The Alpine Club of Canada's

State of the Mountains Report

Volume 5, September 2022

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The Alpine Club of Canada's State of the Mountains Report

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Cover: Parks Canada dismantling of Abbot Pass Hut, June 2022. Photo: Pete Hoang
Inside Cover: Participants at the ACC's 2021 Mount Mummery General Mountaineering Camp. Photo: Mary Sanseverino

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Looking Back and Looking Ahead

Background: GMC 2021 after dark. Photo: Christopher Candela

Image: State of the Mountain Report covers from 2018 to 2021

Welcome to the fifth annual State of the Mountains Report, produced by the Alpine Club of Canada. When we began this project in 2018, our goal was to provide a summary of accessible, current, and accurate information about the forces that are influencing Canadian mountain places, ecosystems, and communities. We also intended that the Report would be a collaborative effort between the ACC, mountain researchers, community members, and partner organizations, and we continue to rely on the generous contributions of many experts who have provided their insights and perspectives. Our role as editors would be to solicit and compile these stories, and to share them with Canadians and the world so that we can all be better stewards of these special places.

Over these first five years, the State of the Mountains Report has included some sixty articles covering a wide diversity of topics related to the state of mountains in Canada.

Over these first five years, the State of the Mountains Report has included some sixty articles covering a wide diversity of topics related to the state of mountains in Canada. Mountains provide critical natural and economic resources, like water, biodiversity, forests, minerals, and recreational opportunities. Mountains are also home for many people living in small and remote communities, and the impacts of both local and global influences are still not well understood. Indeed, these are concerns and trends that are shared by mountain regions around the world. Hardly a week has gone by this summer that there hasn't been reports in the news about major rockfall events, collapsing glaciers, flash floods, extreme temperatures, wildfire and other extreme events, in the European Alps, in central Asia, and many other mountainous places.

Looking back across the contents of the Reports, it's hard not to notice a variety of worrying trends. Natural hazards like landslides (2020), avalanches (2018), and wildfire (2019) captured our attention. And the impacts of the COVID-19 pandemic could not be ignored either (2021). Many of the contributions to the Reports have highlighted the ways that rising summer temperatures or changes in winter snow may influence mountain biodiversity, from plants to salmon to butterflies and mountain goats. We have also examined the vital role that glaciers play in sculpting the landscape, and how their widespread and accelerating retreat can lead to dramatic and irreversible impacts, with widespread implications for lowlands too.

For Canada's mountain communities, many of which are dependent on vulnerable sectors, such as tourism, forestry and agriculture, climate change will bring adaptation challenges that can best be met with early acknowledgement and planning. This resilience will require information and knowledge, and will involve building community adaptation literacy to understand the risks and actions needed for success. In the words of Kevin Hanna, from our first volume in 2018, "forewarned is forearmed." To dig deeper into these possibilities, we have featured stories about this resilience for the towns of Revelstoke, BC (2021) and Banff, AB (2022), as well as for ski resorts across western Canada (2018).

We have also tried to highlight Indigenous perspectives about mountains, and the need for the co-production of knowledge, which, at its foundation, begins with mutual respect, dialogue, and exchange. Research in traditional territories of Indigenous communities needs to be driven by the people who live there, and several articles have provided insights about bringing Indigenous knowledge and Western science together in collaborative partnerships to inform and enhance decision-making.

Finally, we have also examined some of the ways that the Alpine Club of Canada and its members have contributed to our collective understanding, use, and appreciation of mountains. These stories include the state of mountain guidebooks (2021), our network of alpine huts (2019), Canada's mountain guiding association (2020), and the evolution of mountain literature (2018).

Our feature story this year provides a behind-the-scenes look at the dramatic flooding in Mount Robson Provincial Park associated with the infamous "heat dome" in the summer of 2021. Established a century ago, the park provides critical habitat for hundreds of alpine species, protect the headwaters of the Fraser River, and attracts hundreds of thousands of visitors annually. But the park is also on the front line of impacts of climate change, from melting glaciers, extreme weather and flooding, to insect pests and forest fires. Natasha Ewing unpacks the work that BC Parks is undertaking to understand and adapt to these new risks and challenges, by incorporating a new adaptability into conservation and recreation around Mount Robson.

The cover of this volume (and accompanying story on page 26) captures the final days of the iconic Abbot Pass Hut. Since its opening in 1923, this cherished structure has provided shelter for mountaineers on the Continental Divide, between Banff and Yoho national parks. Early this summer, as the mountain supporting the hut continued to disintegrate as the ground beneath it thawed, Parks Canada decided to remove the hut. Another reminder that the impacts of climate warming reach into even the most remote of places on our planet.

Other contributions in the Report this year are more optimistic! Gabe Schepens and Brian Starzomski (page 20) introduce iNaturalist, a citizen science project and resource that is contributing to a better understanding of the distribution and ecology of alpine species. Bill Snow (page 22) provides an update of the broader implications of the Banff Bison Reintroduction Project, and the ways the Indigenous methodologies have been adopted to study the impact of bison on mountain landscapes. Elizabeth Turner (page 24) introduces some of the oldest known animal fossils on Earth (perhaps over 890 million years), the "skeletons" of sponges from the Mackenzie Mountains in the Northwest Territories. And Alison Criscitiello (page 35) describes her team's successful trip up Mount Logan this past spring, and their recovery of a new 327-metre ice core that will allow us to better understand the climate of northwestern Canada over the past 30,000 years (and maybe even longer).

We hope that once again you find these contributions insightful and thought provoking. This volume, and all of the State of Mountains Reports, can be found on the ACC website. Check them out, and please let us know if there is some aspect of Canada's mountains that you would like to see included in future reports.

See you in the mountains!

Lael Parrott, Zac Robinson, and David Hik
August 2022

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Zac Robinson is the ACC Vice-President for Mountain Culture, and an Associate Professor of history in the Faculty of Kinesiology, Sport, and Recreation at the University of Alberta.

David Hik is an ecologist and Chief Scientist at Polar Knowledge Canada in Cambridge Bay, Nunavut, and Professor in the Department of Biological Sciences at Simon Fraser University.

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Co-editors Lael Parrott (right) and Zac Robinson (left) with the ACC's new Executive Director Carine Salvy (centre-left) and President Isabelle Daigneault (centre-right) at the ACC's Wheeler Hut, 2022.

A Path to Recovery: The Berg Lake Trail Flood at Mount Robson

Mount Robson in Spring. Photo: Natasha Ewing

Natasha Ewing

When driving east on Highway 16 towards the Continental Divide of the Rocky Mountains, there is a magical moment – good weather permitting – when the distinct outline and snow-capped peak of Mount Robson comes into perfect view. That's the moment when just about every nature-lover squeals in amazement. Mount Robson is the tallest mountain in the Canadian Rockies and the namesake for Mount Robson Provincial Park, the second oldest park in British Columbia. The mountain is traditionally known as Tsyécelcten, which loosely translates to "Mountain of the Spiral Road," in the Secwepemctsin language.[1]

Welcoming hundreds of thousands of visitors each year, Mount Robson Provincial Park is one of nature's special places.

Over the last century, since its creation in 1913, Mount Robson Provincial Park has developed into one of the province's flagship parks. In 1990, the park was designated as part of the Canadian Rocky Mountain World Heritage Site by UNESCO, alongside Hamber and Mount Assiniboine provincial parks, and Jasper, Banff, Kootenay, and Yoho national parks. Together, these seven parks create one of the largest protected areas in Canada, covering 23,068.84 square-kilometres.

Welcoming hundreds of thousands of visitors each year, Mount Robson Provincial Park is one of nature's special places, offering excellent camping opportunities, diverse recreational activities, important habitat for flora and fauna, and stunning views. The park is home to many charismatic species, such as grizzly bears and wolves. It's refuge for 182 documented species of birds, and it protects the headwaters of the mighty Fraser River.

One of Mount Robson's greatest draws is the world-renowned Berg Lake Trail – twenty-three kilometres (one way) of extraordinary backcountry hiking amidst incredible scenery. Following the vividly blue Robson River, outdoor enthusiasts pass by towering mountains, dozens of thundering waterfalls, icy cold lakes, and the majestic glaciers that feed them.

A Shift in Climate

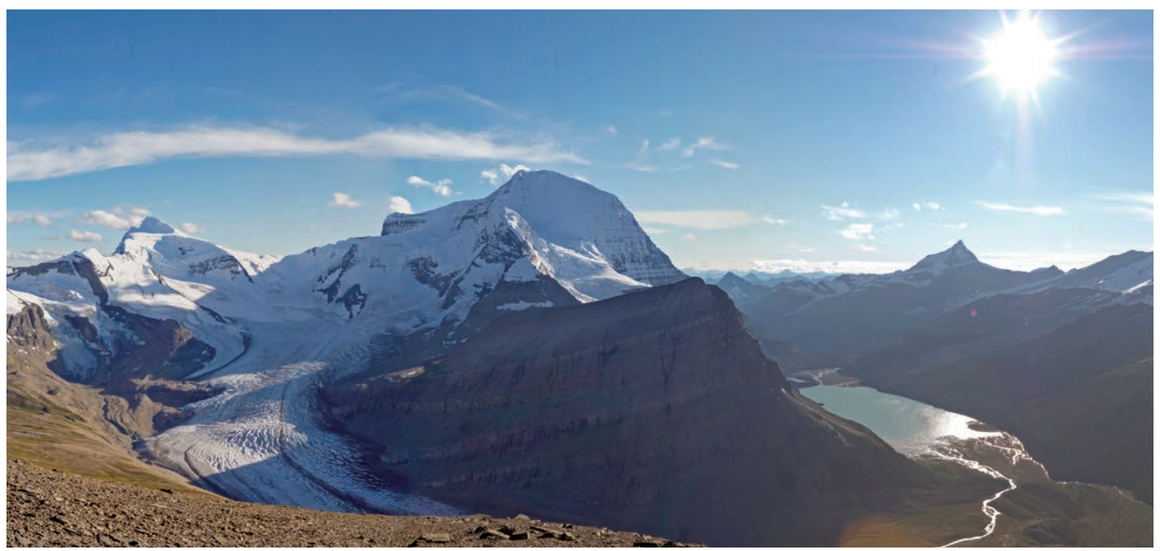
One of the earliest known photographs of the Robson Glacier was taken in 1911 by the Director and founding President of the Alpine Club of Canada, Arthur O. Wheeler. And in it, however grainy and faded, the terminus of the glacier is unmistakable, nearly extending to the shores of present-day Berg Lake. One hundred years later (2011), a repeat image taken by the Mountain Legacy Project highlights the startling retreat of the glacier. With significantly more rock exposed, the adjacent bedrock and debris continues to warm at an accelerated pace, further contributing to the recession of the Robson Glacier at nearly fifty metres per year.

