

KNOWING OUR *CHANGING* HOME

SNOW & ICE EDITION



Alaska Climate
Adaptation
Science Center



20
26



Creative Team

Lia Ferguson | editor, project direction, contributor

Diego Noreña | editor, project direction, contributor, photographer

Suzanna Caldwell | editor

Christian Thorsberg | contributor, photographer

Taylor Saulsbury | contributor, illustrator

Gigi Friedman | contributor, illustrator

Molly Tankersley | design, layout

COVER: Root Glacier in Wrangell-St. Elias
National Park. Photo by Mike DeLue.

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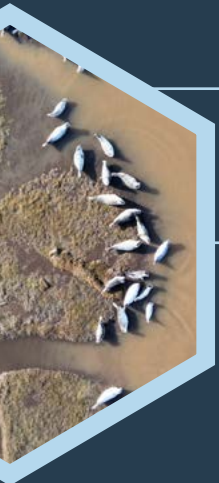
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STATEWIDE

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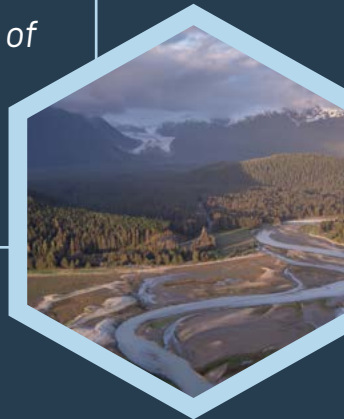


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FOREWORD ❄️

As a kid growing up in Wisconsin, I remember always sledding on Thanksgiving morning. Somewhere around the time I stopped sledding, sledding on Thanksgiving morning stopped too. There was rarely enough snow on the ground. A few years later I moved to Alaska, where I figured I would always have winter in my life. But after being here over 20 years, I know that stories about Alaska's changing ice and snow are just as common and often more consequential.

At the Alaska Climate Adaptation Science Center, we work to understand and respond to environmental changes by generating science that is rooted in place and relevant to the decisions Alaskans face. Through a partnership between the U.S. Geological Survey and the University of Alaska, our research, convening and capacity building efforts support people across the state as they navigate a changing climate while working to maintain the ways of life they value. This publication – the first in what we hope will be an ongoing series – features stories from across Alaska about how communities are adapting, how science is informing decisions, and how people are working together to address complex challenges in their communities.

Stories aren't just a matter of record, they are an adaptive tool. For millennia, stories have helped people make sense of what they observe and experience, how they feel and what they learn along the way. Stories carry facts, data and instructions, but also hopes, fears and values. When we hear a story, our brains don't just process information, we actually simulate an experience, and as a result, are better equipped to respond to novel challenges.



The stories in this edition reflect a landscape of thresholds being crossed. [The Arctic has warmed nearly four times faster than the rest of the globe.](#) The snow and ice that Alaskans have come to know, understand and rely on are changing. For example, in the Interior, river ice is less reliable for travel. In Western Alaska, changes in snowfall are contributing to shifting caribou migrations. On the North Slope, shorter winters are leading to fish die-offs. In Southeast Alaska, changes in glaciers are causing floods and altering downstream rivers and ecosystems. Together with our partners, communities and fellow scientists, the Alaska CASC is observing these changes, collaborating across disciplines and knowledge systems, and working to communicate what they mean for the future.

And across Alaska's Arctic and sub-Arctic communities, people are already living with these changes. Our hope is that the stories in this publication help illustrate not only how climate change is affecting daily life, but also how Alaskans are studying, responding to, and adapting to those impacts. This is not a comprehensive collection. If you have a story to tell, we invite you to share it – with the Alaska CASC, with your neighbors, with your local newspapers and with one another. Story is how we share knowledge, support one another and ultimately adapt.



Kristin Timm
Alaska CASC University Director



STATEWIDE ALASKA

Across the state, the snow and ice that people rely on throughout the winter is changing. Alaska spans 20 degrees of latitude and 40 degrees of longitude. With diverse terrain, mountainous regions and more coastline than all other U.S. states combined, these changes can look different depending on the complex weather of the region.

For that reason, the stories in this publication are grouped coarsely by region. At the beginning of each section is a summary of the region's projected changes over the next century to provide context for the events we're already experiencing, as well as those to come.

The numbers given are projections. While we do not have a crystal ball to see into the future, these numbers represent the best available science and are based on extensive weather and climate modeling, made from historical records and tested weather models.

These projections are from the [Northern Climate Reports](#), which brings together powerful, community-level climate information in one accessible place. The reports display projected changes of, among other things, temperature, permafrost and precipitation, helping you see how environmental conditions may shift over time in the places you care about most.



NORTHERN CLIMATE REPORTS

See stories and graphics that show how your part of the North may change over time. Use these to better understand and reduce risk, plan infrastructure, manage natural resources, and communicate change. You can also download data.

When it rains, it snows - precipitation changes across Alaska

By Lia Ferguson

The end of 2025 will remain fresh in Juneau’s collective memory as historic amounts of snow fell across the town, blanketing rooftops, boats and roadways, disrupting everyday life and making national news. A few days later, the town readied themselves for an onslaught of rain, prompting a verbal disaster declaration from the governor – [his fourth weather-related disaster declaration in three months](#).

Just one year before, however, Alaska’s weather also made national headlines, this time for lack of snow, as even by March, there was not enough snow in the Anchorage area to host the start of the Iditarod Trail Sled Dog Race.

Anchorage and Juneau are over 500 miles apart and subject to distinct climates, but these snowfall extremes, along with others across the state, give us a glimpse at statewide precipitation changes and how we can prepare.

“It’s important to understand that extreme weather can happen at any time, even under what we’d call a normal climate,” said Rick Lader, an atmospheric scientist with the Alaska Climate Adaptation Science Center. “What you can do is pay attention to the trends.”

Lader helped write the [precipitation section of the National Oceanic and Atmospheric Administration’s Arctic Report Card](#), a report published each year to document scientific consensus on Arctic trends. In 2024, precipitation reached a record high, continuing the observed pattern of increasing precipitation across the Arctic.

The storms in Juneau and across Alaska are also indicative of “an intensifying water cycle,” which causes these extreme events. Not only is there more rain and snow, but a large portion of the increase is falling in these anomalous events, putting strain on populations and infrastructure that were built for the old “normal.”

Another record broken

December in Juneau is typically cold and wet. Residents take advantage of the short days and the slow season when the summer cruise ships are no longer sounding their horns at the dock or offloading thousands of passengers. Juneau also gets a break from the rain when the droplets turn to heavy snow. Residents take to the ski trails, to the frozen lakes or up into the mountains to ski at Eaglecrest, the city-owned ski area. But in 2025, as the new year approached, the town was coming out of a deep freeze and woke to dense flakes falling from the sky.

Coined by local residents as a “snowpocalypse” or “snowmageddon,” the storm dropped a historic amount of snow in a short amount of time, [breaking the previous 5-day record set in 1963](#). At the Juneau airport, 49 inches of snow fell over the course of five days. Other areas of

Southeast Alaska received even more, with reports of 79 inches near Haines and 55 inches in Gustavus.

Residents of these areas shoveled and shoveled to free their cars or leave their houses, receiving only brief breaks in the snowfall between when the snow started on Dec. 27 and ended on New Year's Eve.

Merry Ellefson watched snow pile on her roof while her husband was away on the University of Alaska Fairbanks Research Vessel *Sikuliaq's* expedition to Antarctica.

"I was shoveling every three hours just to get the pathway out to the car, and then at a certain point I thought, I'm going to need some help here," she said.

As a ski and running coach, Ellefson called in some favors from her previous athletes.

"I have to start with a lot of gratitude," Ellefson said. "People brought food, people brought their brute strength. They brought their shovels to help everybody get it done, then checked in on others. You had to keep checking in to make sure everyone was okay."

Like Ellefson, others in town were overwhelmed by the snow. [Roofs collapsed](#) and [a snow removal team had](#)



“I was shoveling every three hours just to get the pathway out to the car, and then at a certain point I thought, I’m going to need some help here.”

- MERRY ELLEFSON

[to be flown in from Anchorage](#) for some commercial properties. Many residents relied on friends and neighbors. Those without a support system or the means to remove snow themselves were left to hope their homes could stand the weight.

Annika Ord, a climate adaptation catalyst with the Alaska Climate Adaptation Science Center, is one of Ellefson's previous athletes.

"It was a vigorous couple of weeks," said Ord, who helped shovel the Ellefsons' roof and her parents' roof.

Ord was also staying on top of snow removal on her sailboat and her family's commercial fishing boat docked in the Juneau Harbors, where over the course of the storm [eight boats sank under the weight of the snow](#).

"I probably shoveled my boat like four times," said Ord. "And we got looped into shoveling boats of people who were out of town."

Ord said the need for snow removal seemed endless.

"Cars would be stuck, and you would just pull over on the side of the road to help people," she said. "Early on, not everyone was prepared with shovels. I helped out a couple who were trying to dig their car out of a berm with only their hands."

At the end of the long week of snow, temperatures began to warm, but the precipitation did not let up. Just a week after the record-breaking snow stopped, Juneau was hit by an atmospheric river – a long band of warm air that carries high levels of moisture. The atmospheric river brought more snow and heavy rain, causing flooding across Juneau as the large piles of snow melted and strained the frozen drainage system. The heavy snow and rain also prompted avalanche and landslide warnings across Southeast Alaska.



What falls from the sky

"When people think of Alaska's changing environment, their first thought is likely related to increasing temperature; but, Alaska's recent experiences should compel us to seriously consider the increasing risk of extreme precipitation," wrote Alaska climate expert Rick Thoman in a [commentary piece in the Alaska Beacon](#).

How Alaskans experience precipitation depends on whether it falls as rain or snow. In other parts of the state, as temperatures fluctuate, shorter snow seasons and mid-winter rain can wreak havoc on daily lives.

Winter rain is rare but increasing in the Interior. The winter rain, or rain-on-snow event, occurs when temperatures dip just above freezing or when a warm air pocket overlies cold air, causing rain to freeze instantly on contact with below-freezing surfaces like roads, snow, cars and vegetation.

Of 24 recorded events since 1920, half have occurred

since 2000. Climate models predict a continued rise in winter rain, estimating an increase of one to three days per decade in Interior Alaska.

In January 2025, high temperatures in the Interior brought about a quarter inch of rain and a sheet of ice that stayed on the ground through April. Hazardous road conditions, vehicle collisions and a smattering of power outages reminded residents just how disruptive these events could be.

And in one of the most remarkable rain-on-snow events in the state's history, in Fairbanks on Dec. 25, 2021, 9 inches of snow fell, covering the town in a pristine blanket. There were just a few hours of a beautiful white Christmas before 1.5 inches of rain fell on top of it.

[Reports compiled by the Alaska Center for Climate Assessment and Preparedness](#) document the far-reaching effects of this single event. Over 20,000 residents of Fairbanks, North Pole and Healy lost power, many for over 48 hours.

ABOVE: Juneau residents shovel snow from buildings and boats with the help of friends. Photos courtesy of Annika Ord and Merry Ellefson. PREVIOUS PAGE: A tree falls against a building on the Ellefson's property on Douglas Island after the snow storm.

And over the following days, drivers called in 54 vehicle collisions and vehicles in distress. The ice sheet that covered the roads stayed through March.

In other areas of the state, where winter temperatures are not as consistently below freezing, winter rain means a shorter snow season. In the winter of 2024-2025, Anchorage had only 6 inches of snow on the ground by late February after earlier snowfalls had melted away. The 30-year average at Ted Stevens International Airport in Anchorage is 46 inches of snowfall accumulation for December through February.

Southcentral Alaska was not alone in feeling the impacts of warmer temperatures and shorter snow seasons as the state faced record winter warmth. In December, in the Nome area, nearly all precipitation fell as rain.

“January started out with ice glazed roads, brown tundra and no snow to be seen. Winter trails were non-existent and thoughts of skiing, dog mushing and traveling by snow mobile remained wishful thinking,” reported [The Nome Nugget in their 2025 review](#).

Shared understanding

After the bulk of the snow had fallen across Juneau, and everyone was preparing for the rain to come, Merry Ellefson looked out across her yard. Seven trees had come down over the course of the storm and 15 more were on their way. Later, as she skied along Montana Creek, she recounted hearing a booming crack as a tree with a 2-foot diameter trunk snapped in half.

“You couldn’t even see the trees through the snow on them. It was spectacular and eerie,” Ellefson said. “I had this realization, these trees have never been through this weather before either.”

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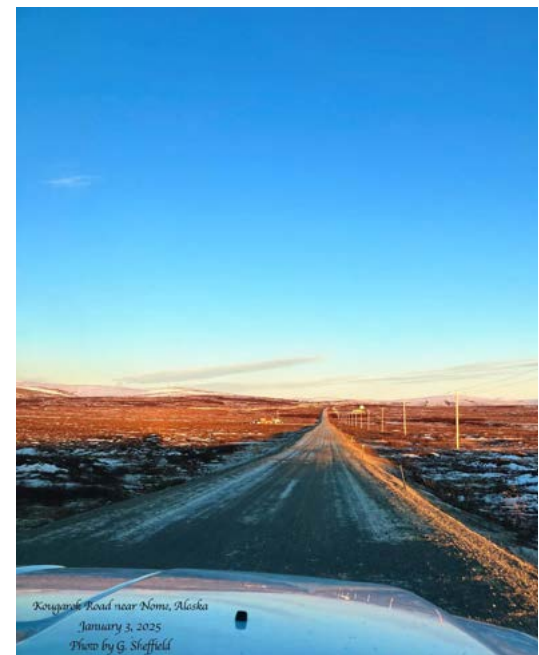
- MERRY ELLEFSON

As we move into unprecedented times, residents of Alaska, human or otherwise, will experience a new climate. Extreme events and anomalous weather will continue to arise, straining budgets, infrastructure, ecosystems and communities, but we have an idea of what’s coming. The trends point to more precipitation overall, but that can look different depending on the region and year. [Expect shorter snow seasons, more rain, more extreme events and warmer winters.](#)

“Knowing what the past has brought, that’s step one. Or maybe that’s step zero,” Thoman said. “We need to prepare for beyond that.”



L to R: Weather camera shows a snowless Iliamna in mid February. Photo courtesy of the National Weather Service. Kougarak Road near Dexter, about 8 miles north of Nome on the warmest December day on record in Nome, Dec. 11, 2025. That day temperatures reached up to 44 F. Facing north up the Kougarak Road, northeast of Nome on Jan. 3, 2025. Photos by Gay Sheffield.



Berry-stained science in a changing climate

By Taylor Saulsbury

Up the Taku River, a washtub sank under the weight of red jewels, glittering in the sunlight. A family skiff held thousands of ripe nagoonberries and strawberries, evidence of a long day of harvest. Afterwards, in a big pot with heaps of sugar, Dr. Angie Lunda's mother made jam over a crackling wood fire, pouring the hot, sticky red liquid into jars to savor in the winter cold.

Lunda is a Lingít educator at the University of Alaska Southeast, where she explores how children can build a relationship with the land through harvesting as well as cultural resiliency.

"It was a whole family affair," said Lunda, who remembers their summer stays fishing and harvesting fondly. "We went every year from the time I was born ... I have some pretty vivid memories of seeing the tub fill up with berries and then also the smell of the berries. So sweet and delicious, like pure sweetness in the summer."

From berry-stained memories of harvest all the way to the kitchen freezer, Alaska berries are vital to our shared ecosystem. According to a study, [rural Alaska families harvest on average twenty gallons of this superfood each summer](#), its flesh full of antioxidants that protect against diseases like dementia, obesity, and heart disease. But berries go deeper, rooted in culture and connection to place and integral in respecting and sharing the land's gifts.

"It's collectivist culture at its best, right? It's not that I'm picking them so I can eat them, but that I'm picking them so that we can all share them. Knowing that some would be given away and some would be eaten by our family," said Lunda.

Due to a changing climate, communities are now finding their cherished berry patches less bountiful, and in some cases barren. The timing of berry flowering and fruiting is shifting, jeopardizing wildlife and Alaskans' harvests.

*A ripe salmonberry, ready to be eaten.
Photo by Taylor Saulsbury.*



Illustration by
Taylor Saulsbury.

Defrosting, thawing winter

Christa Mulder, a plant ecologist at the University of Alaska Fairbanks, researches shifts in berry plant phenology, the timing of when plants flower and produce berries. Phenology is closely intertwined with environmental changes, where differences in snowpack can impact the survival of berry plants through the winter.

Snow cover is essential for numerous berry species in Alaska to protect and insulate these plants through the winter. Snow is made up of intricate crystals with pockets of air in between. These pockets insulate the soil from air outside, keeping delicate buds and shoots safe.

With less snow projected along coastlines like Southeast Alaska, buds formed the previous year are exposed to the winter temperatures, and frost and intense sun can kill buds and leaves, impacting summer berry abundance and harvests.

Mid-winter thaw is another dangerous component and a growing concern in Northern, Western and Interior Alaska, Mulder said.

"If you get a rain-on-snow event in places that you don't normally get rain-on-snow events, that changes the structure of the snow; it reduces insulation," Mulder said. "So now suddenly, instead of having a nice, warm, fuzzy blanket, you've just got a layer of ice. Imagine that now all that water percolating through the snow freezes again, suddenly there are buds encased in ice."

Snowmelt is coming earlier and earlier for Alaska communities and ecosystems. [Melt is expected to be two to four weeks earlier by 2100](#) in large parts of the state. In addition, wind storms are changing throughout Alaska, and average [wind speeds are projected to increase](#) in the winter, leading to varying amounts of snow, disrupting when and if berries emerge.

More snow has the opposite effect. Predicted for Interior Alaska, this could lead to a slower start to berry season. With the combination of climate change driven differences in snowpack, rain and wind, vital pollinators could be impacted.

"Okay, so that one's complicated ... we don't know the exact consequences yet," Mulder said. A lot is unknown about the phenology of pollinators. In theory, as the climate changes rapidly and spring arrives earlier, insects and birds can miss critical windows to pollinate plants that flower early.

Adding to the equation, insects don't produce their own body heat, so when temperatures drop or it rains, they are not as active. They struggle to fly in heavy rain, which is increasing on average across Alaska, impacting how they reach plants like salmonberries and cloudberrries.

