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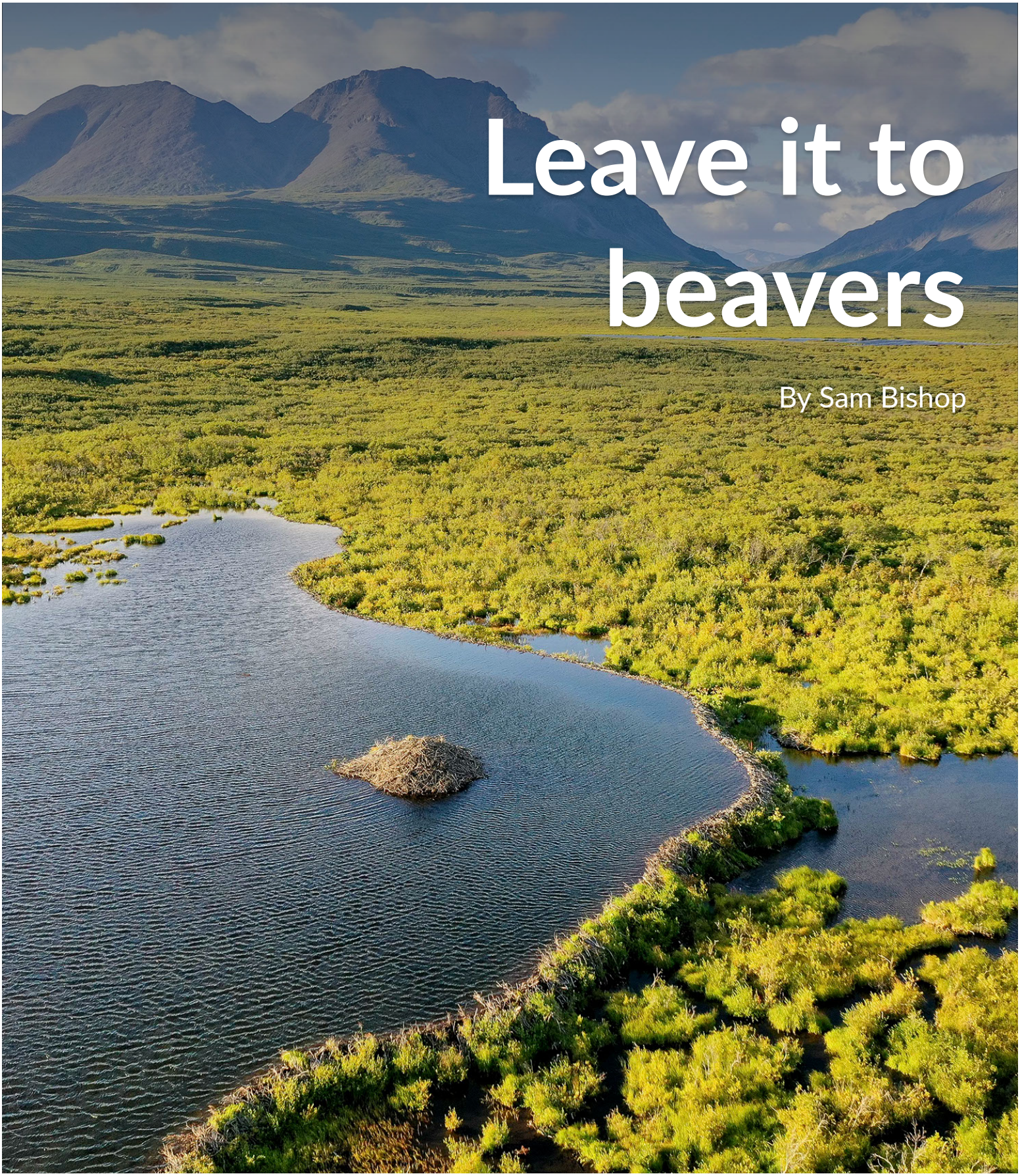


Leave it to beavers

By Sam Bishop

Above: A beaver dam forms a pool encircling a lodge near the Denali Highway in the Alaska Range. Photo by Ken Tape.

A new brush pile clogged a creek just north of Fairbanks in fall 2020. Thousands of burnt-umber willow tops, all cut and laid horizontally, rose in a foot-high stack above the creek surface. Upstream, toward a nearby road bridge, the water level climbed as the bristly

heap restricted the flow.