In British Columbia alone, there are 15,000 glaciers totaling approximately three per cent (~28,342 km^2) of the landmass. While that may not seem like much, the glacial ice across BC is larger than the country of Haiti (~27,750 km^2) and would cover ninety per cent of Vancouver Island (28,156 km^2). For Dr. Brian Menounos, Professor and Canada Research Chair for Climate Change at the University of Northern British Columbia, glacial monitoring and long-term data sets are extremely important for anticipating future trends and understanding how glaciers are responding to climate change. Glacier scientists are not "just documenting the demise of glaciers"; rather, they are collecting important data, including observational data to help develop, calibrate, and improve predictive models of glacier change. Monitoring glaciers is important as they act as freshwater reservoirs; their melt provides a critical cold-water source for plants, insects, and animals, and decreases water temperatures downstream. For some mountainous creatures sensitive to

One of Mount Robson's greatest draws is the world-renowned Berg Lake Trail – twenty-three kilometres (one way) of extraordinary backcountry hiking amidst incredible scenery.

Sun-kissed Berg Lake Glacier on Mount Robson's north side. Photo: Natasha Ewing

The Robson Glacier in 1911. Photo: A.O Wheeler. Courtesy of the Mountain Legacy Project and Library and Archives Canada / Bibliotheque et Archives Canada



The Robson Glacier in 2011. Photo: The Mountain Legacy Project, School of Environmental Studies, University of Victoria

temperatures, this cold-water addition is fundamental to their survival and supporting a healthy ecosystem.

Menounos's research clearly shows that glaciers across the province, particularly in southwestern BC, are receding at an accelerated rate. Like so many things in nature, that change is not simply due to one factor – such as increased temperatures – but a series of exacerbating events. This includes events that sometimes appear unrelated on first glance. For example, increased summer temperatures elevate the wildfire hazard; an increase in fires means higher amounts of airborne ash and soot, material that eventually falls and covers glaciers, causing them to be less reflective and more absorbent of solar energy, which in turn increases glacial melt. These compounding effects cannot be treated independently, rather a whole-system approach is needed.

These types of cascading events are occurring more frequently, with one of the most dramatic events experienced in BC occurring in the summer of 2021. In late June, the province was in the midst of an intense "heat dome," when record-breaking temperatures (as high as 49.6 Celsius in the interior) were documented for several days on end and linked to hundreds of deaths across the province. While everyone was feeling the challenging effects of the severe and prolonged heat, many were worried how nature would respond.

Alpine environments are among the ecosystems most detrimentally impacted. At 1,646 metres above sea level, the temperatures on the shores of Berg Lake were in the high thirties. As the heat dome continued for several days, Emergency Management BC (EMBC) estimated that 80-100 millimeters of snow water per day was expected and that flood warnings were in effect for the Upper Fraser River. In addition to the higher-than-normal temperatures, a major storm rolled through the area on July 1, releasing over 210 millimeters (twenty centimeters) of rain within hours.

Ultimately, the combination of heat, meltwater, and excessive precipitation conspired to create the perfect storm, and it resulted in one of the most the significant flood events to have occurred on Berg Lake Trail.

An Unimaginable Event

When Elliott Ingles became Mount Robson Area Supervisor in 2017, he immediately reviewed and updated the park's emergency and evacuation plans, knowing that it was not a matter of *if* they would be needed, but *when*. The plans would serve as a guidebook for staff on the ground, laying out clearly the steps and procedures needed to be taken in a worst-case scenario.

On the afternoon of June 28, 2021, tired hikers emerged off the Berg Lake Trail full of excitement, good memories – and concern. They reported to park staff that there were a few spots along the trail that were flooded. Rangers immediately started up the trail expecting to find some minor flooding of the Robson River in a handful of the usual areas. By kilometer two, the river had poured over the bank, and likewise a little farther up the trail – all in places where flooding hadn't occurred before. Hoping that what they had found was the worst of it, staff got busy creating a trail reroute to avoid the deepest sections that afternoon.

An email from EMBC the next day warned that the Upper Fraser River was being placed under a flood warning, and that the area was at further risk should rain occur. Unsure of what was in store for the Robson River, staff began to carefully monitor the situation, and planning commenced in earnest. Ingles proactively called the BC Wildfire Service to ask for assistance in the coming days should the flooding increase. Backcountry hikers heading up the trail on June 29 were educated about the standing water on the trail and advised to use extra caution.

The following day, June 30, was a critical turning point. Fifty percent of the trail – between the trailhead and Kinney Lake – was suddenly submerged under more than a half-metre of standing water. Cold and fast-flowing water breached the riverbanks, rushing around bridges, and numerous reports of completely submerged campsites and bear-proof caches were coming in. And in those sections of the trail that weren't submerged, large cracks were appearing, suggesting heavy erosion and slumping activity from underneath.

Flooding along the lower portion of the Berg Lake Trail. Photo: Sean Allin

A decision was promptly made to close the trail on June 30, and to immediately halt any hikers wishing to head into the backcountry. The challenge, however, were the 250-plus hikers who were still on the trail, stretched out over the twenty-three kilometres.

A team of first responders began a trail-wide evacuation. Fortunately, on July 1, it was still possible for the majority of park visitors to walk out on their own. The BC Wildfire Service and BC Parks staff began a coordinated effort to inform hikers of the conditions, with personnel stationed along the trail to monitoring water levels, aid hikers, and provided information on the best course of action. Families with young children were encouraged to hike to their abilities and, if necessary, stay overnight at one of the designated check-in sites. With the incredible heat – temperatures were still in the mid-thirties – and challenging trail conditions, many backpackers were unable to hike out in a single day. Elliott Ingles recalls the staggering heat of the day: "the glaciers,' he said, "appeared to be sweating."

Thankfully, parks staff were well equipped with water filters and made sure hikers stayed hydrated throughout their longer-than-expected trek. By the evening, sixty per cent of the trail-users had made it out to safety. The remainder had checked-in at either Berg Lake, Marmot, Whitehorn, or Kinney Lake campsites and were anticipating hiking out the following day.

Although no Canada Day fireworks were lit off that night, Mother Nature had, it seemed, would have a show of her own.

Rangers stationed at the Berg Lake Cabin could feel the air shift as bright red clouds began rolling in from the north. In mere seconds, a thunderclap exploded, ricocheting off the surrounding mountains. Rain came pouring down – sideways sheet rain mixed with heavy blanket rain. Hail the diameter of dimes came crashing down, and lightning flashed repeatedly, illuminating the cabin like a dance club with multiple strobe-lights. Within six hours that night, over 210 millimeters (twenty centimeters) of rain fell. Ingles had never experienced a storm like it in his life. He immediately became concerned how this surge of additional water was impacting the Robson River.

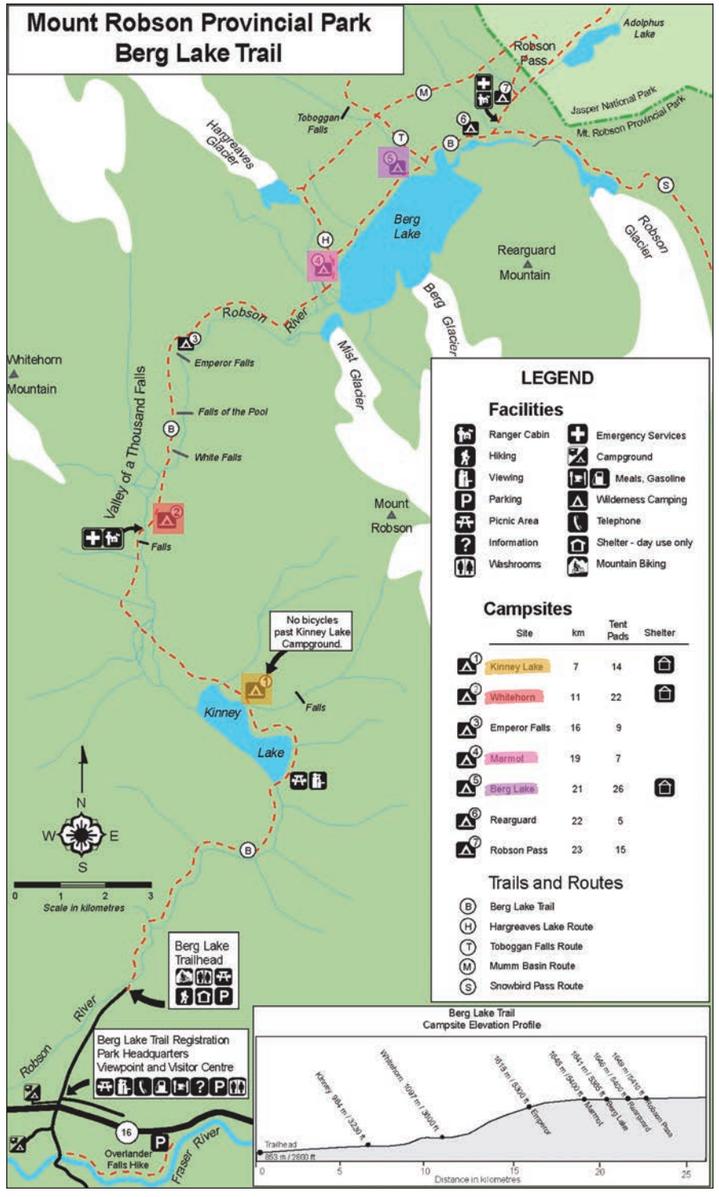
Bridge at Emperor Hill on July 2 highlighting the changing river conditions and the rock debris. Photo: Sean Allin

Tired hikers woke up on July 2 to clear skies, and to news that several bridges on the upper half of the trail were completely gone, impassable due to the damage caused by mobile rocks and boulders, or fully submerged in water. The river had risen a whopping six metres overnight, completely submerging the bridge at Whitehorn Campground and disconnecting the campground from the remainder of the trail. It was quickly realized that anyone camping at Whitehorn or further up the trail would not be able to get out on their own. A new plan was immediately set in motion.

