in these features could also indicate changes occurring in wetland habitat.

In Minchumina Basin, Larsen and Verbyla observed that lakes were shrinking, but only some of them. Verbyla said, "We found that there are areas where lakes are fairly stable, and then areas where lakes change quite a bit." If rising temperatures and evaporation were the culprits, why were not all lakes in the area drying up?

Porosity, permafrost, and plants

Larsen and Verbyla returned in 2007 hoping to discover other factors that might contribute to lake drying, such as soil conditions or permafrost thaw. When they compared the shrinking lakes to soil type, they found a connection. Verbyla said, "In certain places the soil texture itself could be controlling some of the drainage." Larsen said, "Between 2006



This pair of satellite images reveals drying in some of Alaska's lakes. Black areas indicate water; shades of gray indicate land and vegetation. The Landsat image on the left shows lake extent on July 21, 1985; the RADARSAT-1 image on the right shows lake extent twenty years later, on July 8, 2005. Comparing the imagery revealed which lakes had shrunk, highlighted in white boxes. (Courtesy D. Verbyla, RADARSAT-1 image copyright Canadian Space Agency)

and 2007, we saw about a 16-centimeter [6.3-inch] water level drop in areas underlain with sand." During the same time, lakes surrounded by fine silt or clay lost little water.

Frozen soils provided another clue to the shrinking lakes. Most of the Minchumina Basin is located over discontinuous permafrost, meaning that some of the soil surrounding the lakes is frozen. While the ground directly under a lake may not be frozen, permafrost often forms a protective ring around the lake. "It's almost like a bathtub," Larsen said. "The permafrost surrounding the lake prevents water from going anywhere."

Areas of discontinuous permafrost are particularly vulnerable, because the ice trapped in the soil is near the melting point and thaws easily in response to slight temperature increases. But plants and other ground cover, such as peat, an accumulation of dead and decaying vegetation, can help insulate permafrost. During the summer, Larsen looked for peat around lakes. "We wanted to see how much peat and organic material was lying on the surface of that soil, protecting the ice in the frozen layers below from melting," Larsen said.

Larsen and Verbyla discovered that lake drying did not depend directly on temperature, but on factors underneath and around the lakes that may respond to temperature changes. A warming climate would not affect soil type, but it could thaw permafrost and cause changes in the overlying vegetation, leaving lakes more susceptible to drying.

Adapting to change

Drying lakes in Minchumina Basin reflect similar changes happening across the state. Decreasing water levels affect many wildlife populations such as muskrats, small, semi-aquatic rodents similar to beavers. Larsen said, "Muskrats need open water under the ice in order to survive. So if more of these lakes get so shallow that they freeze during the winter, then muskrats are losing habitat." Shrinking lakes and other habitat changes may be contributing to the unexplained decline of muskrats across North America.

The researchers are now trying to place shrinking lakes into a larger climate context: Is lake drying temporary and reversible, or are disappearing lakes a permanent consequence of climate change? While temperature records across Alaska and many other Arctic and sub-Arctic areas confirm

Muskrats need open water year-round to survive. They feed on aquatic plants like cattails, and build their lodges in ponds and lakes. But many of Alaska's lakes have become so shallow that they freeze during winter; researchers think that declines in muskrat populations may be linked to the drying of Alaska's lakes. (Courtesy M. Soveran) warming, regional climate variations also play a role. Interior Alaska's climate is governed by a larger pattern, which alternates between warm, dry periods and cool, wet periods. Since the 1970s, Alaska has experienced a warm phase, but recent evidence indicates that the state may be returning to a cooler phase of the pattern. Scientists are not yet sure whether this oncoming shift will restore lower temperatures, or if global warming will prevent significant cooling. Larsen, Verbyla, and other scientists will capture data during the shift, to observe how Alaska's wetlands and other sub-Arctic ecosystems respond.

Past lake changes may also provide clues. Verbyla said. "I'm going back in time, using historical aerial photography and satellite imagery to delineate where the lake shorelines were. That will tell us what the variability has been over the last twenty to twenty-five years." Larsen will take sediment cores to see whether the lakes fluctuated over the past 8,000 years, and determine if Alaska's wetlands have undergone, and recovered from, a similar drying period.

Larsen and Verbyla plan to continue combining satellite data and fieldwork to create a long-term time series of data for interior Alaska's wetlands. Wetlands provide habitat and feeding grounds for large wildlife populations, and Larson wonders how these changes will affect the state's national parks. She asked, "How are we going to sustain moose populations in these regions once these important feeding areas are gone? What about muskrats? What about beavers? What happens if we're losing the lakes that support them?"

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About the remote sensing data used

Satellite	Canadian Space Agency RADARSAT-1
Sensor	Synthetic Aperture Radar (SAR)
Data set	Fine-beam SAR data
Resolution	8 meter
Parameter	Land cover
Data center	NASA Alaska Satellite Facility SAR Data Center

About the scientists

Amy Larsen is an aquatic ecologist with the United States National Park Service (NPS) in Fairbanks, Alaska, specializing in monitoring shallow lake dynamics. Her work focuses on monitoring lake level dynamics and the corresponding impacts on lake chemistry, geomorphology, and food web dynamics. The Central Alaska and Arctic Networks of the NPS Inventory and Monitoring Program supported her work. (Photograph courtesy A. Larsen)

Dave Verbyla is a professor in the Department of Forest Sciences, University of Alaska Fairbanks. His research interests include landscape-level changes in Alaska's boreal forest associated with climate warming, estimating wildfire severity from remote sensing, and validation of remote sensing products. The NASA Land Cover/Land Use Change Program and the Bonanza Creek Long-Term Ecological Research program funded his research. (Photograph courtesy D. Verbyla)

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Riordan, B., D. Verbyla, and A. D. McGuire. 2006. Shrinking ponds in subarctic Alaska based on 1950-2002 remotely sensed images. *Journal of Geophysical Research* 111, G04002, doi:10.1029/2005JG000150.

For more information

NASA Alaska Satellite Facility SAR Data Center
http://www.asf.alaska.edu

Canadian Space Agency RADARSAT-1
http://www.asc-csa.gc.ca/eng/satellites/radarsat1/default.asp

National Park Service Central Alaska Network
http://science.nature.nps.gov/im/units/cakn/index.cfm

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