But these are potential risks. At present, little is known about when pollinators emerge after the winter. "It's one of our biggest knowledge gaps in our understanding of pollinators. We don't know very much about how they overwinter and what triggers them when they come out," Mulder said.

Mulder's graduate student Kara Kornhauser has been investigating these knowledge gaps, examining shifts in pollinator activity and flowering. Kornhauser's new study compares plants that flower early and those that flowered at the average time. They recorded visiting pollinators and how much pollen they deposited.

According to their new study, plants that flowered earlier didn't get as many visitors. When they flowered later, about five times more pollinators visited. When snow melts earlier, berry plants follow, disrupting and desynchronizing pollination.

Some berries, like crowberries, can be pollinated by wind as well as by insects, making them less vulnerable to mismatches with pollinators. As the climate warms, the season that pollinators are active could lengthen in some parts of the state, where greater rates of pollination could occur in some areas.

Berries rooting, budding

Alaska berries are one of many voices whispering environmental change. Their voices tangle with memories of harvest and are rooted in place. To harvesters in Southeast Alaska, these whispers are loud and mighty. Here, they have been listening to the changes for generations.

“When you are harvesting, you must have an intimate knowledge of the place to know how to harvest efficiently...I think that’s where that value of respect starts to come in,” Lunda said. Five years ago, Lunda remembered a harsh frost that killed all the salmonberries along the coast in Juneau. That year, the only berries she was able to harvest were all the way up the slopes of Eaglecrest Ski Area and Mount Juneau.

Salmonberries, which are unique in their ability to thrive in post-burn environments, are primarily found near these coastal areas. [Paired with increased fires](#), communities in Southcentral and Western Alaska could find salmonberries in future harvests. But in Southeast Alaska’s coast, salmonberries are disappearing.

As winter temperatures become less severe and their growth season lengthens, salmonberry shrubs expand northward and up the mountainside, becoming less accessible.

“We’ve had decades of the environment telling us that we’re hurting it, and it’s changing. But because [berries] don’t have this mainstream impact, but impacted our culture and our traditional cultural ways of using and being on the land, it wasn’t deemed important. It’s always been important, though.”

- WENDY K’AH SKÁAHLUWAA TODD

“They’re no longer in the traditional areas where people have harvested for generations, and what that means is our aunties and naanaas that used to be able to go and harvest can’t now because they’re not able to get there,” says Dr. Wendy K’ah Skáahluwaa Todd, a Xáadas (Haida) scientist – an observer of the world, as her elders call it. Todd is an Associate Professor of Indigenous Science at the University of Alaska Southeast, as well as a mentor at the Sealaska Heritage Institute. She said disappearing berries creates a lasting cultural disconnect.

“We’ve had decades of the environment telling us that we’re hurting it, and it’s changing. But because [berries]



Two citizen scientists examine berries. Photo courtesy of the Winterberry Team.

don't have this mainstream impact, but impacted our culture and our traditional cultural ways of using and being on the land, it wasn't deemed important. It's always been important, though. Who cares if berries move? We do," Todd said.

Winterberries: Stories of collaboration

The Winterberry Project is a citizen science project that engages high latitude communities to monitor berry changes. As a part of the project, volunteers, students and UAF scientists monitored overwintering berries, which hold onto their fruit all winter long, critical for animals as well as people.

Overwintering berries are vital for animals in the winter. To prepare for the cold, bears and migrating birds depend on these plants that keep their fruits longer, sometimes through the whole winter. Non-hibernating animals like voles, foxes, and squirrels depend on these berries when other food is scarce.

While doing fieldwork, Mulder and her team have stumbled upon evidence of this relationship everywhere. A collaborator at the project once found a tree hollow packed full to the brim of glistening red cranberries by squirrels — a secret cache for the winter months.

Animals give back to berries in their own way too. Once, Mulder happened upon purple splotches littered along a forest path, flies swarming. To her, it looked like someone took bunches of blueberries and squished them all over the forested trail. She quickly understood it was a fox's previous meal, scat full of half-digested blueberries spreading precious seeds for the next generation of berry plants.

But animals aren't the only ones harvesting these berries. Overwintered lowbush cranberries are sometimes gathered in the spring, said to become sweeter and more delicious after the first frost. [This berry has the highest level of antioxidants](#) of 16 Interior and Southcentral Alaska berry species.

"We realized there was really no information on when we're losing the berries. There's just no data on when plants were dropping their berries. So we thought, well, how could we know if that's changing if nobody's tracking it?" Mulder said.

Thousands of children, as well as school groups and volunteers made up their berry task force. They tracked prickly roses, crowberries, highbush and lowbush cranberries. They saw that the [plants lost their fruits at a constant rate, instead of all at once](#). Only a couple of the bushes they studied lost more than 15% of the bushes' bounty in one week.



Jam sessions, pun intended, happened after the final collection of data. Youth were encouraged to look towards what a better berry future could look like – the best berry future.

“There was a group of kids in Two Rivers, close to Fairbanks, who were concerned about losing things like high bush cranberries,” Mulder said. “So, they decided to plant some other berries, like honeyberries to compensate for that in their schoolyard. The project prompted students to ask questions like, ‘What can we do about it? What can we plant?’”

“We are part of the environment. We are connected to it. What we do in our environment is going to go back to us. If we take care of it, it will take care of us,” Todd said.

Understanding how berries are impacted by a changing climate is complicated and its effects are continuing to shift. Through collaboration with community members and funding from the Alaska Climate Adaptation Science Center, Mulder and other berry experts have created [berry booklets](#) on five Alaska berries to provide information on these changes and how berries will respond.



Get involved



To give back to berries, Alaskans can help monitor berries in your secret patch, in your backyard or along your favorite trail. Visit the [Alaska Berry Futures site](#) to help.

Note:

This article was written with the core cultural value of protecting and honoring our land, or Haa Aaní or ìit' Tlagáaa in mind, values laid out by the Sealaska Heritage Institute.

These stories belong to the storytellers. Gunalcheesh and Háw'aa for sharing your experiences and your knowledge.

LEFT: Students monitoring berries in Fairbanks. BELOW: Students and researchers monitor berries in the winter in Anaktuvuk Pass. Photos courtesy of the Winterberry Team.



Studying a melting world: Seventy years of glacier records threatened

By Taylor Saulsbury

Changing routes, inaccessible weather stations and an uncertain future.

For more than 70 years, scientists have woven a tapestry of glacial data from snowy expeditions, satellite imagery and dozens of marked-up yellow notebooks, all to better understand how glaciers respond to a changing climate.

Spanning decades, this data is a part of the longest-running and continuous project to monitor glacier change in North America: the U.S. Geological Survey Benchmark Glacier Project.

Today, the future of this record is at risk, impacting our ability to track glaciers, the heartbeat of Alaska's mountains.

Twice a year, glaciologists travel to five glaciers in Montana, Washington and Alaska to take seasonal measurements of how much ice the glaciers gained in the winter and lost in the summer, otherwise known as glacier mass balance.

Due to climate change, warmer temperatures have led to less snow precipitation and longer melting seasons for glaciers, directly affecting their mass balance. As a result, all five of the benchmark glaciers have a negative mass balance, and are retreating and shrinking into the landscape.

Glaciers lose mass in the form of meltwater, which directly

impacts local and global communities. Since the turn of the century, [glaciers have contributed to about 21% of global sea level rise, according to a 2021 study published in Nature](#). Alaska glaciers make up a quarter of the sea rise.

The Benchmark Glacier Project is one of few continuous records of how glaciers react to climate and temperature. The project provides critical data for modelling rising sea levels, global climate predictions and worldwide decision-making. Scientists at the U.S. Geological Survey Alaska Science Center in Anchorage are responsible for tracking these changes at three glaciers in Alaska. This includes Lemon Creek Glacier on the Juneau Icefield, Kenai Peninsula's Wolverine Glacier, and Gulkana Glacier, a popular recreational spot southeast of Fairbanks.

These Alaska Benchmark Glaciers are a part of the [only 60 glaciers worldwide with long-term and continuous monitoring for over 30 years](#).



USGS map of Benchmark Glaciers across Alaska, Washington, and Montana. These glaciers have been monitored for decades.

Reaching the glacier measurement sites is a task in itself. Scientists take snowmobiles or helicopters or trek on foot to these glaciers each fall and spring to collect data, carrying sometimes more than sixty pounds of equipment on their backs and often traveling roped together in case snow bridges crumble beneath their feet.

Alaska glaciologists are having an increasingly difficult time tracking glaciers as historical routes change and disappear, critical weather stations become inaccessible and continued funding is uncertain.

“Wolverine Glacier, Gulkana Glacier and Lemon Creek Glacier are all going to be gone in 100 years. There’s going to be no ice left there at all,” said Louis Sass, the head of the Alaska Benchmark Glacier Project.

Sass and other glaciologists have spent decades recording how the glaciers are evolving, documenting these places before they disappear. As these glaciers rapidly lose mass, scientists need to adapt quickly – giving the term “glacial pace” a whole new meaning.

Losing, gaining, shifting routes: Navigating new glacial terrain

[Alaska glaciers lose 66.7 billion tonnes of ice each year](#), enough to cover Manhattan in 270 feet of water, and this glacier melt is accelerating.

Scientists at the Benchmark Glacier Project are experiencing the effects of this loss firsthand, needing to assess their routes every season. Last fall, accessing Gulkana Glacier was hard work. As the glacier recedes, it is leaving endless fields of soft, silty mud, which makes getting to the glacier challenging.

“It’s almost like quicksand. To avoid it, you end up walking on this loose, unstable moraine,” Sass said.

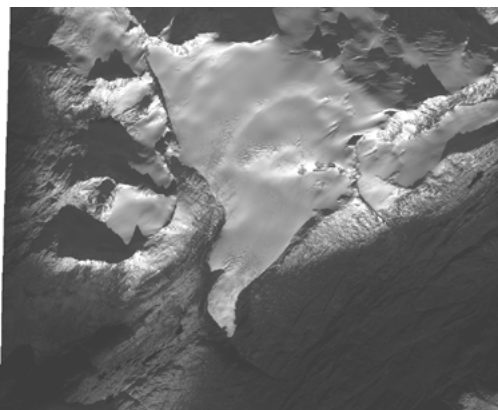
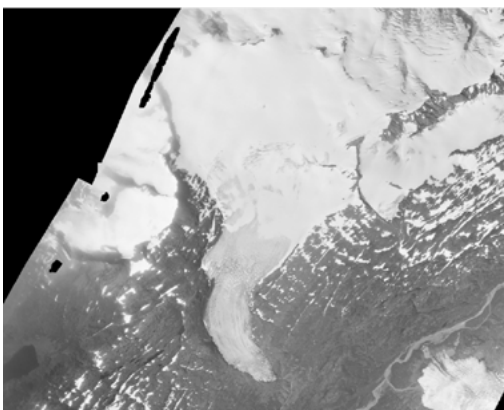


Glaciologist Chris McNeil traversing a glacier roped to Emily Baker, a past glaciologist at USGS. Photo courtesy of Emily Baker.

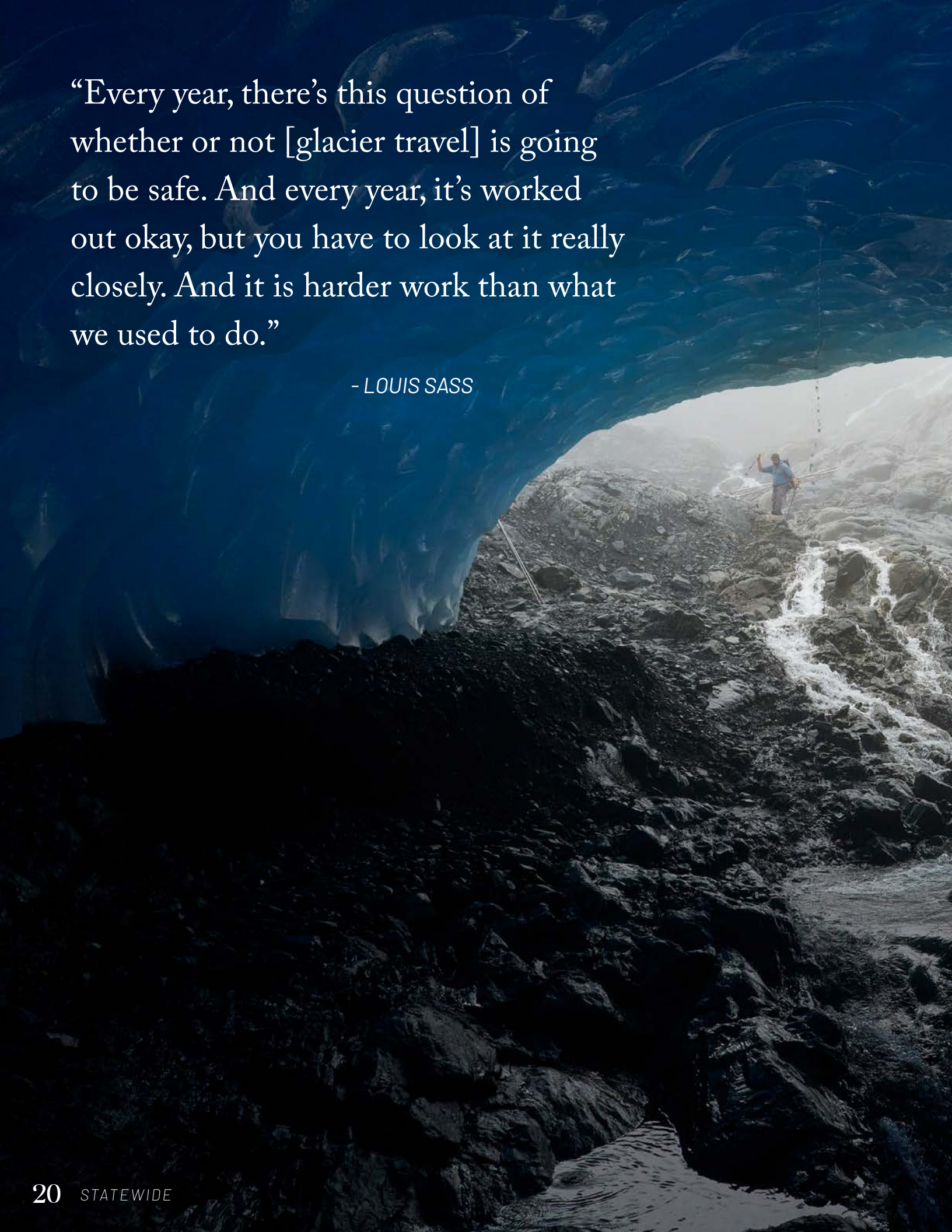
In the 2000s, the silty field was about half the size of a soccer field. Now, Sass says it’s the size of more than a half dozen soccer fields.

At Wolverine Glacier, situated in the Kenai Mountains, a massive channel of milky blue meltwater burst from the side of the glacier in 2019, forming a seasonal lake. As of spring 2024, the access point scientists have used for over 50 years is now completely submerged underwater.

When geophysicist Chris McNeil joined the Benchmark Glacier Project 12 years ago, getting on the glacier was straightforward. They could access the glacier in minutes, using snowmachines to drive over snow-covered crevasses. In the past 10 years, the glacier has shrunk, making it increasingly harder to access. After the river appeared, McNeil and the team watched the lake grow further, creeping towards their typical access path.



Aerial of Wolverine Glacier, situated in Alaska’s Kenai Mountain Range, in 1978 (left), compared to 2020 (right). It’s predicted that this glacier will be completely gone in 100 years, or approximately four to five generations. Photos courtesy of Benchmark Glacier Project.

A photograph showing the interior of a glacier tunnel. The walls are made of dark, jagged rock, and the floor is a mix of rocks and a stream of water. A person is visible in the distance, standing on the rocky path. The lighting is dim, with a bright area at the end of the tunnel.

“Every year, there’s this question of whether or not [glacier travel] is going to be safe. And every year, it’s worked out okay, but you have to look at it really closely. And it is harder work than what we used to do.”

- LOUIS SASS



The team passes by a newly formed ice cave at the lower part of Wolverine Glacier, which has since disappeared and melted away. Photo courtesy of Louis Sass, USGS.



Last fall, scientists found the Wolverine Glacier access point flooded and riddled with large crevasses. Seracs, attached columns of ice that slowly peel away from glaciers, towered hazardously over the path, threatening to give way. This past spring, they needed to find an entirely new route onto the glacier.

Their new route, however, was good news, at least for now.

"Honestly, what we found this past spring at Wolverine was an easier route than the thing that we had been doing for the last 10 years," Sass said. "This year, it was hard enough ... we needed to find something different. It turns out we found something that was more straightforward. Sometimes you can't do what you did before, and what you find is more complicated. We found something that was great. That's not always the story."

Now the Benchmark Glacier Project team has to reassess their routes every year, sometimes on a seasonal basis.

"Every year, there's this question of whether or not it's going to be safe. And every year, it's worked out okay, but you have to look at it really closely. And it is harder work than what we used to do," Sass said.

For Sass, Wolverine Glacier "kind of feels like a new glacier every time I see it now." Monitored by USGS since the late 1960s, this glacier has lost about 10% of its area since 1966 at an accelerating rate.

Rod March, a past glaciologist at the program, had been working for the Benchmark Glacier Project since the early 1980s. When Sass started in 2008, March showed him where Wolverine Glacier's terminus was at the beginning of the 1980s. In almost three decades, it had barely moved.