Local RCMP activated Search and Rescue (SAR) to assist hikers coming down from Kinney Lake and to spearhead helicopter-assisted evacuations for the fifty now-stranded backpackers. Park staff coordinated hikers into groups for a heli pick-up at each location, while SAR provided guidance on how to safely board a helicopter. Constant communication between Rangers and SAR members was necessary to confirm that every hiker had been accounted for. While some hikers were more than ready to leave the Berg Lake Trail behind, others enjoyed the unexpected helicopter ride and saw it as the exciting highlight of a two-day adventure.

A Coordinated Effort

By early evening on July 2, every hiker was safely evacuated from the Berg Lake Trail with no reported injuries. As a guiding principle, BC Parks strives to provide an excellent visitor experience and ensure park users get home safely. Despite a heat wave, excessive flooding, an unparalleled storm, and a complex evacuation, everyone made it out safely – a huge success for staff and supporting agencies on the ground. However, this would have been a very challenging task without hikers being respectful of the situation and following directions. The evacuation plans Elliott Ingles had updated during the first few months in his role as Area Supervisor were executed and proved to be incredibly valuable. Ingles had emphasized fostering strong relationships with local responders and government agencies, and was thus able to call on the highly skilled people he needed to ensure a successful evacuation. Each organization – BC Wildfire, SAR, Park Operators, EMBC, Yellowhead Helicopters, and the RCMP – were there and ready to help navigate the dangerous situation. Despite the constant changes in weather, the dynamic state of the Robson River, and the day-to-day unknowns that continued to present themselves, the overall evacuation was relatively "uneventful due to careful and detailed planning."



Map of Berg Lake Trail. The four campgrounds that were deemed "check-in" spots during the evacuation are highlighted.

A Series of Tough Decisions

Throughout what remained of the 2021 season, the trail continued to see substantial changes each day. Park staff worked extremely hard to install temporary bridges, however, within hours or days the Robson River would shift, and those bridges would again be washed out. In some places, the opposite happened – three bridges that normally had two metres of water under them would become elevated pathways over dry riverbeds. Recognizing the safety hazards of allowing hikers back on the trail during such unpredictable

changes in the river, BC Parks' first big decision was to keep the trail closure above Kinney Lake in place for the remainder of the season.

For Adrian Batho, BC Parks' Conservation Specialist for the Omineca Peace Region, the most surprising part of the Berg Lake Trail flood was the magnitude of change within the Robson River – particularly its movement across the entire valley. As Batho noted, "there are an infinite number of potential pathways the river could choose throughout the Kinney Flats; it is all mobile material."

Engineering around nature, unpredictable rivers, and potential future events is not an easy task, especially while preserving the Berg Lake Trail's international status as an exceptional "beginners backpacking trip."

Engineering around nature, unpredictable rivers, and potential future events is not an easy task, especially while preserving the Berg Lake Trail's international status as an exceptional "beginners backpacking trip." Knowing that bridges were completely gone or deemed unsafe, that excessive slumping and erosion along the trail had occurred, and that rivers channel had significantly shifted, BC Parks had a series of tough decisions to make when considering how to rebuild.

Historically, the first seven kilometres of the trail (Trailhead to Kinney Lake) was deemed a "front-country trail," as it was open to a wide variety of users, accessible for a range of abilities, and required virtually zero navigational skills. The trail beyond, from Kinney Lake to Berg Lake, was deemed a "backcountry trail." BC Parks thoroughly reviewed the options of rebuilding to historical "trail" standards or downgrading all or sections of the trail to a "route," which meant little-to-no infrastructure and limited navigational aids, thus requiring increased backcountry skills from users. As the Berg Lake Trail has high use from a variety of users with varied mobility needs, is an international destination, and is relatively easy to access, BC Parks intends to rebuild the entire trail to previous "trail" standards.

It will take time to rebuild to "trail" status and mitigate risks along the way. The Berg Lake Trail's "new normal" will take years to harmonize. This recognition meant that a third tough decision for BC Parks had to be made: and that is to keep the trail closed throughout the 2022 season and prepare for a phased-opening approach. By first focusing on rebuilding the lower section of the trail (Trailhead to Kinney Lake), park managers and contractors will have time to see what shifts occur farther up the trail. Although the rebuild is expected to take several years, Adrian Batho sees the reset as smart: "we have the opportunity to use a variety of tools to mitigate risks, make educated decisions, and balance the speed of reconstruction with thoughtful reconstruction."

Next Steps: Rebuilding with Climate Resiliency in Mind

While the likelihood of another significant flood event in the Robson River is challenging to predict, one thing is clear. This flood occurred due to the "perfect" combination of excessive temperatures, rapid melting, and additional rain. However, as Dr. Brian Menounos warns, "one should prepare for future events. Heat waves will not only continue, but they are also expected to become more frequent." And what is one supposed to do when a 1000-year event becomes, say, a 50-year event? Or one that reoccurs even more commonly?

As BC Parks navigates this next stage of rebuilding, there are many questions: What tools are available to mitigate risks and make educated decisions? How can we balance changes in climate with recreation while protecting biodiversity and ecosystem processes? How does one build with climate resiliency in mind?

From Batho's perspective, building with climate resiliency in mind means "looking at the standard we are striving towards and then putting on a lens that takes into consideration what the trail could experience." To do this effectively, it is critical that staff understand the hazards that are present, potential future climate impacts, and be able to make educated decisions based on available information. We have an opportunity to work through this systematically, mitigate future risks, and not play environmental "whack-a-mole."

Fortunately, there are many tools to support BC Parks in understanding the landscape and changing climate. For example, remote sensing and aerial photography permit a better understanding of the hazards on a landscape, as well as the changes that might occur due to severe weather. Climate modeling for the region projects changes that will likely occur in future climate scenarios. Collaborating with glacial scientists, like Dr. Brian Menounos, and the Hakai Institute, allow for information sharing, cross agency learning, and partnerships related to climate change adaptation. These tools, and others, will all support the re-development of the Berg Lake Trail and assist BC Parks in making appropriate decisions for the trail in the long-term.

Additional monitoring tools installed by BC Parks, such as cameras and staff gauges, will help identify shifts in the Robson River in near real-time. The cameras take snapshots at five-minute intervals, gathering photo-evidence of how the river changes overtime, while the staff gauges will quantify the water level and help highlight potential blockages or flood conditions. Through this ongoing river assessment, it may prove necessary to mitigate hikers' time spent near the river and consider options to rebuild aspects of the trail well-beyond the dynamic river zones. At the end of the day, Mother Nature will choose where the river will go – and BC Parks will adapt and engineer around it. [insert Heli-slinging equipment up the trail]

In advance of the 2022 annual spring freshet, all structures along the trail that were damaged beyond repair must be removed so they do not become additional obstructions should the river flood or shift again. Some structures need to be repaired and have abutments secured, while other bridges that are sitting high and dry need to be relocated. All equipment and personnel must be helicoptered in and out – one of the many challenges with working in isolated environments. And of course, snow-free conditions are needed to begin construction, and crews will need to work expeditiously and complete as much as possible before the early-autumn flurries return.

Over the next few years, BC Parks expects the rebuilding of the Berg Lake Trail will not be without unexpected challenges. New questions will arise. Staff, partners, engineers, hydrologists, and contractors will be learning, re-assessing, and making changes as we navigate this complex and challenging project over the next three years.

Conclusion

Area Supervisor Elliott Ingles doesn't mince words when asked what was the biggest lesson to be taken from the 2021 floods: "Mother Nature rules over the park," he says, "we must adapt and come up with solutions to make recreation safe, while respecting park values and the ecosystem it inhabits."

When news about the Berg Lake Trail closure went out, park visitors recognized the challenges associated with climate change impacts. It continues to become clear that climate-related events are increasing in both frequency and magnitude, causing dramatic impacts in a variety of ways. Consequently, we will continue needing to creatively work together in order to overcome and mitigate these challenges.

Our changing climate means an unpredictable and uncertain future. While BC Parks works to understand and adapt to the risks, park users can do also do their part. This means recreating responsibly, following park rules, and acting as environmental stewards. The Berg Lake Trail closure may offer a wonderful opportunity for reset and refocus – to reflect on and incorporate a new adaptability in conservation and recreation.