Ken Tape '04, '11 had to investigate.

"I flew a drone down there and took a picture," he said.

That's been something of a theme for the University of Alaska Fairbanks research associate professor during the past five years.

Beavers built the new Goldstream Creek brush pile — actually their winter's food cache and a dam — just a mile or so from Tape's house in suburban Fairbanks.

Above: A beaver's food cache clogs Goldstream Creek's channel just downstream from the Ballaine Road bridge near Fairbanks in fall 2020. A lodge sits on the left side of the channel in the foreground, and a dam extends from the lodge across the creek to the right bank. Photo by Ken Tape.

But, while Tape is personally curious about this local bit of beaver engineering, similar works a few hundred miles northwest have caught his professional eye.

Tape, fellow UAF researcher **Ben Jones '13** and several other scientists have used satellite images taken across time to document the march of beavers into Arctic Alaska. They say the invasion's potential impact on ecosystems is vast.

Consider a few facts they reported on June 30, 2020, in the scientific journal Environmental Research Letters:

- On 100 square kilometers of the Baldwin Peninsula just south of Kotzebue in northwest Alaska, the number of beaver dams grew from two in 2002 to 98 in 2019.
- In that part of the peninsula, the surface water visible in satellite imagery grew 8.3 percent during the same years.
- Two-thirds of the increase in total surface water area appeared in what the researchers classified as “beaver-influenced” water bodies — mostly lakes and streams blocked by beaver dams.

A pair of beavers work over some branches in shallow water south of Glennallen in central Alaska. Photo by Ken Tape.

Beavers may be moving into these tundra areas for a few reasons. A warming climate allows more growth of the deciduous trees and shrubs they eat. The rising winter temperatures also may prevent beaver ponds from freezing to the bottom and reduce the time beavers must survive on brush cached under the pond ice.

If such beaver range expansion occurs in similar areas across the circumpolar Arctic in coming decades, the effects could alter entire ecosystems as the permafrost under their ponds thaws. The beavers' engineering may even contribute to climate warming.

Discovery via theory

“Man, it is coming down,” Tape observed as an early November snowstorm tried to dampen a crackling fire pit outside his home.

He and Jones agreed to an outdoor interview to avoid any sharing of the coronavirus making a resurgence in Alaska.

The coronavirus shutdown canceled their first planned fieldwork this past summer. Their research into beaver range expansion to date has been mostly conducted using satellite images and aerial photography.

Top: UAF faculty members Ken Tape, left, and Ben Jones meet near Tape's home for an outdoor interview in November. Bottom: Postdoctoral researcher Jason Clark video conferences with Ken Tape and Ben Jones after the interview. UAF photos by JR Ancheta.

"We've been going at this for five years, and we're still at the cusp of our first major field season," said Tape, who works in the UAF Geophysical Institute's Snow, Ice and Permafrost Group.

Tape first started thinking about beavers while studying the recent appearance of other boreal forest species, including moose and snowshoe hare, in Arctic regions. As the climate warmed, the deciduous trees and shrubs that such animals eat spread northward.

Those plants include willows, birch shrubs and poplar saplings — the preferred food species for beavers in

Alaska.

Beavers dam up creeks, sloughs, lake outlets — anything that produces water. They do so to create deep water, which serves several functions. It surrounds their lodges, covering the entrances so predators such as wolves and bears can't enter. Beavers also use the deeper water to float woody material for their dams and to cache their food.

The water needs to be deep enough that ice does not freeze to the bottom, allowing beavers to swim between their lodges and caches all winter. So beavers often flood large areas upstream from their dams, which can create new ponds and lakes. It also can expand not only existing ponds and lakes but also river channels and sloughs.

In April, beavers emerge through holes in the ice around their lodge in Goldstream Valley near Fairbanks. Photo by Ken Tape.

"What really caught my attention was they leave a mark on the landscape you can see from space. Very, very few animals do that," Tape said. "That's what underpins a lot of this work and the excitement about it. You can watch the change in distribution of this animal."

Tape soon realized that satellite imagery might help him see what was happening by using it to find new beaver ponds.

"The moments of discovery were sort of theoretical," he said. "It wasn't like standing out in the tundra and saying,

‘Oh, here’s this pond.’”

High resolution is the key

Jones, a specialist in remote sensing, joined the investigations early on, even before coming to UAF as a research assistant professor in the Institute of Northern Engineering’s Water and Environmental Research Center in 2018. He and Tape enlisted several other researchers, as well.