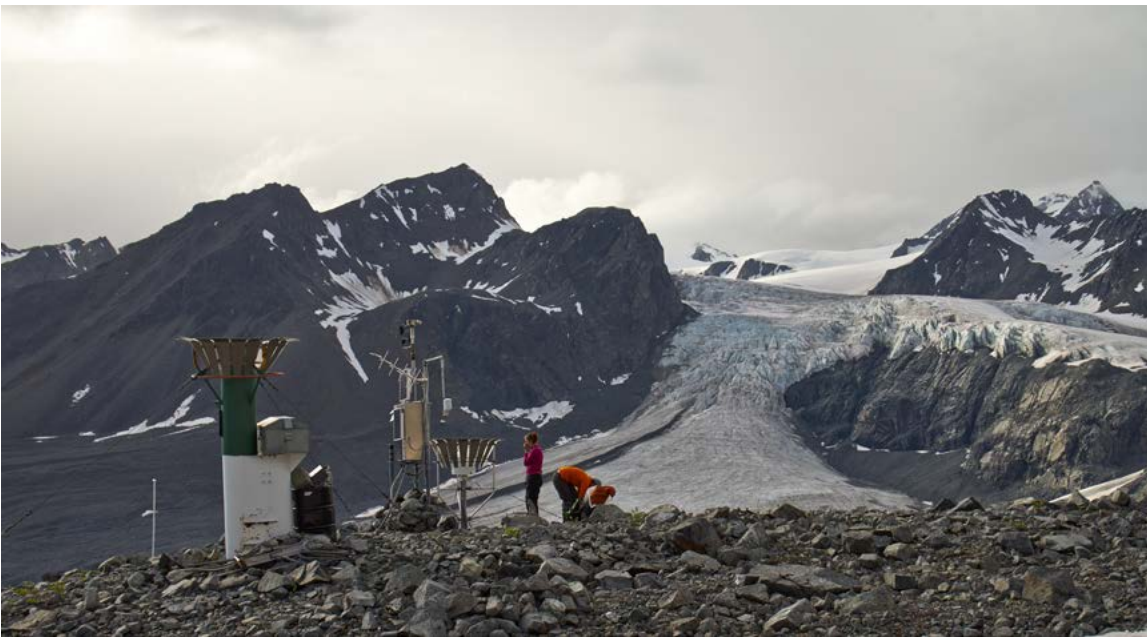
According to the Fifth National Climate Assessment, Alaska is warming two to three times faster than the global average, and Alaska glaciers are losing more mass than anywhere else in the world. Since March left the program, Louis Sass said the glaciers they studied together changed drastically, far more than they had in the decades March worked for the project.

"I was talking to Rod March last year on the phone, telling him how much change we'd seen since he left here in 2012, and he was floored by that," Sass said.

Lost weather station: Finding solutions at Mendenhall Glacier

Due to thinning ice, glaciologists on the Juneau Icefield face similar access challenges. As the ice continues to melt from Áak'w T'áak Sít' (Mendenhall Glacier), the glacier now sits far below the USGS weather station. Perched above Suicide Basin, the station is one of the sites used to monitor annual glacial lake outburst floods. Dr. Eran Hood, a glaciologist and professor at

ABOVE: Researchers used to carry loads of equipment and gear up and down from the weather station above Suicide Basin. This new and more hazardous route used to be located under the ice in a place where the team could walk from the glacier directly to the site. Since then, the glacier has noticeably shrunk. Photos courtesy of Anna Canny, KTOO.



the University of Alaska Southeast now looks up toward the station and sees a hazardous cliff between him and necessary data.

“Now, it’s so difficult that we’ve mostly abandoned that site,” Hood said. As the glacier thins, it drops loose rock and boulders, creating an unstable terrain. Combined with hauling heavy equipment, it’s far more hazardous to get to the station, forcing researchers to avoid it altogether.”

USGS scientists now fly helicopters to the cliffside weather station, presenting its own series of hazards. Currently, USGS is developing plans for a helicopter pad to access it safely, which will require more time and resources.

“It’s important to understand that as the glaciers change, the way that we study them has to change as well,” Hood said.

An uncertain future

Two years ago, the Benchmark Glacier team was forced to decommission one of the longest running and highest weather stations in Alaska. This station was critical to understanding the relationship between weather and glacial change, using local measurements of temperature, precipitation and wind to help decipher the timing of these changes.

“It’s important to understand that as the glaciers change, the way that we study them has to change as well.”

- ERAN HOOD

Situated along the margin of Gulkana Glacier, this station gathered weather data for more than 60 years. Unbeknownst at the time of its construction, it was built on top of an ice-cored moraine, an area of the glacier covered in sediment and rock. For decades, the moraine remained stable. In 2012, the team noticed the ice underneath melting, and quickly built Nunatak Weather Station.

“We did our due diligence; we created a new station, and there’s about 10 years of overlapping the data before decommissioning the old, so that’s the way that you try to bridge the old with the new,” said Emily Baker, a past glaciologist on the program. “It took a long time to build the value and long-term records of both the broader Benchmark Glacier Project and this weather station. You can really destroy things in an instant.”

In 2023, they helicoptered the station away in pieces.

ABOVE: The decommissioned weather station on the east side of Gulkana Glacier in 2014, one of the longest-running stations in Alaska. The site became more unstable as the glacier melted, forcing the team to helicopter it away in parts in 2023. Photo by Louis Sass, USGS.

"If we had left the weather station there, I think the whole thing would have actually slid down into a deep pile of rock," Sass said.

Accessing weather data remains a continuous challenge for the team. Nunatak Weather Station is now getting harder and harder to access every year.

Paralleling rapid glacial changes, Sass and his team also have to consider the whirlwind of federal funding. Baker left her position in May 2025 due to unpredictable funding going forward.

"The huge uncertainty over the future funding of federal science has been traumatic, I would say, as an employee. I was there for over eight years ... it was a long-term job that I found to be very fulfilling," Baker said.

At Juneau Icefield's Lemon Creek Glacier, fieldwork in spring of 2024 didn't happen. This glacier is one of the longest running monitoring programs in the world, monitored jointly by USGS and the Juneau Icefield Research Program. Now, there's talk of cutting fall monitoring on Lemon Creek Glacier all together.

"Once you miss a season of measurement, you can't go and get it back. Anytime you have discontinuous data, it really messes up your ability to do some statistical testing. It's bigger than losing just one year of data. It's losing the continuity of the data," Baker said.

Funding issues aren't new. In the early 2000s, a stream gauge employee at Washington's South Cascade Glacier volunteered his time to take measurements for the Benchmark Glacier Project when funding fell through. For scientists at this program, measurements are personal.

"People really value these records emotionally. They want to see them continue. People have really put a lot of blood, sweat and tears into keeping this going," Baker said.

But these measurements are bigger than the scientists. Five percent of Alaska is glaciated, roughly the size of the largest freshwater lake in the world, Lake Superior. With 33,000 square miles of ice, [Alaska's glaciers are projected to be the largest contributor to global sea level rise](#) from warming temperatures of any glaciated region in the world.

Benchmark Glacier Project data is critical in informing how communities will adapt around the world to sea-level rise, destabilizing landscapes and changes in local water resource management. Their measurements are used in global decision-making, including reports from the Intergovernmental Panel of Climate Change.

"The data we collect exceeds the precision of anything that we can currently collect from space. As the cryosphere of the planet continues to change, it's really critical that we continue to have these data sets on the ground," McNeil said.

With the project losing more staff, getting these measurements will become more challenging.

"I don't think it's a very controversial statement to say that if you don't have the people to make the measurements, you won't have the measurements," Sass said.

As these glaciers recede, taking historic routes and weather stations with them, scientists now spend more time and resources rebuilding stations, revisiting plans and changing routes.

Weaving together all the uncertainties, glaciologists must adapt to continue creating this tapestry of shifting ice. As the glaciers change, so will they.



Zanden Frederick searches for pieces from a decommissioned weather station in the USGS Field Station in Anchorage, coming up empty handed. The station's parts were recycled and repurposed for other projects. Photo by Taylor Saulsbury.

“People really value these records emotionally. They want to see them continue. People have really put a lot of blood, sweat and tears into keeping this going.”

- EMILY BAKER



The Benchmark Glacier Project team watch northern lights on an expedition to Gulkana Glacier in April 2017 Photo by Louis Sass, USGS.

NORTH SLOPE

On the North Slope, average annual temperatures may increase by about 16°F by the end of the century. Winter temperatures are projected to increase by over 20°F, and precipitation could increase by nearly 50%. The North Slope, the region of the state situated solidly within the Arctic Circle, is facing the most intense warming. The ecosystem that its inhabitants rely on is shifting rapidly.

**The climate projections for the North Slope come from the Northern Climate Reports, North Slope NOAA Alaska climate division. Models have higher uncertainty with regard to precipitation, and the summary is across all models and scenarios. See northernclimatereports.org for more information.*



Photo by Paxson Woelber, CC BY-SA 3.0
<https://creativecommons.org/licenses/by-sa/3.0>, via Wikimedia Commons.

Overflow ice (*aufeis*) covers Birch Creek Wild and Scenic River at the put-in at mile 94, Steese Highway. Photo by Craig McCaa, BLM Alaska.

In Alaska's tundra desert, freshwater fish survival depends on a lesser-known — and thinning — permafrost feature

By Christian Thorsberg

On the North Slope, all eyes are on *aufeis*.

Fewer than 30 miles from the shores of the Arctic Ocean, where the Shaviovik River wove as blue, frozen braids across the Coastal Plain, the peculiar wanderings of one wolverine — a scavenging male nicknamed Nimbus — sparked the beginnings of a mystery in April 2022.

Five cold weeks passed that spring at Kavik River Camp, an abode built just outside the Arctic National Wildlife Refuge and the home base for several wildlife ecologists from the University of Alaska Fairbanks. In the shadow of the Brooks Range, the team spent the season outfitting live-trapped wolverines with GPS collars as part of a study to better understand the mammals' movement patterns.

"Anywhere that they spent more than a couple hours was of potential interest to us," said Tom Glass, a UAF research ecologist. Almost immediately, Nimbus's travels, which appeared as recurring lines and dots on Glass's computer screen, caught his eye.

"I saw the data start to come in from this animal, and he was returning to this same site repeatedly over the course of days," Glass said. "He might go out to a surrounding area and spend an hour or two away from that place, but he'd always come back."

Nimbus journeyed with a determined fervor, trekking over and over again — no less than 17 times over a span of 50 days — to a stretch of land known as Shaviovik Spring. Though the spring itself spans more than a mile across the Shaviovik River, Nimbus always settled for hours within the same 60-yard radius.

The behavior was typical of a wolverine that had found and was gradually eating a moose, muskox or caribou carcass. But when Glass and a colleague ventured to the spring via snowmachine, expecting to find bones and last leftovers of frozen flesh, they came upon something much different: heaps of frozen, glittery, fish scale-filled poop.



An Arctic grayling frozen in overflow ice at Shavirovik Spring, April 2022. Photo courtesy of Tom Glass.

“Studies have estimated that the aquatic habitat on the Coastal Plain of the Arctic Refuge shrinks to just five percent of what it is during the summer.”

- JULIAN DANN

“I had never seen that before,” Glass said. “I’d been doing this kind of work for three years on the North Slope, following around a lot of wolverines. I’d never seen them eating fish.”

The unexpected discovery inspired further investigation. When Glass eased his vehicle across the frozen river’s floodplain to the middle of the channel, he was taken aback when he saw — sticking a Go-Pro camera through a layer of newly formed ice — nearly 100 dead Arctic grayling frozen inside, a layer of liquid water just beneath them.

Nimbus had been digging holes in the shallow ice and eating trapped fish, the spring his own well-stocked freezer.

“It was a morbid scene, and I was shocked,” Glass said, recalling when he first saw the footage on his computer back at camp. “I ran over to my coworker’s bunkhouse and showed her the video, and she was shocked, too. It was this very surprising, eye opening moment.”

All eyes on augeis

The die-off Glass and his colleagues discovered and later wrote about in the journal *Ecology* speaks to the fragility of Arctic freshwater ecosystems on Alaska’s North Slope, where temperatures rarely exceed single-digits and often linger well-below zero degrees Fahrenheit through the winter and spring.

“Studies have estimated that the aquatic habitat on the Coastal Plain of the Arctic Refuge shrinks to just five percent of what it is during the summer,” said Julian Dann, a graduate fellow with the Alaska Climate Adaptation Science Center.

The only fresh water that remains liquid throughout these seasons is found either deep in lakes or pooling as small springs that receive a consistent flow of warm groundwater. These liquid springs, few and far between across the region, often hug the edge of larger river

systems. Because they are the only locations where Arctic grayling and Dolly Varden populations are able to survive the winter, researchers like Glass often dub these perennial springs “fish oases.”

These oases typically remain liquid year-round, though their shallower, downstream shores tend to gradually freeze in the frigid conditions. Thin, sheet-like stripes of ice, called aufeis, thicken as they layer against each other. Over the course of a winter, aufeis fields can grow tens of miles in length and width, and may freeze to be several meters thick.

Because of their massive size, aufeis endures on the Arctic landscape. Unlike snow, which disappears soon after the weather warms, aufeis melts gradually throughout the summer to create consistent freshwater flows. Fish rely on these passages to connect to main river stems, spawning grounds and feeding sites. In unglaciated basins, aufeis is the second-largest source of summer surface freshwater storage, a crucial resource for human communities.

Glass [later wrote](#) about his experience at Shavirovik spring in the *The Revelator*: “Old reports we found mentioned thousands of fish preparing to overwinter here in autumn, and we learned that it’s known to the local Iñupiat, who harvest these fish for food, as the ‘Place Where the Land Sweats.’”



“This morbid find, equally fascinating and disturbing ... connected seemingly distant corners of the ecosystem — fish, ice, wolverine, people — and reminded us that even little things, like a slow spring or a cold winter, can tip the balance.”

- TOM GLASS

Historically, Dann said, aufeis fields have accumulated more mass in the winter than they lose in the summer. But aufeis coverage in some locations is changing. Communicated in a series of Alaska Climate Adaptation Science Center funded studies published [as recently as this spring](#), Dann has worked to improve satellite imaging that distinguishes between aufeis and snow. Analyzing data collected between 2010 and 2021 across 83 aufeis sites in northeast Alaska, he showed that the seasonal extent of aufeis fields is shrinking.

While the exact cause is unknown, Dann has hypothesized that warmer winters means it takes longer for aufeis to freeze, resulting in longer fields with thinner ice, which melt faster and more completely in the spring.

This positive feedback loop — less aufeis forming in the winter, more melting in the summer — means less aufeis overall, which threatens water availability and the survival of fish in the summer. In the winter and spring, thinner aufeis fields and shallower bodies of water are more sensitive to dynamic temperature changes, resulting in melting and freezing that never occurred in the past.

This may explain what occurred at Shavirovik Spring, the Shavirovik river’s [only known](#) overwintering habitat for freshwater fish.

Frozen Arctic grayling. Photo courtesy of Tom Glass.

"In the springtime, when frozen rivers start thawing out, they don't flow based on the gravel or riverbed underneath," said Randy Brown, a fish biologist with the U.S. Fish and Wildlife Service who has been studying North Slope river systems for decades. "The meltwater goes right over the top, and wherever there might be a fissure in that ice, it'll run it right down to the gravel," Brown said. "It'll start flowing and it melts that ice on the top of the aufeis field."

That a fish oasis had suddenly become a trap clearly shows how variable seasonal temperatures influence water availability, aquatic life and mammalian survival.

"This morbid find, equally fascinating and disturbing ... connected seemingly distant corners of the ecosystem — fish, ice, wolverine, people — and reminded us that even little things, like a slow spring or a cold winter, can tip the balance," Glass wrote.

The age of water

Hydrologists speak of Alaska's Coastal Plain the same way experienced pipefitters might size-up an old toilet: its plumbing is relatively straightforward.

What begins as rain in the Brooks Range gradually seeps underground and drains northward, filling lakes, rivers, springs, and forming aufeis fields as it flows towards the Beaufort Sea.

For years, it was assumed that the underground portion of this water's journey was exceptionally long. Early UAF research, based on data collected between 1985

"Traditional literature talks about the old age of water coming out of underground aquifers and into these aufeis fields. But using some new methods, we were able to show that, in fact, a lot of that water has only been in the ground for a short amount of time."

- JOSH KOCH



*Wolverine scat filled with fish scales.
Photo courtesy of Tom Glass.*

and 2009, indicated that it took at least 1,000 years for groundwater to move completely through the system, from mountains to coast.

But the small group of scientists focusing on aufeis in recent years have found alarming and conflicting realities. The actual number, said Josh Koch, a research hydrologist with the U.S. Geological Survey, may be closer to 20 years.

"Traditional literature talks about the old age of water coming out of underground aquifers and into these aufeis fields," Koch said. "But using some new methods, we were able to show that, in fact, a lot of that water has only been in the ground for a short amount of time."

Underground aquifers in other parts of Alaska are massive and extensive, Koch said, sometimes encompassing the size of entire states. Researchers knew this wasn't the case on the North Slope, though a lack of long-term data collection meant no one was exactly sure what lay beneath their feet.

In the spring of 2021, Koch and his colleagues used chemical tracers to follow and measure the age of water as they settled in aquifers beneath Alaska's Arctic Slope. The tracers contained a signature of the atmosphere from when the water fell as rain, and seeped underground.

“By looking at the chemistry of that water, we could sort of back-calculate when that water must have recharged into the aquifer,” Koch said.

Koch and his colleagues were surprised to learn how the aquifers beneath Arctic National Wildlife Refuge were fed by short, shallow flows. The amount of water below ground was limited, traveled short distances before returning to the surface, and completed its journey through the system in only a few decades.

“We went into this study asking: Can we quantify how old the water is, how regionally connected water may be, and how much availability there is?” Koch said. “We learned that water is young and very limited. There’s no regional deep aquifer.”

These findings, [published in March 2024](#), show the vulnerability of one of the world’s largest wetlands, home to fish and 200 species of migratory birds, as well as Alaska Native communities who rely on healthy streams for subsistence foods and water.

The prevailing 1,000-year timeline, scientists thought, would allow time for any pollutants to filter out of the water as it traveled for centuries through cool, frozen subsoils. But smaller volumes of groundwater, which follow shorter paths underground, are more susceptible to pollution and warming — an especially important

conclusion as the Arctic National Wildlife Refuge, which is experiencing atmospheric warming, is also being considered for oil and gas development.

“With the short flow paths, we know that there’s a risk of contamination, and so any contaminants that do get into the subsurface are going to show up in our surface waters quickly,” Koch said. “There could be impacts for what that means for water temperatures as well.”

Contradictingly, while the Coastal Plain’s underground aquifer is currently smaller and shallow, warmer seasons and permafrost thaw are causing it to expand. As soils thaw, there’s more volume underground to store groundwater. Eventually, this water reaches the surface and forms afeis.

“In some places afeis fields are decreasing in size, but in other places they’re actually increasing,” Koch said. “We’re really challenged in the ways we can learn about the subsurface. These afeis fields are these great windows into what’s happening below ground.”