Heli-slinging equipment up the trail to begin removing unsafe bridges and debris. Photo: Mike Palangio

Natasha Ewing is BC Parks' Community Liaison Officer for Northern British Columbia. She first hiked the Berg Lake Trail in 2019, and has been enamoured with Mount Robson Provincial Park ever since.

The author wishes to thank the following individuals for agreeing to be interviewed for this article: Adrian Batho, Conservation Specialist, Omineca/Peace, BC Parks; Andrea Zemlak, Recreation Section Head, Omineca/Peace, BC Parks; Dr. Brian Menounos, Hakai Institute Affiliate / Professor and Canada Research Chair, Department of Geography, Earth, and Environmental Sciences, University of Northern British Columbia; and Elliot Ingles, Mount Robson Area Supervisor, BC Parks.

Additional monitoring tools installed by BC Parks, such as cameras and staff gauges, will help identify shifts in the Robson River in near real-time.

References

1. As the written form of Secwepemctsín evolves, spellings of place names have changed. Mount Robson has also been known as Tsyexyexéscen or Yexyexhésqen, both of which are variants of Tsyécelcten. Tsyécelcten comes from engagement with Secwepemctsín language speakers from the Simpcw First Nation.

Sustainable Banff

Car-free Canada Day celebrations on Banff Ave. Photo: C. DiManno

Corrie DiManno

Banff needs to change to stay the same. Whether it is adapting to climate change or envisioning the future of tourism, we must take measures to ensure we remain sustainable. As a mountain town beloved by so many across the country and beyond, our actions will help to protect our wild spaces and preserve our small-community charm.

These pedestrianization decisions fit into our track record of sustainability initiatives that we consider leading-edge for a community of 8,000 residents.

Like most municipalities in Canada, we are grappling with how to prevent and prepare for the impacts of a warming world. As a tourism town nestled in a national park, Banff already faces several challenges – affordable housing, cost of living, and vehicle congestion, to name a few – but climate change is the most imminent one because it can cause dramatic change to our lives and livelihoods. Wildfires season is starting earlier, and more fires are occurring across Canada each year. Severe storms are more frequent, as are floods, and the glaciers that feed our water tables are receding faster than ever. As a major tourist destination, we can't escape the fact that our visitors – arriving, as they do, by road and/or air – are contributing to global greenhouse gas emissions.

As such, we strive to be a model environmental community and are motivated to make a difference locally, while inspiring the four million visitors who we welcome every year.

Banff is primed to be an example of how we make use of this precious window of time before it is too late to move the needle. We have set ambitious goals when it comes to climate action: achieving thirty per cent emissions reductions by 2030 and eighty per cent by 2050 (relative to 2016 emissions levels), as well as achieving 100 per cent renewable energy by 2050.

A major area of focus to reduce our carbon footprint is through demonstrating transportation and environmental leadership. As a reminder, the town's mandate – as directed by the federal and provincial governments – is to provide services to visitors. However, we have too many personal vehicles on our finite road network during peak seasons, and we know cars are a leading factor in contributing to emissions in the Town of Banff and in Banff National Park. We continue to invest in transit from Calgary to Banff through the On-It Regional Transit summer weekend service, and we strongly encourage visitors, once in town, to travel on Roam Public Transit when they are exploring popular destinations in Banff and throughout the park.

More parking lots cannot solve the problem in the long run. Rather, we believe the future depends on affordable and convenient mass transit from Calgary. We look forward to the new Banff National Park Management Plan and Parks Canada's Expert Advisory Panel on moving people sustainably and Banff National Park's recommendations for ideas and best practices on managing our capacity of visitors coming by personal vehicle.

Until then, we are slowly developing an 'active modes' oasis in Banff, because as a town within Canada's first national park, we need to advance the values of a national park, which include protection of this place in the Rockies and fostering the behaviours that promote long-term sustainability.

The town is also only four-square kilometres in area, so it just makes sense to promote walking, cycling, and connectivity with transit, and most importantly, to provide the infrastructure to make it an inviting choice. For example, we recently transformed Bear Street, our second main street, into a pedestrian-friendly commercial hub, where drivers quickly realize they are a guest on the street. With public seating, tree cover, bike racks, and paving stones, we have created a European-style plaza in the heart of Banff.

One street over, we renewed our commitment to the Banff Avenue Pedestrian Zone with a two-year pilot for the summers of 2022 and 2023. What started as a project to keep people safe and appropriately spaced during the COVID-19 pandemic is now a way to support economic recovery and to foster environmental sustainability and active lifestyles. By closing Banff Avenue to vehicles, we open the public space to people: pedestrians, cyclists, skateboarders, wheelchair users, parents with strollers. We want to support the outdoor pursuits that put Banff on the map – skiing, climbing, hiking, paddling, and increasingly cycling – and bring that lifestyle into our urban centre.

These pedestrianization decisions fit into our track record of sustainability initiatives that we consider leading-edge for a community of 8,000 residents. We built our first pedestrian bridge over the Bow River almost a decade ago, and later this summer, we will finish construction on a second pedestrian bridge. Banff created a transit system and grew Roam Public Transit to go everywhere in and around Banff, with connections to Lake Louise and Canmore. Last year, we implemented pay parking in our downtown core to stimulate turnover in short-stay parking and to encourage drivers to park in our free parking lots on the edge of town and then walk the eight minutes to downtown. From the funds received through pay parking, we funded e-bike rebates because many of our neighbourhoods are up hills on the side of a mountain, and we funded fare-free transit on local routes for residents to help them shift from using their cars.

Sunday night cruise down the Banff Ave Pedestrian Zone. Photo: C. DiManno

The future's looking bright in Banff. Because together, with the community, the Town of Banff, Parks Canada, and Banff & Lake Louise Tourism, we are developing a sustainability-focused ten-year Tourism Master Plan for the destination. This plan will become a guidepost as we develop our approach to tourism in Banff National Park, by addressing environmental sustainability, community wellbeing, cultural integrity, and economic prosperity. We see this as an opportunity to build forward from the pandemic to ensure we protect our environment while maintaining a strong economy and a healthy community.

We learned just how resilient we can be during the last two years, and we need to carry that grit and resolve into the future as we work together to keep Banff as sustainable as possible.

Corrie DiManno is the current Mayor of Banff, Alberta, but she's been in and around Banff since she was born. When she's not doing mayoral stuff, she loves backcountry hut trips with friends, as well as running, biking, and hiking in the mountains.

A major area of focus to reduce our carbon footprint is through demonstrating transportation and environmental leadership.

Season opener for an active modes summer in downtown Banff. Photo: C. DiManno

The Canadian Mountain Assessment: Engaging with multiple ways of knowing to advance understanding of mountains in Canada

Saskatchewan Glacier viewed from Parker Ridge. Icefields Parkway, Canadian Rockies. Photo: Vanessa Kiss

Graham McDowell

Canada is a country of diverse and exceptional mountains. Around a quarter of the country is covered by mountainous terrain, an area large enough to encompass Switzerland 54 times. It is also a country of mountain people. Approximately, 1.3 million people live within mountain areas in Canada, and an additional 75% of Canada's total population lives within 100km of mountains. Accordingly, many of us are deeply connected to mountains as sources of water, destinations for recreation, places of inspiration and renewal, and more. However, our connections with mountains are at a critical juncture, as climate change and other impacts related to human activities rapidly alter high places across this country.

The CMA is clarifying what we know, do not know, and need to know about Canada's diverse and rapidly changing mountain systems.

The importance and sensitivity of mountains is gaining attention globally, as are efforts to clarity what is known (and not known) about diverse and quickly changing mountain systems. For example, two recent Intergovernmental Panel on Climate Change (IPCC) reports contained chapters focused specifically on mountains,[1] and the 2019 Hindu Kush Himalaya Assessment provided a detailed appraisal of mountain systems knowledge for high mountain Asia.[2] These reports laid important foundations for advancing research, relationships, and policies to benefit mountain environments and people; they also revealed the lack of such a knowledge base for mountains in Canada.

In this context, the Canadian Mountain Assessment (CMA) was initiated in 2020 as a 3.5-year initiative to advance understanding of mountain systems in Canada. The project is based at the University of Calgary and is supported by funding from the Canadian Mountain Network (CMN) and the Natural Sciences and Engineering Research Council of Canada (NSERC).

Introducing the Canadian Mountain Assessment

The CMA is clarifying what we know, do not know, and need to know about Canada's diverse and rapidly changing mountain systems. Uniquely, the CMA is answering these questions through the respectful inclusion of insights from First Nations, Métis, and Inuit knowledges of mountains, as well as findings from a thorough assessment of the pertinent academic literature (~3,000 peer-reviewed articles). This is a first for a mountain-focused assessment.

The CMA's methodology is informed by a multiple-evidence-based approach where Indigenous and Western academic knowledge systems are understood as generating different manifestations of valid and useful knowledge.[3] Our approach highlights the integrity of knowledge systems on their own terms and aspires to respectfully braid multiple sources of evidence together to enrich understanding of mountain in Canada (Figure 1).

The CMA is guided by a Stewardship Circle (Figure 2), a team of Indigenous and non-Indigenous individuals who come from a variety of professional, cultural, and geographical settings. Members have worked together closely from the outset of the project to co-develop the spirit, intent, and approach of the CMA.

The structure of the CMA—which takes the form of a book length assessment report—includes five core sections: Mountain Environments, Mountains as Homelands, Gifts of the Mountains, Mountains under Pressure, and Desirable Mountain Futures. Each section includes diverse manifestations of mountain knowledge, such as text; video recordings of conversations with First Nations, Métis, and Inuit knowledge holders (accessible through embedded hyperlinks); and art, photographs, and maps.

Sections of the CMA are co-led by Indigenous and non-Indigenous individuals and supported by additional Indigenous and non-Indigenous authors. In total, approximately 60 authors are working collaboratively to illustrate the depth and diversity of mountains systems knowledge across Canada.