They started looking for changes in surface water by working with imagery from the Landsat satellite system, which has been capturing landscape data since the 1970s. Each pixel in a Landsat image represents a square about 30 meters on each side — not a very precise resolution.

“You can see these water area changes over time, but you have a hard time telling really what’s causing them,” Jones said.

They also had a lot of terrain to search. So they used a computer to narrow the imagery to areas with potential beaver activity.

“You kind of train (the computer) to search for surface water area,” Jones said. “You give it so many training samples, let’s say maybe 500 in a typical scene, and then it

kind of searches the rest of that scene for similar-looking samples or pixels."

Once the areas with surface water changes were identified in the Landsat imagery, the researchers looked at those locations using 1-meter resolution commercial satellite imagery, which became available starting in 2005.

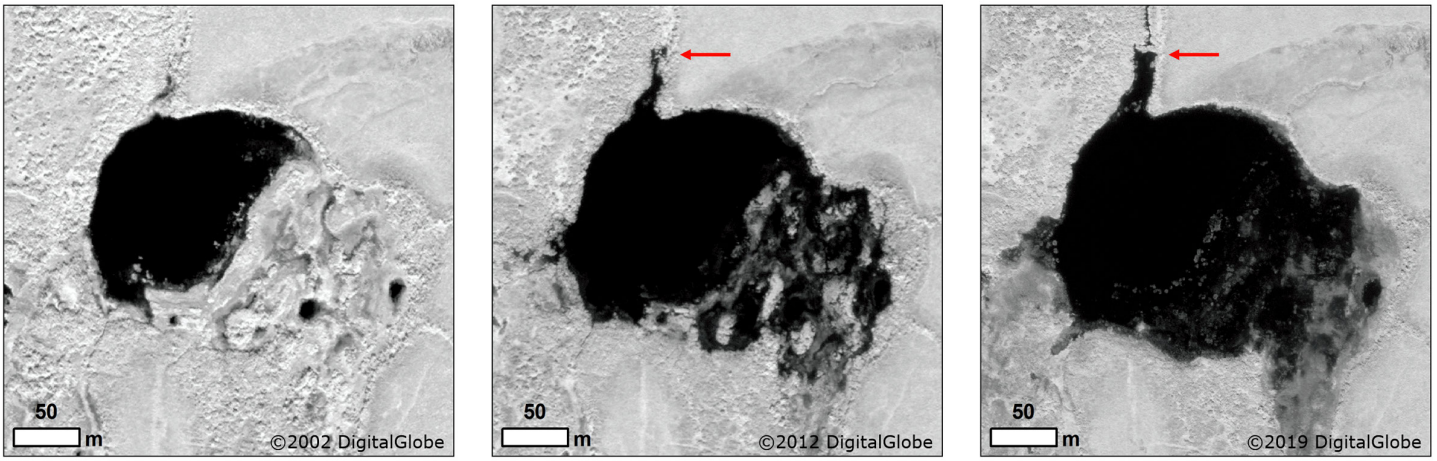
At that resolution, they could see beaver dams associated with new or expanded lakes, ponds and waterways.

"We wouldn't have been able to attribute that to beavers without going to this higher resolution imagery," Jones said. "So that's really what made the study possible."

Their first paper, published in 2018, reported that between 1999 and 2014, 80% of the new water areas identified through Landsat imagery were caused by beavers. That study looked at the Wulik and Kivalina river drainages, as well as a portion of the lower Noatak River drainage, all in northwestern Alaska.

In the most recent study of the beaver boom in the nearby Kotzebue area, the researchers found a 435% increase in dams from 2010 to 2019 across a broader swath of the northern Baldwin Peninsula.

They also discovered that beavers on the peninsula create the majority of their new ponds in old thermokarsts, scars created when frozen ground thawed and collapsed in the past.



Above: These three images, first published in the journal Environmental Research Letters on June 30, 2020, show the same lake near Kotzebue in 2002, 2012 and 2019. The 2002 image shows a partially drained lake basin before any evidence of beaver activity. The red arrows show where beavers then built a dam. The dam caused the lake's surface water area to double by 2012. By 2019, the water area grew another 18%. The lake's expansion caused extensive thawing of permafrost in the old basin. Images courtesy of Environmental Research Letters.

"These drained lake basins went from being dry to super darn full over our time series," Jones said.