70,000 walrus, seals and sea ice

By Diego Noreña

The loss of Arctic sea ice has cycled through headlines for decades, rising and falling in public attention as new records are broken. But for researchers like Maeghan Connor and Donna Hauser, sea ice loss is not a trending headline, it is the focus of their lives' work.

In 2024, Connor worked alongside U.S. Geological Survey researcher Anthony Fischbach to study Pacific walrus, a species increasingly forced onto land as the sea ice they once used for resting and foraging disappears. Historically, walrus relied on sea ice as mobile platforms above feeding grounds. As that ice vanishes, tens of thousands of animals now crowd onto narrow barrier islands, which creates dangerous conditions where a single disturbance can trigger deadly stampedes.

To monitor these massive haulouts, the team combined satellite imagery with drones to estimate herd abundance without disturbing the animals.

"Both satellite imagery and drones offer non-invasive ways to do that," Connor said.

Connor's role was to assist with "ground truthing" the satellite data. By flying drones at the exact moment a satellite passed overhead, the team could compare high-resolution drone counts with broader satellite signatures to ensure accuracy. Because walrus are highly sensitive to sound and movement, Connor closely monitored herd behavior during flights.

During one field season, Connor witnessed approximately 70,000 walrus packed onto a single barrier island.

"It's just a crazy number, hard to wrap your head around ... you can lie on the ground and feel vibrations from them calling and moving ... you feel this vibration in your chest ... and it's just you and one other person, and, like, 70,000 walrus. It's pretty intense."

She is now continuing to work with Fischbach to validate imagery and count carcasses, with the goal of understanding how stampede events impact walrus populations.

Connor's independent research builds directly on these methods, shifting focus from walrus to spotted seals. While spotted seals are also ice-associated, they haul out on land during the summertime, unlike other seals that remain in deeper waters or closely tied to sea ice year-round. Connor is planning to investigate whether spotted seals are remaining healthy as sea ice loss alters Arctic food webs and prey availability.

Using drones as a "virtual tape measure," she plans to apply photogrammetry to measure the length and width of individual seals, allowing her to estimate their

“All of the vessels moving in and out of the Pacific have to cross through the Bering Strait. But it’s also an incredibly important migratory corridor for many Arctic marine mammals, so the potential for conflict and overlap is high.”

- DONNA HAUSER



Spotted seals lounge in summer in Dease Inlet, Utqiagvik. Drone imagery was taken as part of graduate research work by Maeghan Connor.

body condition. Her work is conducted in collaboration with the North Slope Borough Department of Wildlife Management and Indigenous harvesters. By pairing drone measurements with Indigenous Knowledge, such as hunters’ observations of blubber thickness during harvests, Connor aims to create a more complete picture of seal health in a warming Arctic.

Hauser’s own research sits at the intersection of marine mammal ecology, sea ice loss, and increasing human activity in the Arctic. Trained as a marine biologist and ecologist, her career has evolved from studying animal behavior to examining how environmental change reverberates through social and ecological systems.

A major focus of Hauser’s work is the “opening” of the Arctic as sea ice retreats, exposing marine mammals to new stressors such as vessel traffic and shifting species distributions. The Bering Strait is a focal point of this concern.

“All of the vessels moving in and out of the Pacific into the Arctic have to cross through the Bering Strait,” Hauser said. “But it’s also an incredibly important migratory corridor for many Arctic marine mammals, so the potential for conflict and overlap is high.”

These changes have ecological and cultural significance. Marine mammals remain central parts of life for coastal and Indigenous communities.

Through close collaboration with Indigenous harvesters, for example, her research examines how changing sea ice and migration timing affect access to bearded seals in Kotzebue Sound and spring bowhead whaling in Utqiagvik. She also studies emerging indirect threats, including the northward movement of humpback and fin whales and the growing presence of killer whales in Arctic waters.

While sea ice loss feels distant to much of the world, the work of Connor and Hauser illustrate the changing relationship between sea ice, animals, and people across the Arctic.



Walrus haul-out on a beach near Utqiagvik. Photo by Maeghan Connor.

INTERIOR ALASKA

In the Interior*, annual average temperatures could increase by 11-13°F by the end of the century.

Winter temperatures are expected to increase the most, with projections of a 20°F increase in the central Interior. Spring and fall may transition from below freezing to above freezing, shortening the window of deep freeze that the region relies on.

These temperature increases are likely to lead to more above freezing days throughout the winter as well, causing destructive rain-on-snow events and travel hazards. Precipitation is likely to increase, with more precipitation falling as rain than as snow throughout the year.

** The data for Interior Alaska comes from the Northern Climate Reports and is a summary of the Southeast Interior, Central Interior, and Northeast Interior NOAA climate divisions. Models have higher uncertainty with regard to precipitation, and the summary is across all models and scenarios. See northernclimatereports.org for more information.*



Ice science from pre-k to gray

By Diego Noreña

Father Think Van Tran knows about ice. A Catholic priest who serves the Diocese of Fairbanks, he's spent time in the remote rural Alaska communities of Nulato, Koyukuk, Galena and Kaltag, deep in Interior Alaska. During that time he's come to appreciate how river ice serves as a major transportation corridor for these communities.

"We are always waiting, waiting," he said. "When we see the cold, freezing cold, real cold temperatures for a week or so, with 7 inches of ice, we're really happy with that because we know that it's really good freezing up and safe."

River ice serves as the highway in winter for Alaskans living off of the road system. If the ice fails, their highways fail and their lives are genuinely at risk. In the fall, anticipation becomes high when the river freezes and the water highway opens, providing a means of transportation again.

But with this form of travel comes many dangers. It is not uncommon for people to fall through the ice, which is exactly what happened to Tran in 2024 while traveling across a slough near the Yukon river.

"I broke the ice, my snowmachine couldn't make it over the holes, then I fell into the water. There was

a homestead two and a half miles from where I fell through, wolves and bears are still out there, so I took my axe and walked to that house. Then a guy at that house came out and helped me," Tran said. "I was so lucky."

It's avoiding moments like this that inspire Tran to report his local observations to Fresh Eyes on Ice (FEOI). Beginning in 2019, Fresh Eyes on Ice has worked to connect Arctic communities through a modernized water observation network. It relies on students, educators, elders, pilots, and even priests like Tran to report what they're seeing on the waterways. The program's core goal is to support and sustain observations of lake and river ice to inform public safety, document responses to a changing climate, and promote science education and participation across the state of Alaska.

Fresh Eyes on Ice



Submit observations and download data on river and lake ice conditions in your area on the [Fresh Eyes on Ice](#) website.

The ground truthing and involvement of communities in the Arctic is irreplaceable. The high-tech eyes in the sky, satellites, didn't catch what the community monitoring captured 23% of the time. That's almost a one-in-four chance the satellite is missing a detail with features which can be deadly for people traveling at speed on a snowmachine. Satellite data are made more robust and trustworthy when they are verified by these local observers.

This local monitoring is standardized using GLOBE (Global Learning and Observations to Benefit the Environment) protocols. Fresh Eyes on Ice uses GLOBE methods extensively within the program, providing standard research methods for students to engage in science. This effort is amplified by the Arctic and Earth SIGNs (STEM integration GLOBE and NASA assets), a NASA-funded initiative focused on culturally responsive climate change education. It teaches youth science through the focus of climate change because it is a topic that is very present and meaningful to them. Over 4,000 participants shared

over 6,000 images through the NASA GLOBE Observer app, alongside the Fresh Eyes on Ice website and social media. This information streams directly and immediately to the National Weather Service.

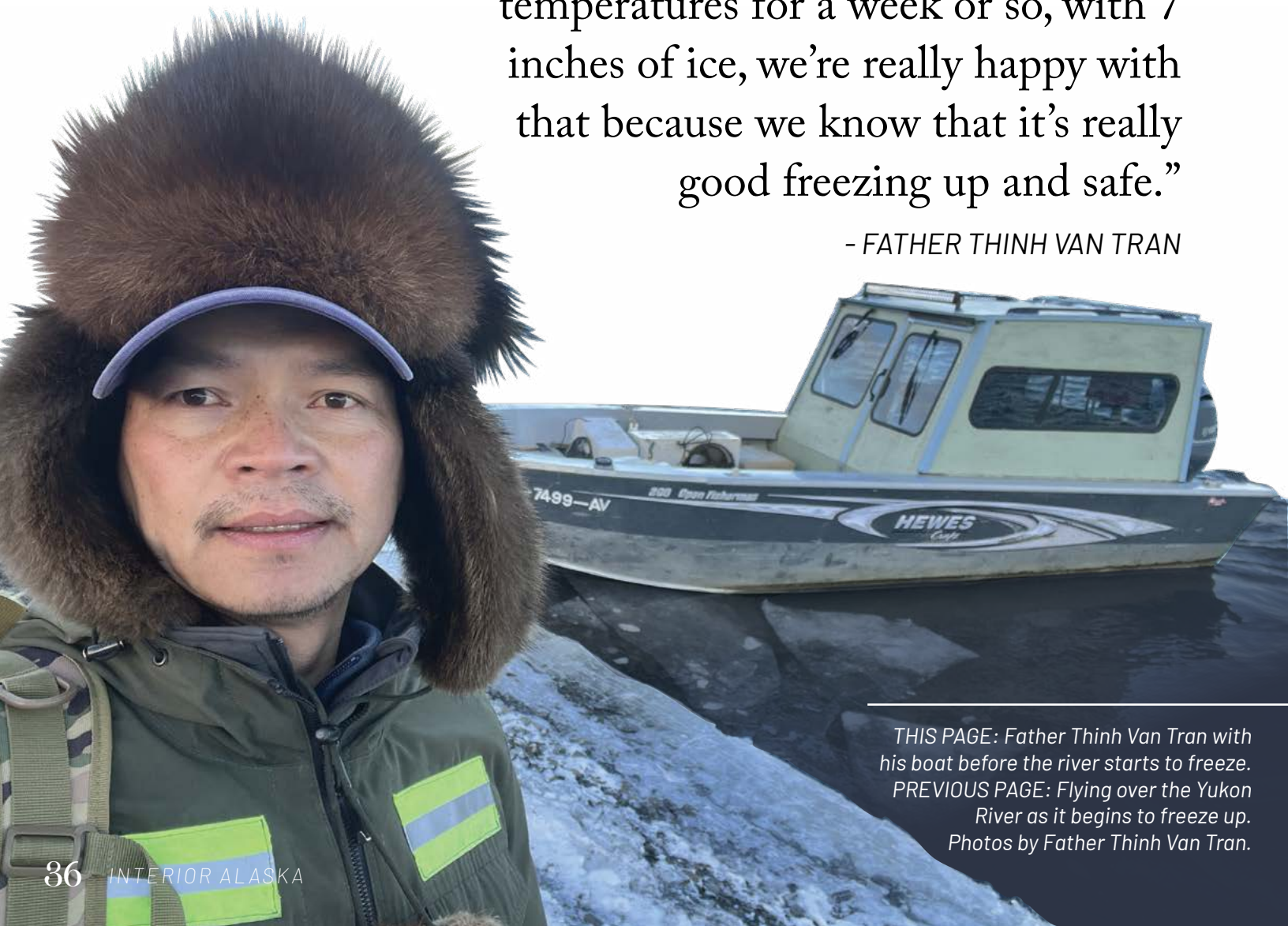
To sustain the relationship and continue data collection, Fresh Eyes on Ice scientists completed a 1,500 mile traverse by snowmachines. This approach counteracts the "parachute scientist" narrative by traveling like locals.

Sarah Clement, one of the scientists on the traverse noted, "so that was the intention, to show them we're visiting you on snowmachines. We're traveling like how many of you travel in the winter and we're showing up to do ice science with you guys."



“We are always waiting, waiting. When we see the cold, freezing cold, real cold temperatures for a week or so, with 7 inches of ice, we're really happy with that because we know that it's really good freezing up and safe.”

- FATHER THINH VAN TRAN



THIS PAGE: Father Thinh Van Tran with his boat before the river starts to freeze.
PREVIOUS PAGE: Flying over the Yukon River as it begins to freeze up.
Photos by Father Thinh Van Tran.



WESTERN ALASKA

In Western Alaska*, average annual temperatures may increase by about 14°F by the end of the century. Winter temperatures are projected to increase the most, with an over 20°F increase by 2100.

Coastal weather patterns may shift, and Spring and fall could transition from below freezing to above freezing in the future. The already decreasing sea-ice season will shorten even more. Precipitation is likely to increase, particularly in the fall.

In Western Alaska, many communities rely on snow and frozen rivers for travel to area hubs and subsistence camps. Well-worn paths may become unreliable as frozen rivers and snowpack change drastically. Migrations of birds and caribou will shift, likely requiring more travel on uncertain terrain.

** The climate projections for Western Alaska comes from the Northern Climate Reports and is a summary of the West Coast NOAA Alaska climate division. Models have higher uncertainty with regard to precipitation, and the summary is across all models and scenarios. See northernclimatereports.org for more information.*



A single caribou stands in 2019 amid cottongrass and other tundra plants near the Hulahula River in the Arctic National Wildlife Refuge. Photo by Alexis Bonogofsky, U.S. Fish and Wildlife Service.

Caribou herds in Arctic Alaska tundra areas are on opposite trends

By Yereth Rosen

This Article was [originally published by the Alaska Beacon on Jan. 20, 2025](#) and has been edited only for length and style. It is published here under [Creative Commons license CC BY-NC-ND 4.0](#). Notes from our editor are marked as superscripts and can be found at the end of the article.

The Western Arctic Caribou Herd, once the biggest in Alaska, is faltering, having fallen from a high of 490,000 animals in 2003 to only 152,000 as of 2023. But to the east, the [Porcupine Caribou Herd](#) appears to be thriving, with an [all-time high](#) of 218,000 animals recorded at the last census¹. That makes it, rather than the Western Arctic herd, the state's largest.

Why are the herds following opposite trends? An answer, Alaska scientists say, is found in what is growing on the ground – and the way the warming climate has changed those plants.

Woody shrubs and even trees are spreading rapidly over Arctic regions of Northwest Alaska, the area where the Western Arctic herd ranges, said Roman Dial, a professor at [Alaska Pacific University](#). But that plant transformation, which scientists refer to as "[shrubification](#)," has been much slower on the eastern side of Arctic Alaska, the range for the Porcupine Caribou Herd, he said.

For caribou, growth of woody plants like alders and willows means problems. Caribou depend on tundra plants like lichen and mosses; the shrubs and trees taking over the terrain are reducing the availability of that food favored by the animals.

Dial has studied changes in Alaska plant growth for several years and has been traveling in the Brooks Range since he was a teenager in the 1970s.

Even though his recent years' work in Arctic Alaska has been focused on plants, he said encountering willows and other woody plants covering what used to be open tundra west of the Dalton Highway made him think right away of animals.

"A lot of caribou trails were getting overgrown and disappeared, and you'd find really old antlers that were in skulls that were kind of buried in the tundra, so caribou hadn't been there for a long time," he said. "Right away it was, like: 'Wow, caribou are changing their routes.' And you could see it."

The overgrown state of caribou trails that had been etched into tundra terrain over multiple years of migration was instructive, Dial said.

When he [presented](#) his studies during the December annual meeting of the [Western Arctic Caribou Herd Working Group](#), the advisory panel representing villagers and others dependent on the herd, Dial described what might be a caribou's view of the plant takeover, and he used a brief [video](#) from the field to illustrate his point.

He does not like walking through willows that can be eight feet tall, "and I don't think caribou like going through willows either," Dial told the working group. "If my antlers were all tender and velvet, I wouldn't want to go through a bunch of tall willows. And also, when you go through willows, there's bears in there."

Changes in caribou habitat are linked to reduced Arctic sea ice, which itself is a direct result of accelerated climate warming in the Northern Hemisphere, Dial said.

Open water leads to more snowfall, he said, as there is [more moisture](#) sent into the atmosphere to fall as [precipitation](#). More snowfall insulates the ground, keeping soil temperatures warmer through the winter, he explained. Warmer soil temperatures encourage plant growth and the spread of woody shrubs and trees. More woody plants on the ground make life harder for caribou, both by displacing their usual tundra food sources and by creating new obstacles to movement.

Open water does not affect Alaska's western and eastern Arctic tundra regions equally, and the results are seen on the ground, Dial said.

Sea ice retreat usually forms later and melts earlier in the [Chukchi Sea](#), which lies off the northwestern coast, than in the Beaufort Sea, which lies off Alaska's northeastern coast. Utqiagvik – the nation's northernmost

“A lot of caribou trails were getting overgrown and disappeared, and you'd find really old antlers that were in skulls that were kind of buried in the tundra, so caribou hadn't been there for a long time. Right away it was, like: ‘Wow, caribou are changing their routes.’ And you could see it.”

– ROMAN DIAL

community – is the point where the two Arctic seas meet. Relatively warm Pacific Ocean water flows into the Chukchi through the Bering Strait, making ice there more seasonal, meaning it forms and melts earlier each year. In contrast, an ocean circulation system called the [Beaufort Gyre](#) sends old multiyear ice from north of Canada into the Beaufort, making the freeze there [a little more resilient](#). While ice retreat has been significant over the past decades in both seas, the characteristics of the Chukchi make it [particularly vulnerable](#), and it has lost both the thickness and extent of ice at a [faster rate](#) than almost any marginal sea in the Arctic, according to climate scientists.



Two bull caribou of the Western Arctic Caribou Herd swimming across the Kobuk River during fall 2011 migration in Kobuk Valley National Park. Photo by Kyle Joly, National Park Service.

Both the Western Arctic herd range and the Porcupine herd range have become [warmer](#) in summer and snowier in winter, according to records kept by the Alaska Center for Climate Assessment and Policy² at the University of Alaska Fairbanks. But the summer change has been [more intense](#) in the western range, particularly in coastal areas off Nome and Kotzebue, according to the data.

The work by Dial and his colleagues to track the changes involved an old-fashioned method: walking the ground.

The idea to do that was inspired by studies of shrub growth that is spreading up to higher elevations around Anchorage – and made necessary by the COVID-19 pandemic, which shut down National Science Foundation-funded air travel in 2020, Dial said. Some of the Alaska Pacific University students who were working with him on studying vegetation were enlisted to go north to be part of the Brooks Range expeditions.

In 2020 and 2021, they walked hundreds of miles of the terrain, smartphones in hand, looking down and recording changes in the plants growing on either side of the Dalton Highway. “It kind of added a new dimension to hiking,” he said. A study published in June details the [findings from their treks in 2020](#).