Recent Developments and Next Steps

Since 2020, the CMA has completed several significant activities such as conducting foundational analyses,[4] articulating knowledge sharing and co-creation protocols, and defining the structure of the assessment (Figure 3).

Until recently, CMA activities were completed remotely/online due to Covid 19 restrictions. However, in May 2022 the CMA was able to host two important in person gatherings in Banff: A Learning Circle that included 20 First Nations, Métis, and Inuit individuals from across mountain areas in Canada and an author meeting that included 20 CMA authors (Figure 4).

The CMA Learning Circle began with opening words by Stoney Nakoda and Blackfoot Elders. We then spent several days in conversation about mountain environments, homelands, and gifts as well as pressures affecting mountains systems and the characteristics of desirable mountain futures. Knowledge holders participating in the Learning Circle shared incredibly powerful, illuminating, and specific stories and knowledges about mountains. Following proper consent, this sharing was video recorded as a way to document stories and knowledges transmitted orally. These recordings have been reviewed by Learning Circle participants are now being woven into CMA sections under their guidance. Importantly, these contributions can be removed from the CMA at any time at the discretion of participants, and important manifestation of the principle of ongoing consent.

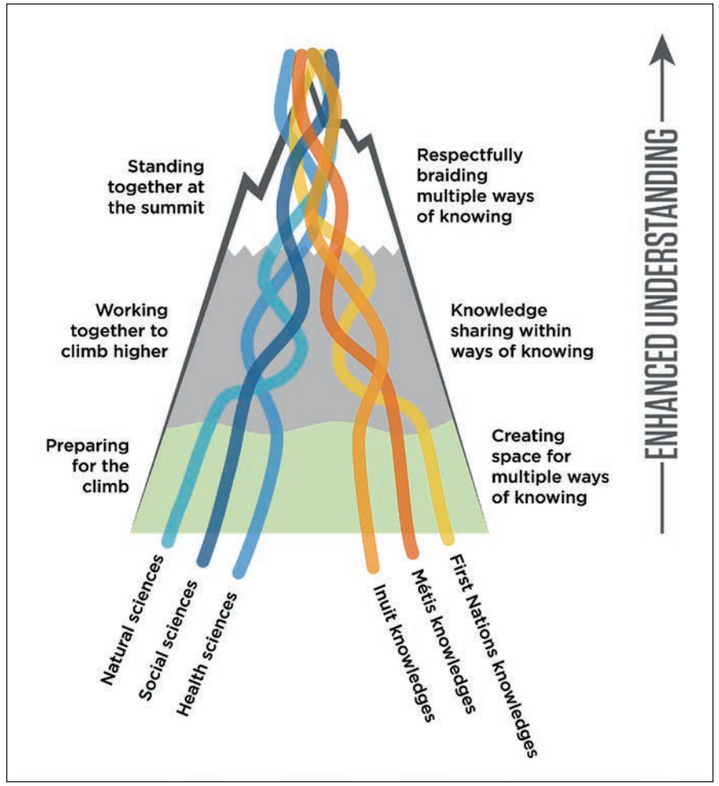


Figure 1: Simplified depiction of a multiple-evidence-based approach in the context of the CMA.

The CMA Author Meeting devoted considerable time to discussing the CMA's engagement with text and non-text materials; traceability and transparency; and the challenges, opportunities, and limitations of knowledge co-creation activities in the context of an assessment report. The gathering helped to solidify mechanisms for operationalizing key

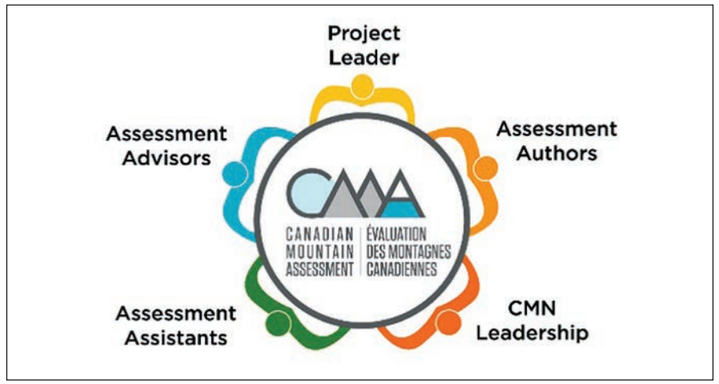


Figure 2: CMA Stewardship Circle

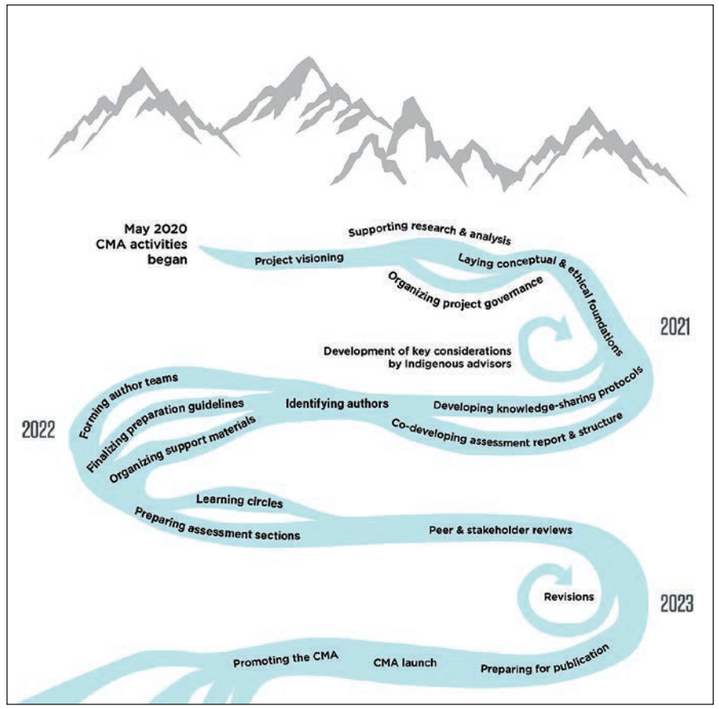


Figure 3: CMA timeline and key activities.

ideas and aspirations and generated considerable momentum for the final push of CMA preparation activities.

Author teams are now actively preparing CMA sections. The initial drafts of CMA sections will go out for review in the late summer of 2022, with section revision activities taking place into early 2023.

The final CMA report will be launched in the fall of 2023 at the Whyte Museum of the Canadian Rockies as an official event of the Banff Centre Mountain Film and Book Festival. We look forward to sharing what we learn about the state of mountains systems knowledge in Canada. Stay tuned!

Dr. Graham McDowell is the Project Leader for the Canadian Mountain Assessment, a two-time Intergovernmental Panel on Climate Change (IPCC) author, and a global leader in the study of human vulnerability and adaptation to climate change in mountain regions. He lives in Canmore, Alberta, on Treaty 7 lands, in the heart of the Canadian Rockies. Personal website: https://grahammcdowellresearch.com/

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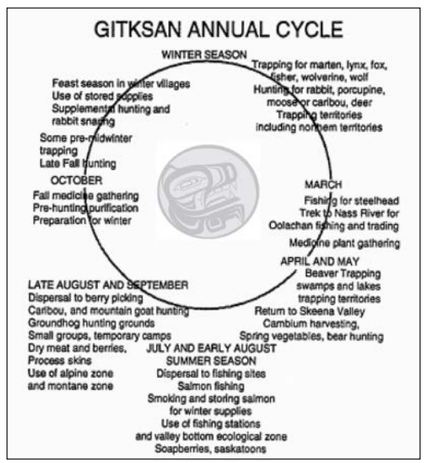
Figure 4: Images of participants at CMA gatherings in Banff . Photos by David Borish & Graham McDowell

Gitxsan and Secwépemc Resilience to Climate Change

Janna Wale

Indigenous communities in British Columbia (BC) hold deep relationships with their Lands, and are being disproportionately affected by climate change. Community climate resilience is an emergent body of work that examines select indicators to create an overall picture of climate resilience in human communities.

My work focuses on climate resilience in Indigenous communities. Essentially, it explores what we already know as Indigenous peoples – that we are strong and resilient. My approach to better understand our resilience was to study how the seasonal round of activities in two nations – the Gitxsan Nation and the Secwépemc Nation – are being impacted by climate change. A seasonal round is the intersection between cultural practices and what is happening on the Land at any given point in time during the year (Figure 1). For many Indigenous people in BC, life was, and continues to be, founded upon the change of seasons; the seasons influence the areas in which we live, hunt, and harvest. Each new season brings with it different resources, different cultural events,



Above: Figure 1: Gitxsan seasonal cycle, inclusive of seasonal activities (Main-Johnson 1997). Gitxsan Moon by Brett Huson

Right: Traditionally harvested salmon and corn cooking over hot rocks. Photo. J. Wale

A member of the Gitxsan First Nation cleans a salmon; the parts that are not used feed the river. Photo: J. Wale

It is important to understand that a change in relationship does not necessarily translate to a loss in relationship.

and different processes that define and shape the Indigenous way of life. Since climate change directly affects the Land through shifts in the timing of ecological processes, I expected to see these changes reflected in the seasonal rounds of my study communities.

The Gitxsan (Gitksan) are a northwest coastal people who live in the drainage of the Skeena River in northwestern BC. The Secwépemc peoples are interior Salish peoples, who occupy a large area in the southern interior of BC. I interviewed and surveyed thirty-six community members from these two Nations about changes they are seeing on the Land, and how these changes are beginning to impact aspects of their culture and their seasonal rounds.

The two case studies revealed three major themes. First, community members are reporting that seasonal patterns are shifting. Secondly, the rate and magnitude of the change is not consistent across territories. Thirdly, communities are demonstrating resilience through the use of traditional management to favour sustainability.