Some thermokarsts may be free of permafrost soil — an area known as a talik. However, the beds of many other thermokarsts contain permafrost, since the mean annual air temperature in the area remains below freezing. When a beaver pond covers it, the permafrost will most likely start to thaw again.

Given their results, Tape and Jones argue, if beavers are in the area or nearby, then they should be a big part of any explanation of what's driving landscape change in the Arctic. It's not just the climate.

“Our results challenge the idea that current and future surface water changes in some Arctic and boreal regions are, or will be, directly linked to changes in permafrost and thermokarst resulting from increased air temperature, through-going talik penetration, and precipitation/evaporation trends,” they stated in the latest paper.

The climate component

Permafrost, which underlies most of the Arctic, usually thaws when covered with water. The plant carbon stored in the permafrost can then be released into the atmosphere, reinforcing the greenhouse effect already warming the world.

Given the rate at which beavers are covering some Arctic terrain with water, it’s natural to suspect their work could contribute to climate warming.

A pair of swans paddle through a beaver pond off the Chulitna River in central Alaska. The dam that created the pond forms an arc starting at the lower right in the photograph. The lodge sits just inside the pond near the top of the arc. Photo courtesy of Ken Tape.

Tape and Jones said such effects exceed the scope of their studies, and they aren't even sure beavers are moving north primarily as a result of the warming climate. So far, the researchers are just documenting the landscape and biological changes as they occur.

Nevertheless, their research has drawn phenomenal interest worldwide. Widespread media coverage has mostly focused on the idea that beavers moving north in a warming climate might create a biophysical feedback that hastens that warming.

During the past three years, coverage has included articles in The New York Times, The (London) Times and numerous other publications. The research has also been featured in a National Geographic podcast, a story on the “Here and Now” public radio program, and other web and broadcast productions.

The New York Times’ first article, which was republished in newspapers and on websites worldwide in 2017, bore the headline “Beavers Emerge as Agents of Destruction.”

Tape cringed a bit at that. He’d described beavers as “agents of disturbance” in the paper that drew the Times’ coverage. He actually likes to think of beavers as agents of “construction” rather than “destruction.”

However, the Times’ headline did reflect the article’s focus on the potential significance of the carbon released by beaver-caused permafrost thaw.

“That is one of the primary reasons that people are interested,” Tape acknowledged.

“It could be a big deal,” Jones added, given the volume of water they discovered beavers impounding.

Getting on the ground

Tape and Jones, whose work to date has been primarily sponsored by the National Science Foundation, said they have much more to explore.

For example, they're hoping to find out whether beavers are expanding in the entire circumpolar Arctic, so they're working on a NSF proposal involving Canadian and Russian researchers.

Another question that remains is whether beavers have moved into the Arctic solely because they've followed the increased shrub growth driven by a warming climate. After all, beavers have long inhabited ecosystems with tundra similar to Arctic Alaska, such as the alpine ponds found along the Denali Highway in central Alaska.

It may be that beavers lived in Arctic regions historically but were eradicated by humans seeking pelts, Tape said. Now, with fur in less demand, perhaps they are simply returning.

However, Tape hasn't seen much evidence of beavers in the archaeological record of the northwestern Alaska areas he has analyzed with satellite imagery.

Above: A beaver swims across a pond south of Glennallen in central Alaska. Photo courtesy of Ken Tape.

For example, on Cape Krusenstern, near the Kivalina and Wulik rivers, excavations have revealed the animal species that people used back thousands of years.

“They’ve got 7,000 different bones, and there are zero beavers,” Tape said. “If they were there, they would have been trapping them.”

As soon as they can, Tape and Jones plan to visit northwestern Alaska and take measurements at the beaver ponds that they’ve so far studied only via imagery.

“We’ve got a lot of focus on water temperature, ice thickness, permafrost,” Tape said. “The idea is that those physical measurements will spawn downstream studies related more to the biology — fish, aquatic ecology. Do these ponds behave like groundwater springs where you have these different species? Are other boreal species getting a foothold in the Arctic through these ponds?”

Meanwhile, Tape no doubt also will keep an eye on the beavers just over the hill from his house as they jam up Goldstream Creek with their dam and food cache. After more than five years studying beavers, he clearly remains fascinated.

“You come across some of these engineering works — they make you marvel,” he said.

A beaver dam blocks a creek off the Denali Highway in central Alaska.
Photo by Ken Tape.