A [separate but related study](#), published about a year ago, examined tree rings to show a correlation between growth and proximity to open Arctic water. The study, which Dial did with Patrick Sullivan of the University of

Alaska Anchorage and other scientists, [focuses on white spruce trees](#) from 19 different sites along the Brooks Range. Those trees were small, ranging from ankle to chest height, indicating that they were recent arrivals, Dial said.

The on-the-ground work by Dial, Sullivan and their colleagues adds to past research that tracked the northward spread of woody plants by more distant methods. A [2018 study](#) by scientists from the U.S. Fish and Wildlife Service, UAF and other organizations, for example, used 50 years’ worth of aerial photographs to identify shrub and tree expansion into the Arctic National Wildlife Refuge in northeastern Alaska, where the Porcupine herd ranges. The study found that shrubs had spread into the refuge’s tundra regions over the half-century period, but they had done so at a slower pace than in other Arctic Alaska tundra regions.

The growth of woody plants in Arctic tundra regions affects more than caribou.

In northwestern Alaska, where the growth has been most dramatic, it has attracted a [proliferation of beavers](#), for example. And as beavers colonize the landscape, they are [transforming it](#) with thousands of new dams that pool water that, in turn, speed thaw of permafrost and feed into the cycle of shrub expansion.

A caribou is seen on June 12, 2013, in Gates of the Arctic National Park and Preserve. The park is part of the range of the Western Arctic Caribou Herd. Photo by Zak Richter, National Park Service.



Broader climate change impacts

Climate change [impacts](#) on the Western Arctic Caribou Herd go beyond the spread of shrubs displacing tundra plants.

Warm winter conditions in 2005 produced two days of rain in the herd's winter range, creating a thick layer of ice that encased the tundra plants that the animals eat. A large die-off followed, according to the Alaska Department of Fish and Game.

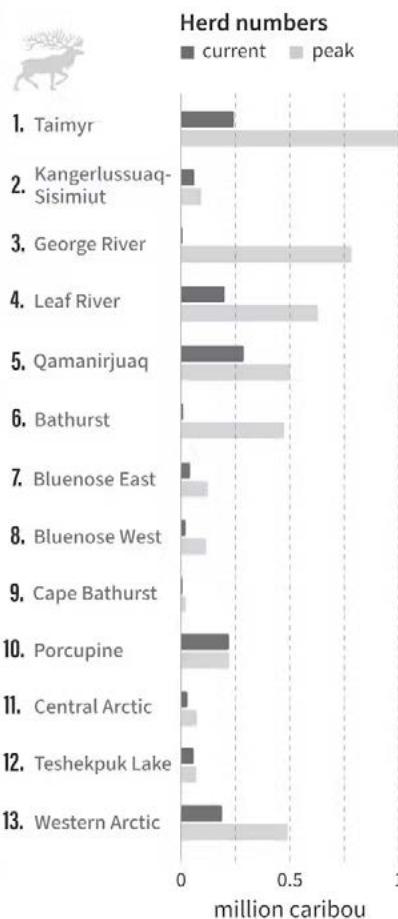
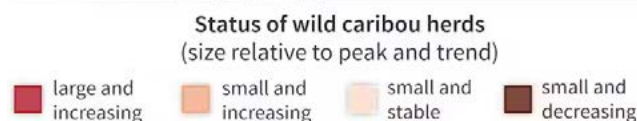
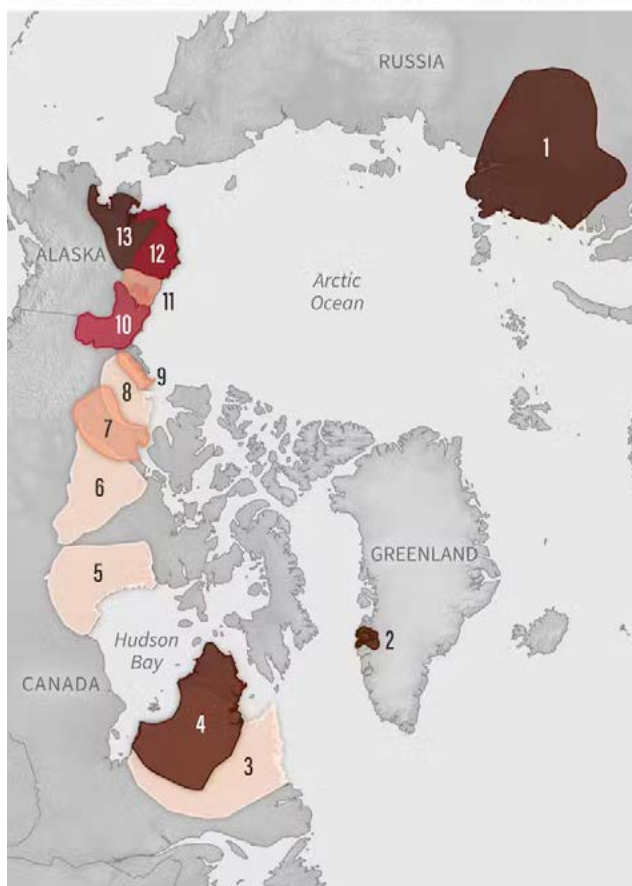
Wildland fires that are becoming more common as conditions warm can also affect caribou by destroying the slow-growing lichen and other tundra plants the animals eat. That has long been known to be an issue for caribou in more southern and boreal regions, such as Interior Alaska's [Nelchina herd](#). Now [wildfire has emerged as a threat](#) to the Western Arctic Caribou Herd's habitat.

The Western Arctic herd's declines are part of a circumpolar trend.

“Warmer summer and fall temperatures, changes in winter snowfall, and an increasing human footprint collectively stress Arctic caribou, altering their distribution, movements, survival and productivity.”

- 2024 ARCTIC REPORT CARD

Low caribou numbers across much of Arctic



Many caribou herds have lost population in recent years, as shown in the 2024 Arctic Report Card. Image courtesy of the National Oceanic and Atmospheric Administration's Arctic Report Card.

NOAA Climate.gov, ARC 2024

Tundra caribou populations across the Arctic have declined by 65 percent over the last two to three decades, according to the 2024 Arctic Report Card released in December by the National Oceanic and Atmospheric Administration. Alaska's Western Arctic Caribou Herd was one of those identified as having the most dramatic declines.

"Warmer summer and fall temperatures, changes in winter snowfall, and an increasing human footprint collectively stress Arctic caribou, altering their distribution, movements, survival and productivity," the report card said.

For the Western Arctic herd, changes go beyond its sliding population numbers. A key metric measured by federal and state biologists who study the herd is the date when southward-moving caribou cross the Kobuk River, a waterway that flows west from the Brooks Range into Kotzebue Sound. Over the decades, most collared caribou spend summers north of the river and winters south of it, though in five years since 2016, fewer than half of the collared animals went that far south in their fall migration, according to the data.

At the December meeting of the Western Arctic Caribou Herd, National Park Service biologist Kyle Joly said the average river-crossing date in 2023 was notably late: Nov. 8.

"It was the latest-ever average time that they crossed. I actually had to extend my graph here because the number didn't fit," Joly told working group members.

Caribou that do cross have also shifted the location of where they do so, and where they spend the winter. There has been a notable lack of caribou on the Seward Peninsula in the western part of the traditional range, according to the data from collared animals. None were tracked into Bering Land Bridge National Preserve, Joly said.

On the-ground observations match the data, he said. "Twenty-five years ago, Unalakeet was a great place to see caribou," he said. Residents haven't seen caribou there for several years, he said.





A caribou herd along the coast of the Beaufort Sea, July 2023. Photo by Christian Thorsberg.

¹Since the time of this article's first publication, the Alaska Department of Fish and Game, working with the Government of Yukon, conducted another photocensus which estimated the Porcupine Caribou Herd at 143,000 caribou. The census shows a marked decrease since the herd's population peaked in 2017 but is still the largest herd in the state and stable enough to support normal hunting guidelines.

²Now the Alaska Center for Climate Assessment and Preparedness

SOUTHCENTRAL ALASKA

In Southcentral Alaska* average annual temperatures may increase by 11-13°F by the end of the century, with winter temperatures increasing 13-16°F. Spring and fall will primarily be above freezing in the future, and further south, winter may be as well. Fluctuations between freezing and non-freezing temperatures may make travel difficult for this area with higher population density.

Precipitation could also increase by around 40%, leading to periods of high snow fall and rain storms which can destabilize this mountainous region, leading to increased risk of avalanches. Glaciers will continue to retreat, and once-glaciated areas will look unrecognizable by the end of the century.

** The climate projections for Southcentral Alaska comes from the Northern Climate Reports, and is a summary of the Cook Inlet, Bristol Bay, and Northwest Gulf Alaska climate divisions. Models have higher uncertainty with regard to precipitation, and the summary is across all models and scenarios. See northernclimaterports.org for more information.*



What happens when a community passes ‘peak water’? Cordova and Kodiak tell two stories of energy and industry

By Christian Thorsberg and Diego Noreña

In many of Alaska’s small, coastal communities, the same old joke has danced on residents’ tongues, and stuck in their noses, for generations: *You smell our town before you see it.*

The familiar mixture of chum, guts and refuse curls unmistakably through harbors, serpentine fishing boats and layering foggy quays. It rises from the floors of canneries, where freshly caught fish are processed and packaged as seafood. The odor lingers in the air above ports, where millions of pounds of exports each year – cans and pouches of salmon, pollock and cod harvested from the Gulf of Alaska – are frozen and barged to Seattle, South Korea and Japan, netting large sums of dollars, won and yen in return.

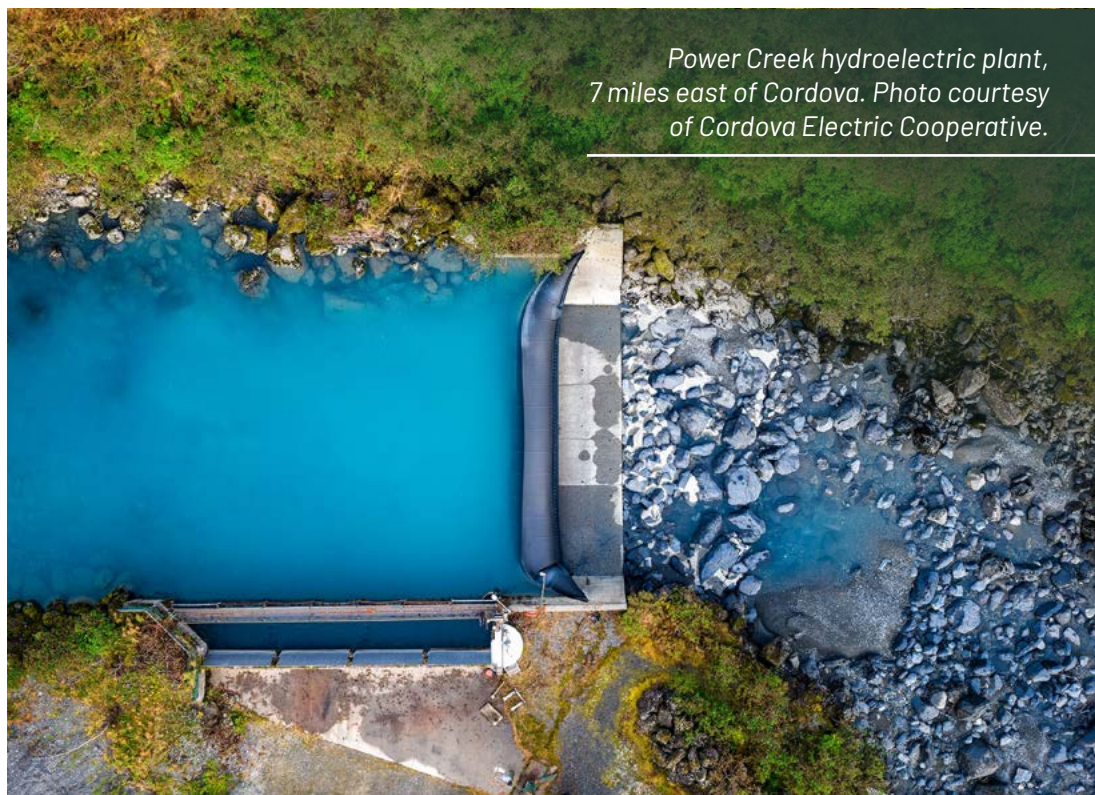
For dozens of Alaskan towns, the canning industry is their economic lifeblood; to smell fish guts is to smell money. Alaska’s commercial seafood economy generates more than \$1 billion each year, and roughly [60 operating canneries](#) across the state’s southern coasts contribute significantly to these dividends.

But success comes at a cost. During the harvesting seasons, canneries’ energy needs – to operate machinery, cool freezers, and clean fish day and night – increase substantially.

Entire towns’ power grids dwindle and recharge in synchronization with these processors’ demands.

In Cordova and other remote coastal towns, that synchronization has always been more than a technical detail; it is a relationship that determines whether workers stay employed, whether processors meet contracts and whether families can depend on seasonal income. When the energy system falters,

the entire economic rhythm of summer begins to wobble, a tension that has grown more palpable in the past decade as both energy availability and fish returns have become less predictable.



Power Creek hydroelectric plant, 7 miles east of Cordova. Photo courtesy of Cordova Electric Cooperative.

Perhaps no one knows the intricate relationship between energy, canneries and the local economy better than Clay Koplín. From 2016-2025, Koplín served as Cordova's mayor and — as is typical in a small town where everyone wears several hats — as CEO of the Cordova Electric Cooperative since 2007.

The Cordova Electric Cooperative operates the Power Creek hydroelectric dam which is perched in the Chugach Mountains above Cordova's population of 2,400 year-round residents. A bulwark, the dam contributes between 60% and 70% of the town's electricity annually, and during any given time of year when other sources are offline, might be relied upon as Cordova's sole energy supplier.

During peak processing weeks, the utility sometimes sees its load nearly double, driven by compressors, blast freezers, ice machines and continuous sanitation. In years with normal water availability in the watershed, Power Creek helps shoulder this surge. But in years with sudden dry spells, the utility must rapidly pivot to backup diesel, an expensive and increasingly risky option for a town not connected to any outside grid.

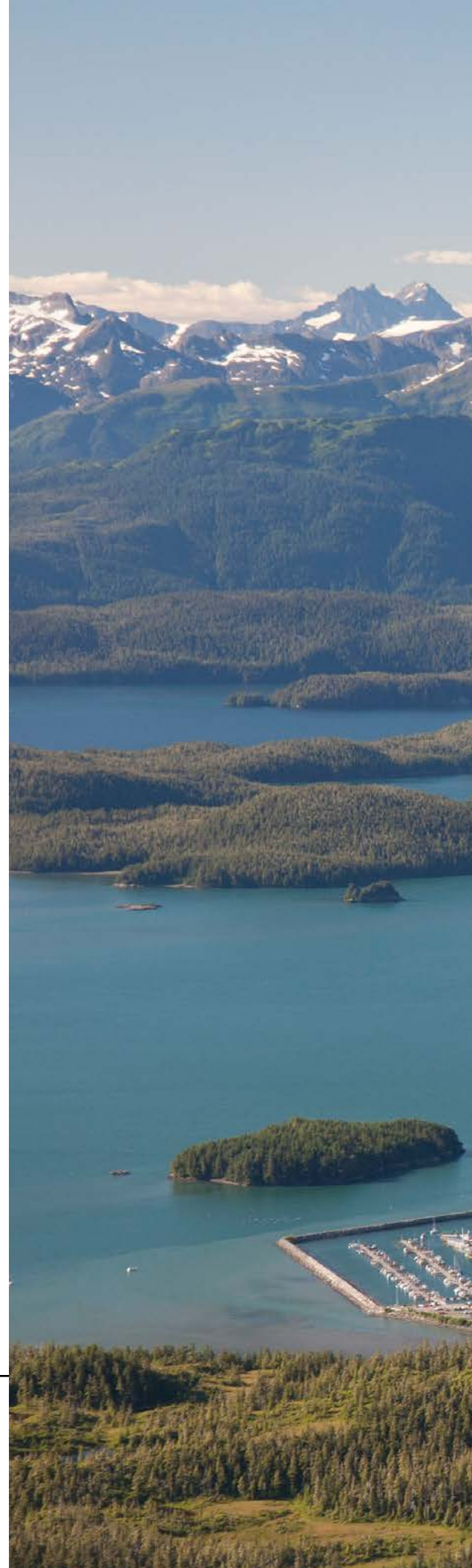
Power Creek dam is named for the watershed in which it sits, an alpine area of 50 square kilometers. Roughly 18 glaciers, including three glaciers larger than 1 square kilometer, cover one-fifth of this landscape. Their meltwater discharge, coupled with rain and snowmelt, comprise the dam's entire inflows.

For decades, Cordova's glaciers have been shrinking. They accumulate some ice in the winter, but more melts throughout the mild summers from May through September. According to Joanna Young, a glaciologist with the International Arctic Research Center, this melt typically peaks in July and remains high through August.

"This is also right around when the fish processing plants have their highest load," Young said. "So it's quite convenient for them that they have high mid-summer water availability, which translates directly into power availability."

But sometime in the mid-2010s, around when Koplín took office, he observed that this seasonal harmony began to ring discordant. Data collected by the Cordova Electric Cooperative signaled a fundamental shift in Power Creek's hydrology. Instead of stretching across May through September, the meltwater entering Power Creek dam was dwindling.

The Chugach Mountains surround the town of Cordova. Photo Courtesy of the U.S. Forest Service.





Young's research with the Alaska Climate Adaptation Science Center uncovered the processes behind this shift. Cordova had long since passed "peak water," a distinction that signals the turning point when the flow of water derived from a shrinking glacier, having initially increased due to melting, began a permanent long-term decrease.

The city was starting to feel it. In Cordova's case, this meant that the glacier-fed Power Creek watershed – the system the town relies on for its lifeblood – was becoming dramatically less reliable.

Young emphasized that this marks more than a hydrologic quirk; it is the hallmark of a watershed in transition. Once peak water is passed, the long-term trend is downward: less ice, less melt and fewer days when the water supply aligns with human need.

For a run-of-river system like Power Creek, this shift becomes visible immediately in the power logs, showing more diesel uptime and rising operational stress on infrastructure.