The first theme is the obvious one – because of course, we are all experiencing climatic changes. The massive fires, the flooding, and the unprecedented weather events of the past few years are symptoms of that change. Take the Gitxsan seasonal round for instance. Gitxsan community members have seen a noticeable increase in rainfall and a shift in the timing of the freeze each year. The inconsistency in temperatures is also affecting the growing cycle of the plants, such that the timing of the harvest is now inconsistent year to year. One of my study participants noted that "it is almost like the plants are confused." The inconsistency in harvestables, in turn, affects moose, who are not found as consistently throughout the territory. These climatic shifts translate into a cultural shift. Having reduced access to moose not only destabilizes the ecosystem, but also is beginning to impact Gitxsan food security. Events like this are becoming more frequent, and are beginning to distort the Gitxsan seasonal round (Figure 2).

The second theme is that, depending on where you are, the shifts will be different. In my research, Secwépemc people observed more changes, at a faster rate, than the Gitxsan – or at least, it came up more frequently in conversation. There are a number of possible explanations for this.

The first possible explanation is the difference in how colonization has played out across BC. Secwépemc'uuluw is more densely populated, and has been subject to more land-cover and land-use change as a result of colonial settlement and resource extraction. Due to disturbance and fragmentation, ecosystems are thus less resilient, and Secwépemc people have reduced access in more parts of their territory throughout the year, which has sped up the distortion of the seasonal round.

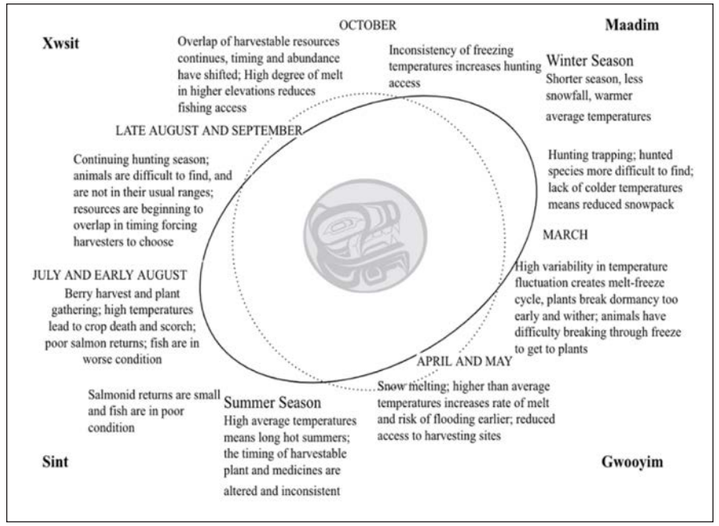
Second, it is also important to consider how Indigenous peoples lived on the landscape in the past. Secwépemc people were highly mobile. The restrictions and forced removals under the reserve system affected Secwépemc access to their traditional territories, which affected – and continues to affect – how they are able to practice seasonality. By contrast, Gitxsan people were less seasonally mobile and continue to live close to fishing and harvesting sites; they are able to maintain access to significant areas, which means less distortion of their seasonal round.

Additionally, Gitxsan territory is within the Interior Cedar Hemlock (ICH) Biogeoclimatic ecosystem zone. The ICH zone has remained relatively stable, and according to climate change projections will greater stability. The Gitxsan seasonal round mirrors the slower shift. Secwépemc territory is within the Interior Plateau of BC, dominated by the dry Bunchgrass, Ponderosa Pine, and Interior Douglas Fir Biogeoclimatic ecosystems. Projections indicate that these ecosystems will undergo rapid change.

It is important to understand that a change in relationship does not necessarily translate to a loss in relationship. For instance, while the relationship that Secwépemc people hold with the Land has changed, they are now using their contemporary relationship with the Land as a way to reassert ownership and territorial boundaries. As one community member put it, "[w]e are marking the posts. We claim it as a traditional activity – a life giving force – and anything we can do to serve that purpose gets integrated to how we are now living on the Land." They are consciously using this relationship strategically, and are revitalizing traditional uses in faraway places throughout Secwépemc'uuluw.

Colonization has worked against our ability to see the interconnections that we have with the living things around us. By reinforcing the connections to traditional seasonal rounds, seasonally-based recommendations can also build Indigenous community climate resilience. Particularly, the revival of traditional resource management can help to mitigate climate impacts. As examples, the Secwépemc are exploring traditional burning in the spring, and the Gitxsan are reviving control over fisheries in the fall. Both of these activities will lead to further sustainable management practices, will increase human-environment interconnections, and strengthen resilience of the Land and people.

Janna Wale (She/Her) is Gitxsan from Gitanmaax First Nation and is also Cree-Métis on her mother's side. She holds a Bachelors of Natural Resource Science – Honours (B. Nrs – Hons) from Thompson Rivers University, and is currently working on completing her Masters (M.Sc.) in IGS Sustainability at the University of British Columbia-Okanagan. Her thesis research focuses on climate resilience in Indigenous communities.



Above: Figure 2: The distorted Gitxsan seasonal cycle based on anecdotal evidence (Wale 2022). Gitxsan Moon by Brett Huson

Below: A member of the Gitxsan First Nation harvesting huckleberries amongst the fireweed. Photo: J. Wale

Alpinists Contribute to Biodiversity Science Using iNaturalist

Pile of grass where it shouldn't be? The above photograph became a research-grade iNaturalist datapoint for American Pika. Photo: Zac Robinson, 2019.

Gabe Schepens and Brian Starzomski

Mountains are an important refuge for species as they adapt to a changing world. Animals with large home ranges like wolverines seek secluded snow-covered areas for denning, while rare flowers sprout uphill of their parents to move up valleys following the toe of a melting glacier. These remote ecosystems are challenging to study, and biologists know much less about alpine biodiversity than closer-to-town habitats. Throughout Canada's vast mountain network, eager alpinists are making important contributions to our knowledge of biodiversity by sharing photos to the *iNaturalist* (www.inaturalist.ca) community science platform.

iNaturalist Projects have been created for many mountainous places, such as popular summits and their approaches, parks, and conservation areas.

In our changing climate, ecosystems are most dynamic at their edges. Mountains are sentinels of change, filled with habitat edges, species range limits, climate zonations, and variable elevation – such regions of transition are called ecotones. These boundaries, such as the treeline, are moving as climate warms and lengthens the growing season at high elevation. While scientists are busy studying these transitions using technology like comparative satellite imagery, we have little time (or funding) to venture into mountain ecosystems to collect data on unique species. In the hard-to-reach places that alpinists go, a few pictures taken with a phone camera can provide valuable data to fill these gaps. From geotagged photographs uploaded to iNaturalist.ca, scientists can study a range of different ecological phenomena. For example, *iNaturalist* photo observations taken in western Canadian mountains provided data for research on the timing of mountain goat coat shedding.[1]

Whether it's the golden-mantled ground squirrel – *not a chipmunk* – eyeing your granola, or the century-old moss campion cushion you sat on, all photographs are valuable. If you don't know what exactly you might be looking at, you can learn with *iNaturalist's* automated identification tools, which can be used on-trail (and offline) as part of the Seek app. Once the photo is uploaded online, *iNaturalist* has thousands of experts who will help identify your observation – be it the alga which causes pink "watermelon snow," or the cheeto-shaped droppings of a ptarmigan. There are so few alpine observations that you may unknowingly document a species new to the region, as Brian Starzomski did with a blurry butterfly photo last summer that was identified as an Edwards' Fritillary.

At last year's Mummery Glacier General Mountaineering Camp (GMC), ACC member and scientist Mary Sanseverino created an *iNaturalist* "Project" to collect the GMC observations by defining the camp's perimeter and time frame.[2] Like an automatic photo album, GMC project photos are all collected to one website, and you can take a look at Mary's photo of the elusive camp marmot. Projects list summary statistics: 2021 GMC-goers submitted 189 photo observations of 70 unique species, which were identified by 30 experts. Once a species identification is confirmed, the *iNaturalist* observation is passed to the Global Biodiversity Information Facility, which hosts and freely provides data to the public and for research.

iNaturalist Projects have been created for many mountainous places, such as popular summits and their approaches, parks, and conservation areas. Before heading out, check *iNaturalist* projects for the area – what rare species might await you along the trail up the Golden Hinde? Are the blueberries ripe? In Strathcona Provincial Park, outdoor enthusiasts have contributed over 28,000 *iNaturalist* observations. [insert Figure 2] While this park is largely covered in rugged mountainous terrain, only nine per cent of these observations were taken in the alpine ecosystem.

For climbers, much like projecting in the crag and peak-bagging in the alpine, gathering species observations can quickly become a competitive endeavour. On a recent trip to a glacial bowl, our team clambered among the rocks in search of streamside flowers while keeping an ear out for the sharp cry of a pika. Over dinner, we compared pictures of wildflowers, and tall tales of the marmot that ran before having its picture taken. Once the photos are uploaded to *iNaturalist*, the Project tallies a leaderboard, which turns naïve naturalists into fierce competitors. Soon, a fun scavenger hunt (sometimes termed "bioblitz") becomes a passion to document as many organisms as possible. Less than a year after I unwittingly downloaded the *iNaturalist* app, my mother made me a 1000-species congratulatory cake – a slippery slope.

What matters much less than the successes of a few nerds are the small contributions of hundreds of engaged members – each traveling to different places in different seasons with different interests. Observations from novice "iNatters" have been used to inform management of endangered species, monitor species invasions, and measure biodiversity across the country. At the time of writing, *iNaturalist* observations in Canada exceed seven million, with over 32,000 species documented. However, the majority of these observations are gathered near roads and urban areas – giving alpinists a unique asset to contribute to our collective knowledge of the natural world. So, next time you're feeling the freedom of the hills, snap a few photos of the plants and animals you encounter, upload to *iNaturalist*, and contribute to alpine science.

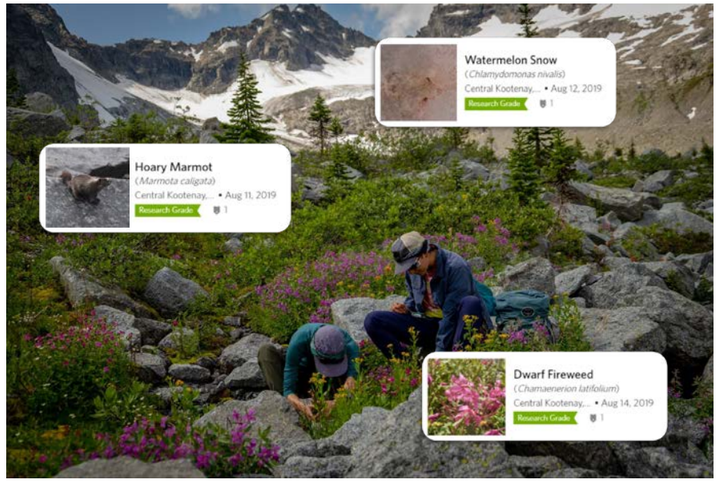


Figure 1: University of Alberta students iNatting at the 2019 General Mountaineering Camp. Bubbles show examples of iNaturalist observations they later uploaded. Photo: Mary Sanseverino, 2019.

Gabe Schepens is a recent MSc graduate from the School of Environmental Studies at the University of Victoria. They have studied mountain ecosystems from plants to wolverines, and they are currently working on habitat modeling for species at risk.

Brian Starzomski is the Director of the School of Environmental Studies at University of Victoria. He studies biodiversity across a variety of ecosystems, using iNaturalist in his research, as a hobby, and in his role on the Committee on the Status of Endangered Wildlife in Canada.

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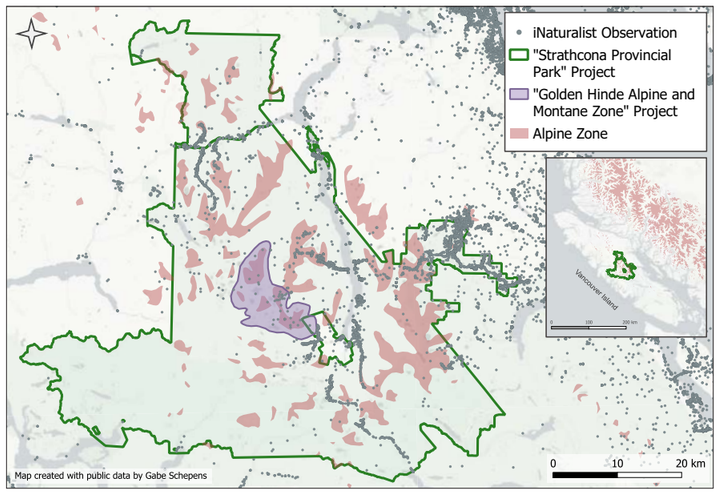


Figure 2: iNaturalist Projects exist for hundreds of popular alpine destinations. Shown here as an example are two Projects on Vancouver Island: Strathcona Provincial Park, and the Golden Hinde Alpine and Montane Zone.

Banff's Bison Reintroduction Project: A Cultural Update

The bison herd at Stoney Indian Park at Morley, Alberta, where many of the Stoney Elder Interviews took place for the Stoney Bison Study.

To fill this gap, the Stoney Nakoda sought out the capacity to conduct a cultural study on the keystone species

Bill Snow

In April 2022, the Stoney Nakoda completed a report, "Enhancing the Reintroduction of Plains Bison in Banff National Park Through Cultural Monitoring and Traditional Knowledge" (The Stoney Bison Study), that considers the bison reintroduction to Banff National Park (Mînî Rhpa Mâkoche) from an Indigenous cultural perspective. In 2017, a plains bison herd (of sixteen head) were translocated to the backcounty of Banff National Park (BNP) from Elk Island National Park. The herd at Elk Island National Park is the most healthy, disease-free bison herd in the world, and thus it is the origin herd for numerous bison reintroduction programs around the world. Five years on, the Banff herd has expanded to over approximately eighty head – an exact number remains unknown, as a few late calves are still expected to arrive this year. The Stoney Bison Study was conducted by Stoney Nakoda Nation, in partnership with Mount Royal University, the University of British Columbia, independent contractors, and the Canadian Mountain Network.

In 2016, an environmental assessment – largely based on non-Indigenous, western science – was completed for BNP's bison reintroduction project. Within the assessment, there was little consideration given to the Indigenous cultural importance of bison on the BNP landscape. To fill this gap, the Stoney Nakoda sought out the capacity to conduct a cultural study on the keystone species that now roam in a 1,200-square-kilometre Reintroduction Zone. Funding was secured in 2019 through the Canadian Mountain Network, an initiative of Canada's Research Granting Agencies. Despite the worldwide COVID-19 pandemic, the Stoney Nakoda were able to complete the study in April 2022, albeit at a slower pace than originally planned.

The Stoney Bison Study began by creating an ethical space, a foundational concept developed by Elder Willie Ermine that is critical to opening cultural discussions between differing groups. The Study starts out with a reflection on the traditional knowledge shared at the Indian Ecumenical Conference, spiritual gatherings that were held at Stoney Indian Park, on the Stoney Indian Reserve, in the 1970s and 1980s. At these cultural gatherings, stories about places and wildlife – and bison in particular – were shared by Elders, and circulated to the wider community. The cultural reflection on this traditional knowledge at the outset of the Study was critical in creating the "ethical" space needed to open further discussions about bison today.

The Study also begins with a discussion about Indigenous methodologies and a brief description of their backgrounds, as well as a discussion on the Stoney methodology on "Biculturalism." There is also a discussion on the "Cultural Monitoring" process that was used to combine Western Science and Traditional Knowledge, whose steps include: Ceremony, Planning, Elder Interviews, Fieldwork, Elder Reconnection, Final Report and Outreach. Elder Interviews took part at the Bison Paddock at Stoney Indian Park, where the Stoney Nakoda have been managing a bison herd since 1970. These gatherings took place in a tipi, where cultural protocols were followed. The Study concludes with eleven recommendations, which focus on the continuance of the reintroduction, conducting ceremony at major stages of the project, the continuance of Indigenous cultural monitoring and harvesting.

In the five years since the start of Banff's bison reintroduction program, we are seeing the adaptation of the plains bison to the mountain landscape, a place where they have roamed for over 12,000 years. At this stage of the bison reintroduction, we are also seeing the impact of bison on landscape and wildlife, other mammals, avian species, insects, rodents, vegetation and soils.

Just as the bison are bringing increased biodiversity back to the land, they're also bringing cultural connections to the land, and to the region's Indigenous people. During the fieldwork section of the Cultural Monitoring process, the "Bison Riders" spoke of having a "spiritual" experience while being in the bison reintroduction zone. Bison Rider Conrad Rabbit would share that "[T]he creator set the sunshine on us until we were heading back – it was very humbling. Way on top of the ridge, you could feel it – 200 years ago, this is where the buffalo roamed and we were in our ancestor's footsteps." These cultural connections to land and wildlife are largely what is missing from much of current "standard" non-Indigenous environmental assessments.

The Stoney Bison Study marks many "firsts." It marks the first time that the Stoney Nakoda have completed a cultural study on bison. Another first was the Bison Blessing Ceremony, held at Elk Island National Park in 2017 in advance of the relocation. Elk Island National Park had never before conducted such a ceremony. Members from Treaties Six and Seven First Nations were all on hand. And in 2022, the completion of the Study marks the first time that Stoney Tradition Knowledge on bison has been considered by Banff National Park.

There are many pressures on our mountain landscapes today – wildfires, flooding events, and desertification are just some of the climate change effects that we are seeing. New and challenging issues require new and innovative solutions. In the words of Jessie Potter, "If you always do what you've always done, you always get what you've always gotten." The Stoney Bison Study is an example of how we can understand differently, how we can understand landscapes and the wildlife they sustain as having important cultural contexts. Having a wider, more holistic understanding of wildlife will add to our collective knowledge base, add to our policy and strategies, and add to our management practices, so that we are enacting this new understanding rather than watching it sit on a shelf. If this looks and sounds different from a normal wildlife study, then that is a good thing.

Hopefully, the Stoney Bison Study will be one of many Indigenous wildlife studies that are produced to assist regulators in their land-management efforts. Considering the Indigenous cultural context alongside the environmental context should be commonplace if we are to manage wildlife and landscapes differently, holistically, and with an eye towards and more diverse and inclusive future, especially in the face of the ever increasing impacts of climate change.

There are many pressures on our mountain landscapes today – wildfires, flooding events, and desertification are just some of the climate change effects that we are seeing. New and challenging issues require new and innovative solutions.

Bill Snow is a member of the Wesley Band of the Stoney Nakoda Nation, and is the Consultation Manager for Stoney Consultation at the Stoney Tribal Administration, Morley, Alberta.

Bison Rider Toby Dixon looking out at the Red Deer River Valley in the bison reintroduction zone in September 2020.

Are the Oldest Known Animal Fossils Preserved in the Mackenzie Mountains?

Part of a mountain formed by a huge cyanobacterial reef in which the possible sponge fossils were found; helicopter for scale. Photo: Elizabeth Turner

Elizabeth Turner

Earth is 4.56 billion years old. Although life as been around for most of that time, our understanding of the first ninety per cent of Earth's biological history is murky because of the lack of large, readily understood fossils, together with numerous other geological impediments. Identifying the timing and triggers for the appearance and diversification of early bacterial life and the more complex organisms that followed, including animals, is among the most challenging problems in Earth-system history.