Young's analysis of flow measurements collected by Cordova Electric Cooperative showed this summer high flow period shortening by 44 days over just a 17 year span. This dramatic shift in hydrology means that the synchronization between nature's supply and the industry's demand is breaking down.

This mismatch has begun to show up even outside the utility sector. Fish processors have reported occasional delays in ice production due to energy shortages, affecting seafood storage. While small on their own, such disruptions compound quickly during peak processing season, when a delayed delivery can ripple through an entire fleet's schedule.

The core issue in the Power Creek watershed isn't just a lack of total water, but a lack of storage. The city is unable to hold onto the energy produced during periods of high water availability to be used later. The solution for Cordova, Young suggested, is technological resilience: "energy storage solutions like batteries or flywheels" to mitigate the changing water availability. Those solutions may work in the short-term, to smooth the trickles and flows of hydropower, but larger storage solutions are also necessary.

Cordova's historic cannery stands north of town. Photo Courtesy of the U.S. Forest Service.



Cordova Electric Cooperative is actively pursuing energy storage solutions such as their Humpback Creek Hydro Storage Project and Crater Lake high elevation water storage.

Cordova, which once relied on a long melt season, is now forced to adapt its energy system to weather the declining supply of meltwater from a smaller glacier. Cordova is building its resilience from a position of urgent vulnerability.

Koplin and Young both acknowledged that energy storage systems are only part of the equation. True resilience, they argued, will require a more flexible system.

Kodiak: A different story of energy independence

Less than 500 miles southwest of Cordova, on Kodiak Island, sits a community of similar size and economic reliance on the fishing industry. But where Cordova is adapting to a hydrological shift, Kodiak tells a different story – one of energy independence.

Kodiak's watershed is dominated by rain-fed reservoirs and supplemented by strategically placed wind turbines. This means its power availability is less sensitive to short-term heat waves and more stable across the shoulder seasons.

The culture of Kodiak is proudly steeped in seafood. Public trash bins are styled like vintage salmon cans and downtown installations celebrate generations of dock workers. But just down the road from the largest canneries, a quiet success story exists in the form of a ghost building and a repurposed sushi restaurant.

Dan Menth, the CEO of Kodiak Electric Association, pointed to the site of his utilities past dependency. Gesturing to a foundation, he recalled, "This is where my office used to be... And that," he says, pointing across the street, "was the old powerhouse."

Where two mighty diesel generators once hummed, sushi is now served.



“Kodiak has been pretty successful, the community has embraced our wind turbines and renewable energy.”

- DAN MENTH

Kodiak decided a decade ago to unhook itself entirely from the volatile price and supply of diesel fuel, divorcing its economic engine from carbon.

The Kodiak Electric Association set a goal in 2004 to achieve 95% renewable energy. By 2017, they revamped the goal to “maintain at least 98%.” Menth’s cooperative has been successful, running “over 99% every year” since. Even during peak fishing season, when the canneries drive the utility’s load to 30 megawatts, the island meets its needs with wind and hydro energy.

“Kodiak has been pretty successful, the community has embraced our wind turbines and renewable energy,”

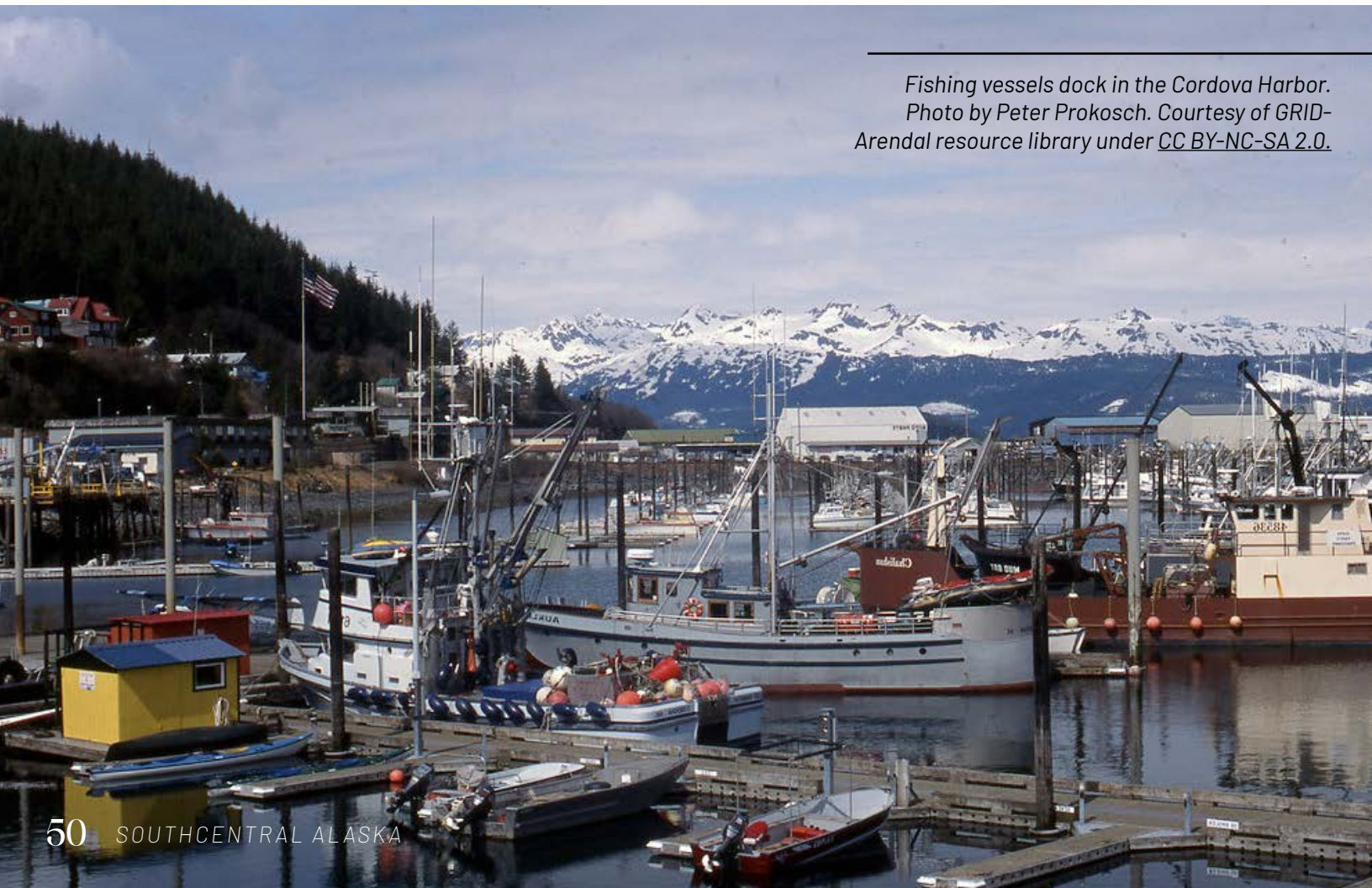
Menth said. Kodiak’s energy success is so profound that residents are now inspired to install their own renewable systems, seeing the giant turbines behind the town as a symbol of economic stability.

Menth explained that the community support didn’t appear overnight. Early wind initiatives faced skepticism from residents who remembered the volatility of diesel markets and doubted whether turbines could withstand Kodiak’s infamous gusts. But after storms repeatedly knocked out the old powerhouse while the wind system held firm, public perception shifted. Today, renewable energy is woven into the island’s cultural identity.

Cordova and Kodiak are two halves of the same Alaska story of specialized adaptation. One community, built on the former high water flows of a shrinking glacier, is searching for a solution to a problem that ramped up faster than expected, but like Kodiak, Cordova has an opportunity to find new energy solutions that suit their unique needs. In Alaska’s coastal communities, the smell of money once belonged to fish guts; today, two towns demonstrate that the true scent of money may soon be reliable electric power and the foresight to secure it.



*Fishing vessels dock in the Cordova Harbor.
Photo by Peter Prokosch. Courtesy of GRID-
Arendal resource library under CC BY-NC-SA 2.0.*





Warm winter culture

By Christian Thorsberg and Diego Noreña

Longstanding Alaskan traditions are being shaped by warming winters. 2025 was no exception.

On the opening weekend of the 90th annual Fur Rendezvous, Alaska's largest and most famous winter festival, crowds walked through downtown Anchorage in awe of what was absent.

Snow.

No blanket of white stretched across buildings and cars, no banks grew taller on parking lots and curbs. The city's much-anticipated [street maintenance dashboard](#) for snow plow information, new and improved for 2025, delivered no updates — there was nothing to report.

By late February 2025, just 6 inches of winter snow had fallen on Anchorage, fewer amounts than the unlikely destinations of New Orleans, Atlanta and Austin. Compared to the record-setting season the year before, which saw a cumulative dumping of more than 132 inches of snow on the state's largest city, residents anticipating vibrant winter sports and classic festivities were let down by relentlessly temperate and snowless conditions. In a city where

winter defines rhythm and recreation, its absence reshaped everything from festivals to identity.

Oddities abounded and traditions were tamped. Instead of clearing icy roads, plows and pickup trucks did just the opposite. Parading down Fourth Avenue on the eve of the Rony, their stows brimming with snow collected from higher elevations around Anchorage, workers dumped snow on the roads and packed it flat, providing an artificial lane through which mushers could guide their dog teams.

The World Open Dog Sled Championships is usually a 26-mile race held over three days, a staple of the Fur Rony's opening weekend. This year it was reduced to just a 3-mile loop.

The following weekend's Iditarod Race experienced even greater disruptions. After the ceremonial start in Anchorage, the teams traveled up to Fairbanks to begin their race, the fourth time in history the race had to restart in Fairbanks.

Disappearing snow and ice are reshaping more than the environment, but the ways Alaskans live, celebrate, and connect with their home.



Dog racing in Anchorage with a lack of snow, 2025. Photo by Christian Thorsberg.

Partiers looking forward to the annual Trailgate, an unofficial tailgate party hosted along the original route, were disappointed when the event was cancelled. The mushers' shortened path, the organizers disappointedly announced, would come nowhere close to the rowdy crowds.

"Tragedy," they wrote on their Facebook page. "You know what else is tragic? Climate change (we need snow!!)"

The frustration from these events wasn't limited to the mushers or the fans. When winters weaken, so do the rhythm's people rely on — for recreation, for work, for identity. In a place like Alaska, no one is entirely spared from climate change.

Scientists feel it too. They may spend their days poring over data and models, but many of them ski these trails, fish these rivers and shovel the same driveways. Winters like 2025 aren't just anomalies to them, they're evidence in a much larger story.

To understand these shifts and help Alaskans adapt, researchers at the Alaska Climate Adaptation Science Center are looking closely at what warmer winters mean.

That includes everything from how melting glaciers change salmon streams and flood coastal towns, to the impact of snow avalanches on wildlife populations, and even sea ice affecting the way of life of walrus, polar bears, and remote Alaskans. Scientists are leaving no iceberg unturned.

In 2023, Jeremy Littell, a research ecologist from the USGS Alaska Science Center, led a [study](#) modeling what the future for snowpack might look like across the state. The results were shocking. By the 2050s, the snow season could decrease by one to five months, and some parts of Alaska may lose persistent snow altogether.

The snowless season of Anchorage in 2025 was a glimpse of what may lie ahead.

From the ceremonial start in Anchorage, to the finish line on the frozen coast of Nome, the Iditarod trail itself looks different now. Disappearing snow and ice are reshaping more than the environment, but the ways Alaskans live, celebrate and connect with their home.





SOUTHEAST ALASKA

In Southeast Alaska* average annual temperatures may increase by 9-11°F by the end of the century. In some areas winter temperatures may increase by 13°F, and winters could transition from predominantly below freezing to predominantly above freezing. Precipitation may increase by around 30% with a large portion of that increase falling as heavy storms and atmospheric rivers that can inundate the communities they land on.

In an area shaped by its ice, these new temperatures will lead to sweeping changes across the landscape, changes already being felt by residents of the area. As the southernmost arm of the state, Southeast Alaskans are experiencing a regime shift when it comes to their ice and snow.

** The climate projections for Southeast Alaska comes from the Northern Climate Reports and is a summary of the Northeast Gulf, North Panhandle, Central Panhandle, and South Panhandle NOAA climate divisions. Models have higher uncertainty with regard to precipitation, and the summary is across all models and scenarios. See northernclimatereports.org for more information.*





Reading rings: Subfossil wood reveals a glacier's climate history

By Gigi Friedman

In 2023, research ecologist Jeremy Littell, along with students and staff from the Juneau Icefield Research Program, skied miles across glaciers and ice ridges to follow up on a report of a five-needle pine tree dwelling in the gnarled, patchy, treeline, known as an alpine ecotone, that lined the Llewellyn Glacier. A finding of this species, known as the whitebark pine, would be biogeographically uncharacteristic to British Columbia's Juneau Icefield. The nearest known whitebark pines reside nearly 400 miles away. While crevasse hopping did not unveil the pine, the team stumbled upon something astounding, a preserved graveyard of weathered, centuries-old tree stumps.

The gnarled wood reveals information about the advance and retreat of tree lines across hundreds of years. Tree lines respond to changing climate and temperatures, inching forward and drawing back at the edges of their survival conditions. Using the preserved wood, the team could investigate past climatic conditions of the Juneau Icefield region, presenting the possibility of better understanding future glacier retreat.

When Littell and his team first set out to locate the whitebark pine, they weren't prepared to sample dead wood. The scientists, first calling themselves the "Treeple" in 2023, revisited the site in 2024 as the Treeple 2.0, collecting 34 samples of both dead subfossil wood and live wood. A question soon arose: What happened to these trees?



USGS scientist Jeremy Littell counts rings through a microscope and displays a tree ring sample from his expedition. Photos by Christian Thorsberg.



Using a combination of dendrochronology, also known as tree ring science, and carbon-14 dating, the team roughly calculated the ages for their trees. C-14 dating works by using the predictable rate of decay of the isotope C-14. Trees soak up C-14 while alive and stop absorbing the isotope once they die. Comparing the amount of C-14 to the ratio of other carbon isotopes, namely carbon-12 and carbon-13, allows scientists to estimate the age of the wood. Using dendrochronology, the scientists analyzed how external factors, such as temperature or precipitation, may have impacted tree growth. Over the course of a year, most trees build a single ring that consists of a light early wood and dark late wood band. The team found temperature to be the primary limitation for growth for the currently living near the terminus of the glacier. Higher summer maximum temperatures corresponded to greater growth.

Littell's team dated some subfossil wood samples to be around 1,000 years old. These trees would have existed during the Medieval Warm Period, a time where warmer temperatures permitted trees to establish themselves at slightly higher altitudes. The Little Ice Age disrupted the warmth with abrupt and rapid cooling. During this time, new seedlings probably could not germinate reliably at the higher altitude tree lines. The adult trees at these heights eventually died, littering their skeletons on the landscape. Trees didn't recolonize that altitude until

Tree lines respond to changing climate and temperatures, inching forward and drawing back at the edges of their survival conditions.

around the 19th century, and then only sparsely, leaving the land unoccupied for several hundred years. Littell searched within the rings to identify a tree that bridged the two periods. However, the team didn't have a sample that convincingly overlapped the living and dead wood.

The search for this overlapping ring will continue. Twenty years ago, other scientists visited this icefield and noted six trees that could fit the bill. If their records are correct, the next generation of Treeple will have the opportunity to build a 1,000 year chronological documentation of tree rings for the region. But first, the Treeple will have to find those trees.





Rivers of change: The impact of climate shifts on salmon habitats in Southeast Alaska

By Diego Noreña

Water is the thread that weaves Lingít Aaní or Southeast Alaska together. It falls from the sky as relentless rain, clings to mountains as snow and collects in ice fields and glaciers. It trickles through peat-rich muskegs and carves deep fjords that open into the sea.

The region's residents are no strangers to water's many forms. Stroll down Juneau's South Franklin Street, and you'll see outfits of Xtratuf boots, rain jackets and soaked hair. Waiting for the rain to stop isn't an option; you dress for the rain and embark on your adventures anyway.

Layering becomes an art form, and rain gear is never kept far from reach, even on sunny days. Locals explore soggy trails. Muddy boots and wet dogs are part of the experience. Fishing, hunting and foraging are deeply tied to the variety of watersheds. Deer, berries and mushrooms are found along streams and wetlands, while large tidal swings facilitate beach foraging and harvesting. People rely on halibut, rockfish, salmon, clams and other foods harvested from the water in Lingít Aaní. Whole seasons are shaped around preserving water-based abundance through smoking and freezing. There's pride in being able to get things done regardless of the weather. Water is an integral part of cultural identity.

The Tongass rainforest thrives under the weight of all that water, with Sitka spruce and western hemlock rooted in rain-soaked soil. Glaciers store centuries of snowfall, releasing meltwater that feeds rivers even in the driest months. Snow blankets mountaintops, storing seasonal moisture that sustains life during the spring and summer. Where rivers meet the sea, estuaries abound with richness, providing crucial nurseries for juvenile salmon, herring and shellfish.

Salmon have a palpable heartbeat in this landscape. As they migrate upstream to spawn and die, they give back to their surroundings by delivering the building blocks of life: nitrogen, phosphorus, carbon and other essential compounds and minerals. Trees absorb these nutrients through their roots, incorporating them into their bark, wood and needles. [Studies](#) show that trees along rivers with salmon grow at faster rates than those near streams without salmon. When bears, wolves and eagles drag salmon carcasses deep into the forest, their decaying flesh, with its pungent and distinctive smell, serves as a natural fertilizer. Everywhere, salmon are part of the forest.



ABOVE: A river plain in Southeast Alaska.
LEFT: Researcher holds an anesthetized young salmonid before scanning a tracker in its belly.
RIGHT: A rain-soaked muskeg.
Photos by Diego Noreña.

Year-to-year instability and loss of habitat diversity: The twin challenges facing salmon in Southeast

For generations, Indigenous peoples of Alaska have understood that a good snow year often means a good year for salmon, a time when rivers run full, water stays cool, and spawning conditions are ideal. Today, scientists are beginning to reaffirm these deep-rooted connections, showing how snowmelt feeds salmon rivers in spring and glacier runoff sustains them through the summer. This understanding is a reminder of the profound and enduring interdependence between snow, ice, salmon and all life in Lingít Aaní.

However, communities and scientists have started to see this relationship change. As the climate changes and alters the timing and scale of global environmental systems, Southeast Alaska is expected to become both warmer and wetter, with overall less precipitation falling as snow. This change is reflected in the glacial changes. In the last two decades, Alaska has accounted for 25% of the global glacier mass loss and 38% of accelerated global glacier thinning.

With less snow and ice in the winter and more rainfall predicted in Southeast Alaska, water temperatures in streams and rivers become less predictable year to year. Nine years ago, when scientist Ryan Bellmore arrived in Juneau to work at the Forest Service Pacific Northwest Research Station, researchers were focusing on the biogeochemistry of glacial, snow-fed and rain-fed streams. Nutrient concentrations, water temperature and flow regimes were particularly important.

One evening, while Bellmore and Jason Fellman, a collaborating scientist, were walking along at the confluence of snow fed Montana Creek and Mendenhall Glacier's McGinnis Creek, they noticed a contrast; one stream was turbid, cloudy and opaque, full of suspended matter, while the other was stained with tannins: natural compounds found in plants, especially leaves, bark and roots that stain rivers a rich, earthy color without making it dirty. Bellmore wondered how the source of a stream affects its ability to support salmon, and how that might change as the climate warms. This curiosity led to new research on how those differences affect salmon.



After several years of collaborative research between the Pacific Northwest Research Station, the Alaska Coastal Rainforest Center, and the Alaska Climate Adaptation Science Center, Bellmore and Fellman better understand how climate impacts salmon in two separate but related ways.

One is short-term, year-to-year variability. This includes the increasing number of extreme flow or water temperature events, such as low flows, droughts, or high water temperatures. Communities are also observing how these changes are impacting salmon across the region.

Annika Ord – now an Alaska CASC Climate Adaptation Catalyst – conducted research at the University of British Columbia, which learned from fishermen, Indigenous Knowledge holders and local scientists about how [glacier retreat is impacting downstream salmon systems in Southeast Alaska](#).

In one of her interviews, a fisherman from Hoonah recounted what it was like when two snow-fed systems near his hometown dried up.

“In recent years, we’ve had streams that produce salmon that had no water in them, and they literally died at the mouth of streams waiting for water,” Ord said.

Judy Daxootsù Ramos, a Tlingit Knowledge Holder and anthropologist from the town of Yakutat on the glaciated outer coast of Lingít Aaní, expressed similar concerns.

“Lots of the salmon rivers are getting too warm for the salmon, and I think they have to migrate further north, which is really hard on our subsistence-based economy and our commercial fishing,” she said. “In many streams, we’ve seen the king salmon just drop down to zero. You can’t even harvest king salmon anymore. And sometimes

“In recent years, we’ve had streams that produce salmon that had no water in them, and they literally died at the mouth of streams waiting for water.”

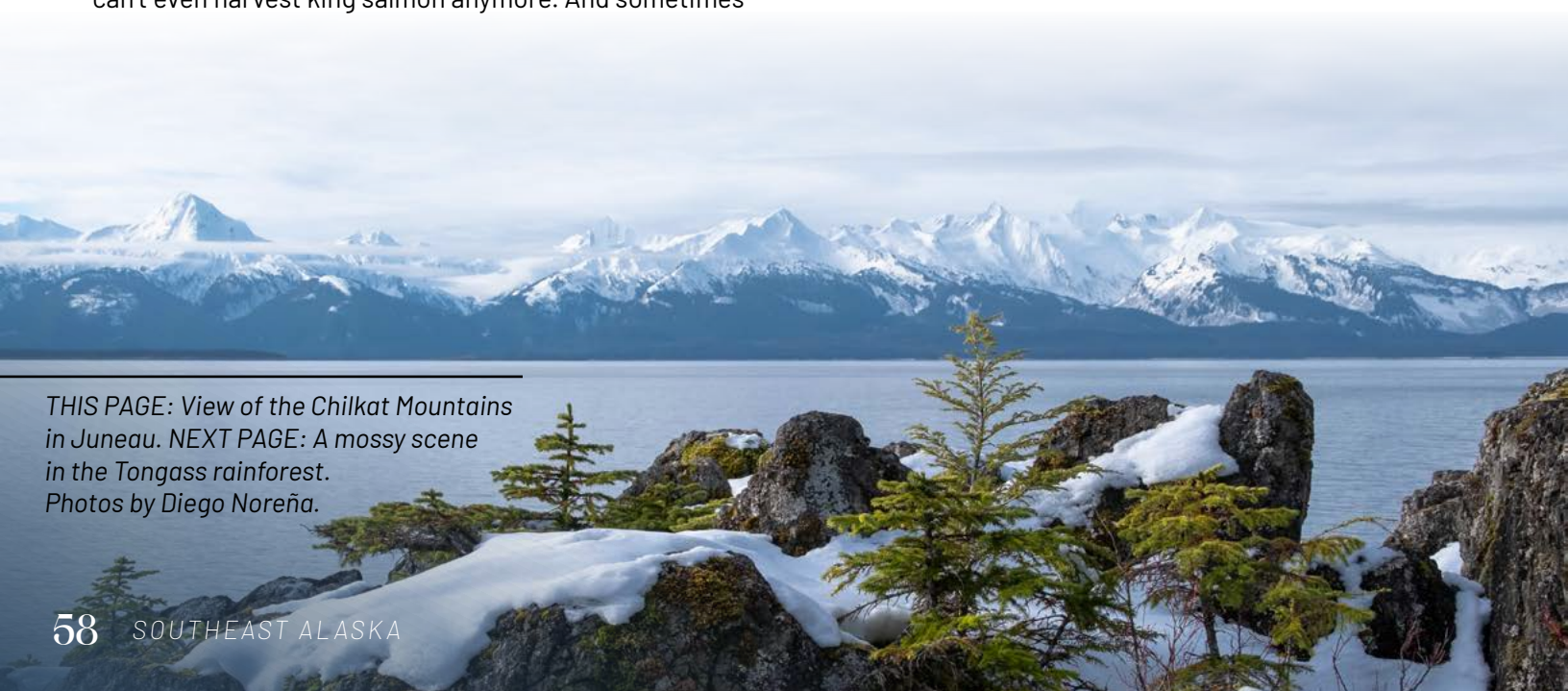
– ANNIKA ORD

the rivers get really hot, it’s kind of alarming how hot the rivers are sometimes. So that’s a concern. If we don’t have salmon runs returning anymore, it’s going to really impact the economy.”

With less snow and ice overall, water temperatures become less predictable from one year to the next. Stream flow regimes, the pattern of discharge including quantity, duration and seasonal variation, become chaotic and dependent on rainfall and air temperature. A different fisherman from Hoonah describes how glacial runoff plays a role in the T’aakú Héeni (Taku River) watershed south of Juneau.

“The Taku system has obviously been influenced by glacier water. The pink run has been pretty good in that system, and it’s been able to persist through the warming temperatures. So, I think those glacial systems really do well when other systems are affected by a lack of snow because they have a big resource to draw upon, almost like a fat resource that they slowly burn down, and then in big snow years, they get it back. If you lose that bumper, that cushion, then the stream could be in peril for sure.”

THIS PAGE: View of the Chilkat Mountains in Juneau. NEXT PAGE: A mossy scene in the Tongass rainforest. Photos by Diego Noreña.





“One of the things about the glaciers is that they just stabilize everything. Because if it’s really warm and dry, then they’re melting and that’s adding runoff to the system.”

- ERIC JORDAN

The expedited retreat and eventual loss of glaciers will have far-reaching effects on salmon, people, and industry. Eric Jordan, a Sitka-based salmon troller, spoke about his fears on the matter.

“Glacier retreat totally concerns me because snowmelt and glacier melt are a big part of what keeps these streams going all year round, and if they’re gone, then you’re dependent on the rainfall, which can be really cyclic. One of the things about the glaciers is that they

just stabilize everything. Because if it’s really warm and dry, then they’re melting and that’s adding runoff to the system.”

Short-term shifts in snowmelt are already straining salmon survival. The second deeper and more troubling transformation for salmon is occurring over a longer timescale: the retreat of glaciers and permanent ice fields is altering the foundational structure of salmon habitats. This process, described by Bellmore as a loss of habitat heterogeneity, may have even more profound implications for the resilience of salmon populations. Initially, it was thought that glacial rivers did not provide high-quality fish habitat because they have high turbidity, cold water and unstable channels. An observation made by Eran Hood, a local environmental scientist, suggests that salmon use glacial systems more than previously thought.

“We’ve gone out and put out all kinds of fish traps, minnow traps, in Herbert River, and there are fish living in there all the time,” Hood said. “So, I think the glacier rivers are more productive in that way than they’ve been given credit for just from looking at what the environmental conditions look like.” ([Ord, 2024](#))

A red salmon, illustrated by Taylor Saulsbury.



Towards predictive models: Understanding how stream diversity shapes the future of salmon

Recent studies by Bellmore and Fellman have revealed something surprising: when glacial, snow-fed and rain-fed streams are all part of the same watershed network, the diversity gives salmon a major advantage. This is known as the “portfolio effect,” a term borrowed from the world of finance that follows the principle: diversity offers security.

Each of these streams carries water with its unique timing and chemistry. Glacial streams are cold and cloudy, snow-fed ones flow strongly in early summer, and rain-fed streams swell with autumn storms. These differences create a seasonal rhythm across the landscape, offering waves of food and habitat that shift over time.

Using food web modeling and field sampling, Bellmore and Fellman’s findings suggest that by moving between these types of streams, juvenile coho salmon and other fish species can take advantage of staggered pulses in food availability. Instead of being limited to one stream’s food source, they feed in tune with the changing season across the watershed. This resulted in a projected 20% increase in their growth rates.



“Lots of the salmon rivers are getting too warm for the salmon, and I think they have to migrate further north, which is really hard on our subsistence-based economy and our commercial fishing.”

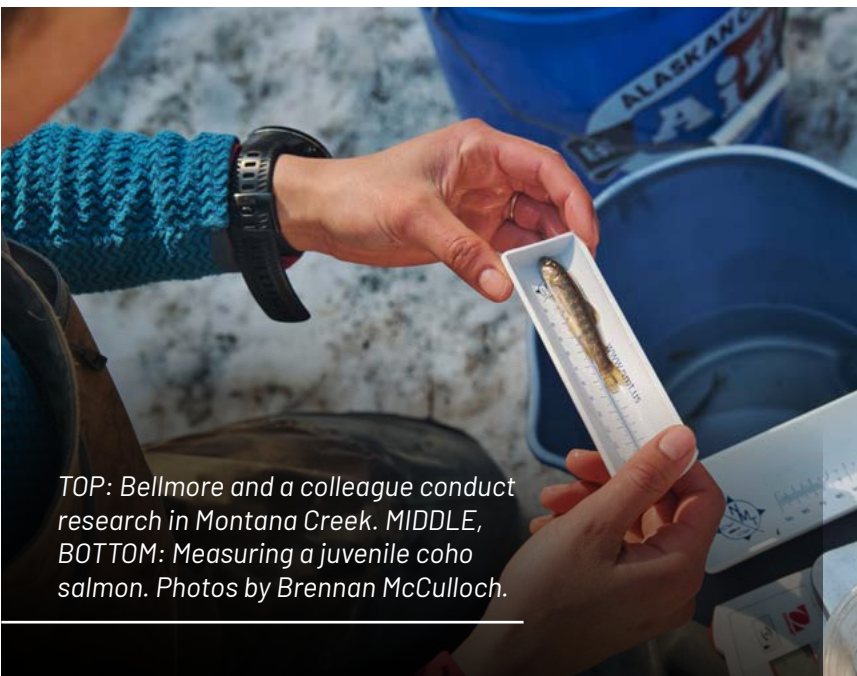
- JUDY DAXOOTSÙ RAMOS

However, the benefit of varied streams only exists when that patchwork of glacial and non-glacial streams remains intact. As glaciers disappear and more streams begin to look and behave the same, warmer and simpler with only rain driving them, the rich variety that once supported these feeding strategies starts to fade.

In response to these troubling shifts, Bellmore and Fellman, along with a broader team of collaborators, secured new funding through the Alaska Climate Adaptation Science Center to deepen their work on climate-salmon interactions. Their current project aims to develop predictive tools that model how salmon populations might respond under different climate futures.



But this is not research for research's sake; it's designed with communities in mind. The idea is to build models in Juneau because it has a mix of accessible watersheds and decades of existing data. Eventually, the models will be used across Southeast Alaska and beyond. Communities will be able to plug in their stream data, temperature, flow and chemistry, and explore how salmon survival might change under different climate scenarios. By studying these ecosystems, researchers can collaborate and create tools that help people understand and prepare for potential changes.



TOP: Bellmore and a colleague conduct research in Montana Creek. MIDDLE, BOTTOM: Measuring a juvenile coho salmon. Photos by Brennan McCulloch.



*The Mendenhall Glacier.
Photo by Diego Noreña.*

Changing ice and rising waters: Glacial floods in Juneau's Mendenhall Valley

By Diego Noreña

It was one of those rare cloudless days in Juneau when the Mendenhall Valley felt like a playground. Kids pedaled along trails, families hiked beside the lake, and lawns buzzed with summer chores. But beneath the glacier, a hidden force was building, and it would soon surge into the city.

On July 19, 2011 floodwaters engulfed roads, swallowed backyards, and swept away campgrounds.

Initially, nobody had any idea where the water was coming from. Following a hunch, scientists took to the air in helicopters and discovered that the flood was coming from a water- and ice-filled basin left in the wake of the retreating Suicide Glacier. It was, they discovered, Juneau's first glacial lake outburst flood.

Glacial lake outburst floods (GLOFs) or Jokulhlaup, as they are known in Iceland, occur when water held behind a glacier, often in a natural reservoir, suddenly releases due to the failure of the dam holding it in place.

These floods are not unique to Juneau; they can happen in any region with glaciers. Glacial lake outburst floods are common in Iceland and also occur in places such as the Swiss Alps, the Himalayas and other high-latitude or high-elevation areas.

Glacial lake outburst floods in other parts of the world often occur without warning. However, Juneau's outburst flood presents a unique case because the geology of the basin, now called Suicide Basin, is causing the floods to strain the community every year.

As Suicide Glacier retreated, it left behind a bowl-shaped basin cradled by bedrock on three sides. The only thing holding the large lake in is the Mendenhall Glacier, which acts like a massive, icy dam.

Each summer, rain and melting ice fill this lake, slowly building pressure. Eventually, that pressure becomes too much, and the lake finds a way out. The water forces itself beneath the glacier, carving a hidden tunnel through the ice. At first the flow is gentle. Then it surges. The tunnel widens, and the flood roars downstream. But just as suddenly as it starts, it stops. The glacier's weight crushes the tunnel closed, sealing off the flow until the basin fills again.

The Mendenhall River, which flows from the glacier and through Juneau, is relatively shallow and narrow. This makes it particularly vulnerable during these sudden flood events, as the river cannot accommodate the rapid increase in water. The river winds through residential areas, placing homes and infrastructure in close proximity to the floodwaters, creating a significant risk to both the environment and the local community.

As the climate continues to change, atmospheric temperatures and rainfall will likely increase in Southeast Alaska, meaning the potential for even greater floods exists.

Additionally, the Mendenhall Glacier, which serves as a natural dam for the Suicide Basin lake, is melting and thinning by as much as 10 to 12 feet per year. This thinning reduces the glacier's ability to hold back water, which can contribute to larger and more sudden floods.

Suicide Basin was draining once again. We had been anticipating the flood all summer long, and now it was finally happening.

The basin itself is widening over time due to ice calving from the Mendenhall Glacier into the Suicide Basin. As chunks of ice break off and float in the basin, they create additional storage space for water, allowing the basin to fill even higher than before. In 2024, approximately 7.5 million cubic meters of ice were still floating in the basin during the flood, some of which melted and contributed to runoff volumes.

Fourteen years after the first flood, on Aug. 5, 2024 at 5 p.m., I received the warning while I was at work on a whale-watching boat in the middle of Lynn Canal.

The City and Borough of Juneau had issued an evacuation. Suicide Basin was draining once again. We had been anticipating the flood all summer long. Now it was finally happening, and I was stuck on a boat while my car and all my belongings were in the flood zone. I tried to maintain a positive attitude and a straight face for the rest of the workday, but in the back of my mind, I worried that my house would be underwater when I returned.

There was nothing I could do but hope, all while the rest of the town evacuated. People packed their cars with their valuables and secured their belongings. There was an estimate of where the flood might reach, but the extent of the damage to come was unknown. Power was cut along the river. Hard-earned salmon, berries, family memories, and vehicles were left to ruin. Nothing was left to do but watch the river rise and the water encroach on the valley.

Thankfully, I got off work before the river reached its maximum flood height of 15.99 feet at 1:30 a.m. At Brotherhood Bridge, in the middle of the valley and overlooking the Mendenhall river, several community

members watched as giant trees swept by in the river. My friends and I were in awe of the raw power contained in this massive amount of moving water. As we watched the water level rise, we wondered how the floods might exacerbate Juneau's already stressed housing market and how future floods might unfold as the climate continues changing.

That year, over 300 homes were flooded, and many people lost their belongings and suffered damage to their properties. Fear and urgency were etched on the faces of residents. This wasn't a new event; we'd been warned and seen it before, but this one was different.

Since the first recorded outburst in 2011, floods have occurred at different scales, though their impact has progressively gotten worse. The 2024 flood was the strongest yet, reaching a river crest height of 15.99 feet, surpassing the previous record of 14.97 feet set in 2023.

There was nothing I could do but hope, all while the rest of the town evacuated. People packed their cars with their valuables and secured their belongings.



More than 42,700 cubic feet per second of water flowed through the Mendenhall River, nearly 22 times greater than the average flow of the Mendenhall River in summer around half of the flow of Niagara Falls.

In 2025, the river rose even higher, but thankfully the Hesco barriers held up. These sand- and rock-filled barriers protected the community to a large degree. However, as long as the glaciers remain, the threat of outburst floods persists.

A group of environmental scientists and glaciologists – including Eran Hood, Jason Amundson and Christian Kienholz from the University of Alaska Southeast and funded by the Alaska Climate Adaptation Science Center – came together to understand the flood and plan response strategies.

The scientists have implemented a variety of forecasting techniques. They have installed cameras that monitor the basin in real time, allowing them to visually determine when the basin reaches full capacity.

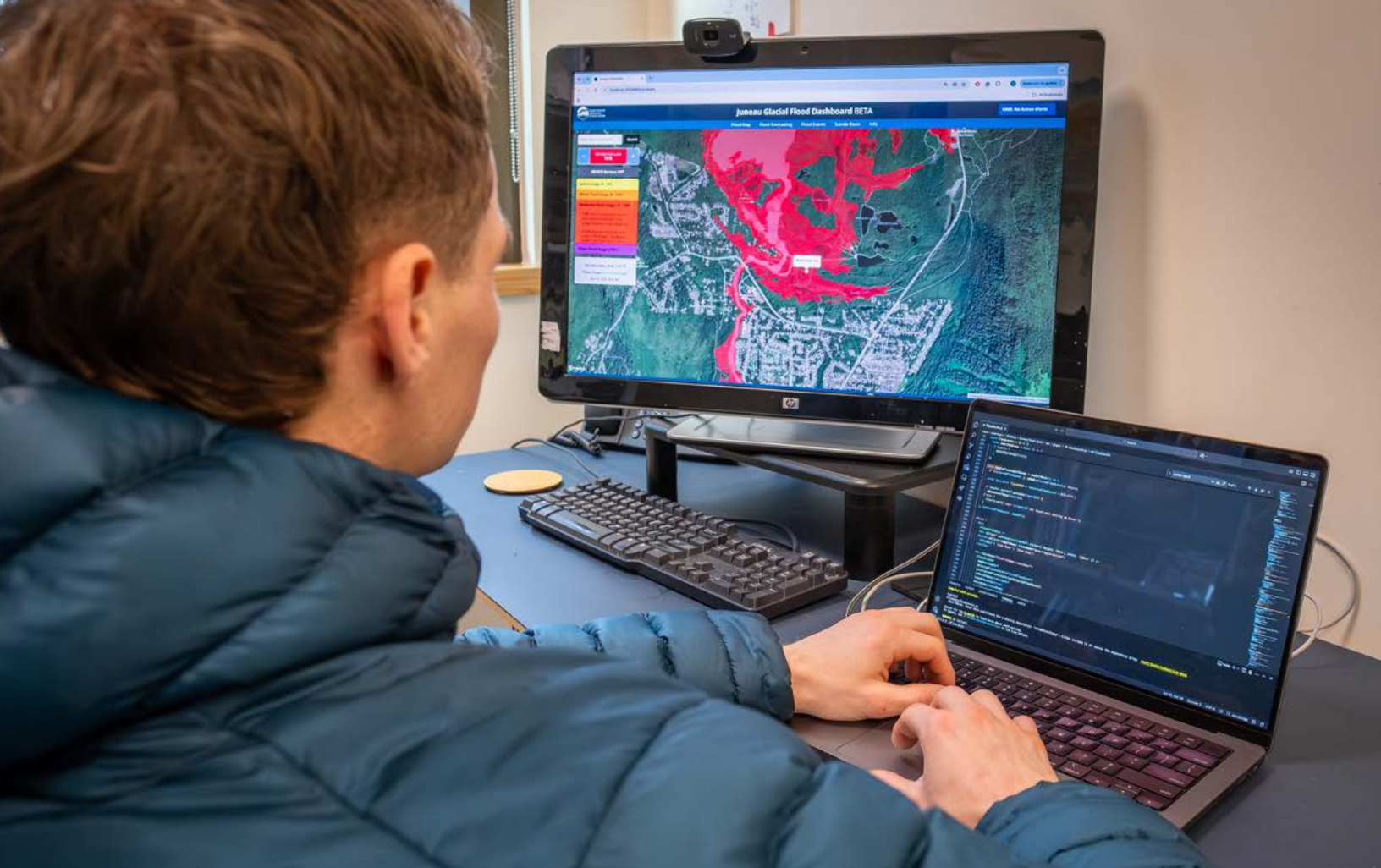
Using drone surveys, the team generates high-resolution models that reveal how the basin transforms over the course of the year and the flood, providing precise measurements of the amount of water stored and released.

Along with the drones, there are in-basin sensors that provide real-time measurements of water levels. These figures help estimate the amount of water present at any given time and forecast potential flood magnitudes before a drainage event occurs.



The Mendenhall Valley after the 2024 flood. Photos courtesy of Eran Hood.

A survey of Suicide Basin in June 2025. Photos by Diego Noreña.



Along with the extensive monitoring program, the Alaska CASC has recently developed a tool for the public. The Juneau Glacial Flood Dashboard is an interactive online tool designed to help residents better understand and prepare for glacial lake outburst floods from Suicide Basin.

Developed by Sean Fagan and Eran Hood with the Alaska Climate Adaptation Science Center, the dashboard includes a potential flood map that visualizes how different flood levels could impact the Mendenhall Valley.

Glacial lake outburst floods are a striking example of how rapidly glacial systems are changing, reshaping, and impacting communities.

As the Mendenhall Glacier continues to retreat and deflate, the dynamics of Suicide Basin are changing, expanding its capacity to store water and potentially increasing the magnitude of future floods. As each year passes, the basin holds more water and releases it more completely. At the same time, the calving of new icebergs into the basin and their subsequent melting

contribute to the volume of water released during a flood. These processes make forecasting increasingly complex, raising questions about what future floods may look like and how quickly they could occur.

Despite these technological advances, significant challenges remain. Glacial systems are inherently dynamic, and their behavior cannot be predicted with complete certainty. The 2025 outburst flood underscored both this certainty and the value of preparedness: although water levels rose higher than ever before, the Hesco barriers held, protecting homes and infrastructure from severe damage. As we look ahead, continued scientific monitoring of Suicide Basin will be essential for informing local response strategies and long term planning. But research alone is not enough. Translating scientific insight into proactive mitigation measures will be critical to safeguarding Juneau's communities and livelihoods as the climate continues to change.



ABOVE: Sean Fagan working on the Mendenhall Outburst Flood Dashboard. Photo by Diego Noreña.

Sentinels of the Northern slopes: mountain goats, avalanches and ceremonial robes

By Diego Noreña

To be a mountain goat is to live where no one else dares. High above the treelines of Southeast Alaska, the alpine mammals creep along ridgelines and mountainsides through dense snow in search of bare ground where they can forage for food. Winds howl through peaks, shaping the landscape, and rain slicks the rocks, making every step a risk. Clouds hug the slopes, sometimes passing intermittently, other times shrouding the mountains in fog for weeks at a time.

Their white coats, tangled with wind and weather, once provided warmth not just for themselves, but for Alaska Native weavers who spun their wool into transgenerational stories. These robes weren't just clothing, they were expressions of ceremony, identity and place.

"Indigenous peoples ... have long used mountain goat wool to weave blankets, and the horns for spoons and bowls. Mountain goat meat is also a vital subsistence resource where other large mammals are scarce," said Kevin White, an ecologist with the Alaska Climate Adaptation Science Center, the Alaska Department of Fish and Game and the University of Alaska Southeast. Today, White is studying one of the greatest and least understood threats to mountain goats: avalanches.

Adapted for danger

To survive in the most extreme alpine environments, mountain goats are well-adapted to challenging weather and terrain. Their hooves have a hard outer rim for edging into rock and soft, textured pads for gripping slick slopes. Shaggy outer hair and dense undercoats not only keep them warm during winter, but they also provide camouflage that lets them blend into snowfields and cloudy mountain peaks.

Their greatest defense is terrain. Wolves, bears, and wolverines – their main predators – rarely follow them where they go. Mountain goats seek the steepest cliffs, narrowest ledges and sharpest spines for safety. It's even where they go to give birth. Within hours, newborns must be able to stand and climb. Their first steps are their first



“They respond more rapidly to climate change compared to species in low elevation areas, making them valuable as barometers for how alpine environments are being affected.”

- KEVIN WHITE

test, and many don't survive. Mountains are their shelter, and also their greatest threat, one exacerbated by a changing climate.

As the climate warms, the frequency, timing and severity of avalanches are changing, and so are the lives of the mountain goats that depend on the steep terrain for survival. Falls are a significant cause of death. Even a seasoned animal missteps as loose rocks give way or snow turns to ice.

They eat whatever is available on the mountain: grasses, sedges, mosses, lichens, and shrubs. In winter, they paw through snow, descend into forests or, as White and his team recently discovered, venture into avalanche debris fields to find exposed vegetation.

Sentinel species of the alpine

On cliff edges, mountain goats carry more than just themselves; they carry signals. They are a sentinel species, animals that can detect early risks to humans by providing warnings of impending danger.

“They respond more rapidly to climate change compared to species in low elevation areas, making them valuable as barometers for how alpine environments are being affected,” White said.

Evidence from long-term climate data has led to a clear scientific consensus that the global climate is changing due to human activities. Within this broader trend, change is occurring more rapidly in high-elevation mountain ecosystems compared to the global average. These environments are particularly vulnerable to shifts in temperature, snowpack and seasonal timing — all factors that directly influence the species adapted to survive there.



TOP OF PAGE: A mountain goat in upper Lynn Canal. Photo by Kevin White. ABOVE: Hoof diagram, illustrated by Taylor Saulsbury.

“It was fascinating and completing to see these animals in the fractured snow avalanche landscape. It gave a sense of how dangerous the environment they live in is.”

- KEVIN WHITE



Because mountain goats depend heavily on snow-dominated systems, their population dynamics offer insight into how alpine wildlife may respond to a warming climate. Snowfall patterns, summer temperatures and the timing and length of the growing season all affect forage availability and quality. These climatic factors also influence the risk of predation and access to forage landscapes.

To study these changes, White and his team placed radio collars on more than 400 mountain goats across four study areas in Southeastern Alaska. Over a 17-year period, they closely monitored mountain goats' movement patterns and causes of death using satellite tracking, aerial surveys and ground investigations. They identified avalanches as the leading cause of mortality, responsible for 36% of all deaths. In the most avalanche-prone regions, this number exceeded 60%.

Not all mountain goat deaths are evenly distributed across age classes. While predators and starvation typically remove young or elderly animals, avalanches kill at random, including healthy goats of prime reproductive age. Such losses can severely impact long-term population viability. Mountain goats typically birth just one kid per year, and population growth rates range between just 1 and 4% annually. With a lifespan of 12 to 15 years, heavy avalanche mortality can quickly destabilize isolated herds.

Beyond their ecological consequences, avalanches themselves are also changing.

“There are two main types of avalanches: Large snowpack avalanches caused by unstable, massive snow accumulations and rain-on-snow avalanches, where rain forms a hard crust beneath a smaller snow layer that causes instability,” White said. “Even years with little snow but persistent instabilities can produce avalanches.”

While avalanches pose significant risks to mountain goats they also provide risky opportunities. One afternoon, White's research team was tracking goats from a plane on a tributary of the Tsirku River in the Haines area. Honing in on the animal, they were unsure whether it would be found alive or dead. As they neared, they saw the goat beside a glide avalanche that had torn through the slope, removing six to eight feet of snow and exposing the vegetation beneath.

With telemetry tracking technology, White was able to track the same animals from winter into spring and summer, and one thing became clear.

“As spring approached and as the area started melting back, the avalanche exposed an area that had greened up much earlier than other areas, and provided food for the goats when they were having kids,” White said.

ABOVE: Elements of the mountain goat diet illustrated by Taylor Saulsbury. BELOW: A mountain goat startled while grazing in a field. Photo by Diego Noreña.





While Southeast Alaska lacks a detailed avalanche trend analysis the region is expected to become both warmer and wetter with less precipitation falling as snow. Collaborative research, including large-scale avalanche modeling may soon provide localized insights, building on work supported by the Alaska Climate Adaptation Science Center and White's foundational studies.

In these ways, mountain goats provide more than a window into their own survival. In northern Southeast Alaska, where deer are absent, they are a key prey species, meaning their population trends influence predators, plant communities, and the overall structure of the alpine food web. Their vulnerability reflects the broader ecological pressures shaping alpine systems, helping scientists detect emerging threats, monitor ecosystem health and understand the cascading effect of climate change at high elevations.

From avalanche to Aatóow

For Indigenous communities in Alaska, mountain goats are a vital source of food, tools, art and identity. Their wool, carefully harvested and spun by hand, is woven into ceremonial robes that tell stories, mark lineages and hold the memory and connection to the land.

Weavers Marsha Hotch and Lani Hotch of the Chilkat Indian Village in Klukwan, along with other Tlingit weavers, have continued to carry the traditional ways forward.

"The wool in particular was valued for weaving robes. Though the hides are thin, the wool was collected and used in Chilkat weaving or even stuffed into moccasins. Sometimes, the wool was mixed with grass for added texture and warmth," said Marsha Hotch.

While the traditional use of mountain goat wool declined with colonization and the advent of more accessible materials, such as merino wool, efforts to revitalize these practices have gained momentum in recent decades.

ABOVE: 2009 National Heritage Fellowship winner, the late Teri Rofkar, wears one of the Ravenstail robes she had woven. Photo by Tom Pich. BELOW: A woven piece by Lani Hotch. Photo by Lani Hotch.





A ceremonial robe, illustrated by Gigi Friedman.

Teri Rofkar, a celebrated Tlingit artist from Sitka, led this resurgence. After more than 15 years of gathering and preparing wool, Rofkar wove the first all mountain goat Ravenstail robe in over two centuries. Much of this wool was provided by mountain goats that died in avalanches collected by White. By providing wool from goats found during mortality investigations, White has helped support Tlingit weavers in continuing their craft with the traditional materials that shaped it.

These collaborations demonstrate that ecological research serves not only conservation but also nourishes culture and supports Indigenous sovereignty.

"It takes four times longer to prepare and spin mountain goat wool than commercial wool. But I still do it, because my ancestors used it ... The robes are not just garments. They hold titles. They tell stories," said Marsha Hotch.

The Hotches represent a powerful continuation of tradition. Their weaving is not only a cultural practice but a form of education, one that holds memory and meaning across generations.

Lani Hotch's approach blends the old and the new. Though her work uses traditional materials and structures, it's guided by her own creative vision.

"Whether you're Native or not, we all depend on this land, on clean water. We all have a responsibility to protect it."

- LANI HOTCH

"I follow the old ways in terms of materials and structures, but I design my pieces. I have a story I want to tell, then I figure out how to weave it," said Lani Hotch. "When you have something really good, you don't keep it to yourself. You share it. Whether that's food, knowledge, or stories, we pass it around. That's how we keep each other going."

But that cycle of giving and creating is increasingly threatened. Climate change is not only altering the landscapes where goats live, it's altering everything dependent on the species.

"[Climate change] affects the snowpack, the river, the fish, and the goats," said Lani Hotch. "If one of those disappears, it's not just a loss of food, it's a loss of culture."

Mountain goats are more than just climbers of treacherous terrain. They are connecting climate science to cultural survival. As scientists like White study the impacts of a changing world, and weavers like Marsha and Lani Hotch carry their knowledge forward, protecting the mountain goat is not just about protecting a species, but a way of life.



CONCLUSION

In Alaska, weather isn't just a topic for small talk and brief encounters, it dictates whether our freezers are full and our grocery stores stocked. It impacts our livelihoods, our recreation, and the safety of our homes and infrastructure. Weather brings us together. In a place where distances between communities are vast and services limited, Alaskans look out for each other.

As our weather patterns shift and once-reliable blankets of snow and ice recede, as storms batter our coastlines and animal populations fluctuate, communities across the state are deeply impacted.

Adaptation needs are diverse and urgent, ranging from flooding to energy instability to rising food insecurity. We are also dealing with these challenges in a time of uncertainty for climate adaptation science more broadly. Yet, it is precisely during these times that rigorous, applied science is most essential.

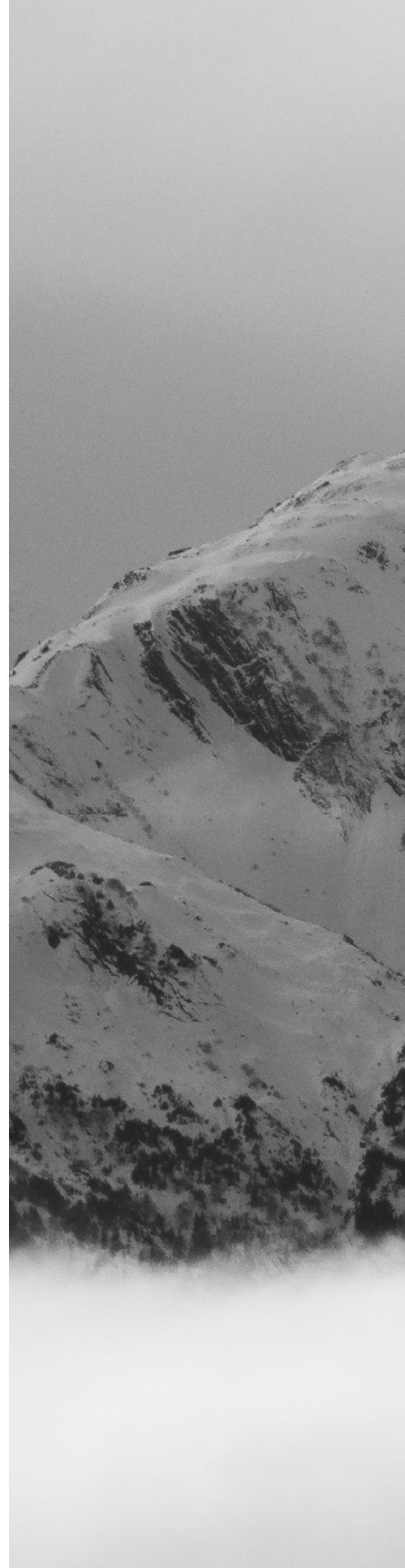
The Alaska Climate Adaptation Science Center is rising to meet this moment. By working collaboratively with a diverse network of scientists, community leaders, land managers and Tribal partners we build sustained partnerships capable of meeting complex challenges. The stories captured through Knowing Our Changing Home represent snapshots of our long commitment to this work and to the wider adaptation efforts happening across Alaska. Adapting to climate change does not have an end date; it is an ongoing effort that will continue for generations. Relationships are the backbone of this work. By meeting this moment together through sustained partnership and trust, we ensure our communities have the tools they need to support a resilient and thriving future.



Annika Ord

Alaska CASC

Climate Adaptation Catalyst





A mountain peak across Kachemak Bay. Photo by Diego Noreña.

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