The different ages and types of rocks are not randomly distributed in Earth's crust or at its surface, and some ages of rocks are rare owing to geological factors.

For outdoorspeople, rocks are a recreational tool. Climbers commonly divide rocks into granite, limestone, and sandstone, and understand that rocks are far from inert, but generally think little more of the factors that underlie their more detailed characteristics. In fact, each of the basic rock types has diverse compositional and textural characteristics that affect how it looks, feels, and "behaves" as a component of Earth's environments, and each rock type encodes a vast amount of information about Earth's deep-time past.

Among the most complex rocks are limestones, which form by precipitation of microscopic mineral crystals from ions dissolved in seawater, under the direct influence of the organisms that lived at that time and place. They therefore encode in their crystal chemistry and microscopic textures information about the biology and geochemistry of Earth's seawater through its dramatic, long-term evolution.

Limestones are among the richest archives of biological evolution. "Normal" fossils are the "hard parts" of animals (shells, bones, teeth). The oldest readily intelligible hard parts are from the so-called "Cambrian explosion," which records the geologically near-instantaneous appearance of a diverse assemblage of complex animals approximately 540 million years ago. Darwin highlighted the absence of any gradational lead up to the sudden appearance of familiar animal fossils in *On the Origin of Species* (1859), and "Darwin's dilemma" has remained stubbornly unresolved since then. The time, nature, location, and cause for the appearance and early evolution of animals remain extremely controversial questions for which even the slightest convincing evidence has remained elusive.

The different ages and types of rocks are not randomly distributed in Earth's crust or at its surface, and some ages of rocks are rare owing to geological factors. To answer a particular question, one has to go where rocks of the appropriate age and type are exposed. Much of Canada's geology remains poorly known owing to remoteness; one such place is the Mackenzie Mountains in western mainland Northwest Territories. There, I may have found evidence of very early animals, in rocks much older than those normally addressed by researchers looking for early evidence of animals.

Animals ingest organic matter to get energy and nutrients. Their metabolisms require oxygen, but Earth's atmosphere and ocean were mainly anoxic or poorly oxygenated for most of its history. It has therefore been assumed that animals either could not appear, or could not diversify, until after a major global increase in oxygen sometime between 815 and 540 million years ago.

It is widely accepted that sponges are the most basic animal type and probably emerged first; some sponges have oxygen requirements much lower that those of more complex animals. A genetic method estimates that sponges may have appeared as much as 900 million years ago. Why, then, have we not found fossil evidence of sponges in rocks that are between 900 and 540 million tears old? There are numerous possible reasons, including looking for inappropriate types of evidence, not looking in all eligible rock types, interrogating only the youngest part of that >300 million-year-long gap, and, most importantly, not thoroughly considering exactly how the simplest, earliest animal might have been preserved as a physical fossil.

Sponges do not have standard hard parts (shells, bones). Some sponges have a scaffold-like skeleton made of microscopic mineralised rods (spicules), but no undisputed spicules have been found in rocks pre-dating the Cambrian. Some sponge skeletons are made of tough protein fibres called spongin [insert Photo 1], forming a distinctive, microscopic, three-dimensional meshwork (identical to a natural bath sponge – have a look with a magnifying lens!).

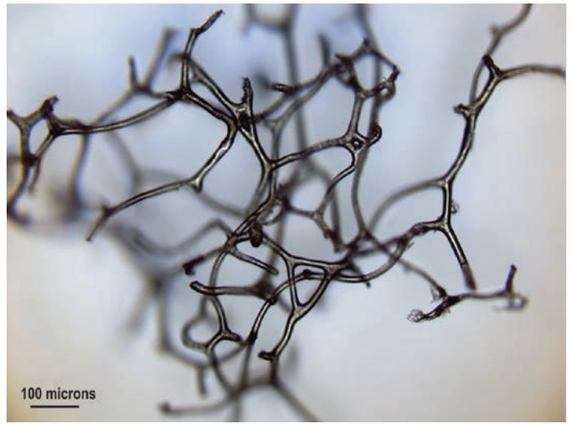
Furthermore, sponges can be preserved in the rock record when their soft tissue is calcified during its decay. If the calcified mass hardens around spongin fibres before they too decay, a distinctive microscopic 3-D meshwork of complexly branching and rejoining micro-tubes results, and can be seen under the microscope. The meshwork configuration is unlike anything made by algae, bacteria, or fungi, and has been documented from limestones younger than 540 million years.

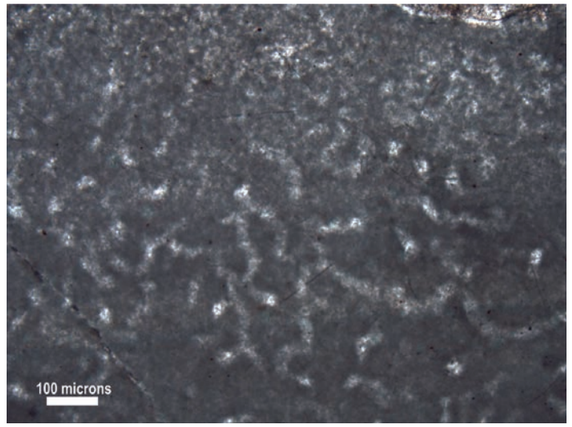
I found and published this exact microstructure in rocks about 890 million years old [insert Photo 2] from a very remote part of the Mackenzie Mountains, NWT [insert Photos 3 and 4]. The early possible sponges lived with photosynthetic bacterial communities that built enormous reefs and acted as "oxygen oases" in an otherwise low-oxygen world. If my interpretation is correct, it may be that early sponges existed, unchanged and unchallenged by evolutionary pressure, for up to several hundred million years, before more complex and oxygen-intensive animals emerged after the major oxygenation event had taken place.

My proposal may seem scandalous, but it is in fact consistent with predictions and assumptions that are common in the paleontological community: the new material seems to validate an extrapolated timeline and a predicted identity for early animals that are already widely accepted. If these are indeed sponge fossils, animal evolution can be pushed back by several hundred million years, and may provide a new perspective on Darwin's dilemma. However, evaluation and possible acceptance of new ideas requires thorough inspection and discussion within the scientific community.

I predict scorching controversy in the years to come.

Elizabeth C. Turner, PhD, PGeo, is a Professor in the Harquail School of Earth Sciences at Laurentian University, Ontario.





Top: A fragment of the spongin skeleton of a modern bath sponge.

Middle: The 890-million-year-old microstructure that may represent the earliest animals.

Bottom: Our remote field work in the Mackenzie Mountains is done on foot from a two-person tent camp placed by helicopter. Photo: Elizabeth Turner

Alpine Lighthouse (Abbot Pass Hut). Photo: Paul Zizka

The Abbot Pass Refuge Cabin National Historic Site

David Hik, Zac Robinson, and Stephen Slemon

> "the rains descended, and the floods came, and the winds blew, and beat upon that house; and it fell not: for it was founded upon a rock."
>
> *Matthew 7, 25. The Sermon on the Mount*

It was never going to last forever. But the house the Swiss guides built high in the mountains – masonry on the outside, plywood wood on the inside, a kitchen, an attic, one dormitory for men and another for women – followed the lesson of the parable exactly. They built on rock – on the high, narrow ridge in the Canadian Rockies that forms Abbot Pass, 2,925 metres above sea level, between Lake O'Hara in Yoho National Park and Lake Louise in Banff National Park, on the Continental Divide.

Just bringing the building materials to the site involved heroic levels of organization and labour. They hired wranglers with horses to carry wood, windows, bolts, and lime for making cement up from Lake Louise to the base of the avalanche-prone Death Trap, a steep, glaciated canyon between Mount Victoria and Mount Lefroy. From there, they carried 35-kilo packs over a ladder that spanned a large crevasse, and then winched sleds up the steep sections to gain the pass, from where they'd quarried the stones.

After moving to Canada, Swiss-born mountain guides Edward Feuz Jr. and Rudolph Aemmer had seen a need for "altitude-accommodation for serious mountaineers" in the burgeoning tourism industry of the 1920s, and they opened theirs in 1923. "Up here," said Feuz Jr. at the inauguration ceremony, "with all those beautiful peaks everywhere, this simple hut is a home."

The Abbot Pass Refuge Cabin should still be standing, the snowmelt from its shake roof still flowing to both the Pacific and Atlantic oceans. Mountaineers should still be coming here during the climbing season, dining, bunking, and warming themselves by the wood stove before making their early morning start for the summits. But this summer, Parks Canada is taking the guides' house down. No-one had accounted for climate change.

How could they have? Until very recently, the Lower Victoria Glacier blanketed much of the north slope beneath the hut. The ice almost reached the hut's northern wall. But now the glacier's edge rests fifty metres downslope. What has been exposed — what was for much of the past century held intact, frozen and insulated from surface erosion and intense solar heating — is the actual composition of much of the hut's footing, and of the pass itself: a mix of compacted

Quarried on site, and etched with the year of construction, this is one of many of the preserved stones from the hut's outer walls.
Photo: Pete Hoang

The Abbot Pass Refuge Cabin should still be standing, the snowmelt from its shake roof still flowing to both the Pacific and Atlantic oceans.

scree and fallen rock, made stable by permafrost. Against the ordinances of nature — increasingly varied, and erratic — the slope is falling away.

The short timeline of the slope's demise is breathtaking. The first report of the slope's instability reached Parks Canada in 2016. A geotechnical assessment followed, and the hut was closed so that Parks Canada could install slope-stabilizing rock anchors. By the end of 2018, remediation costs had exceeded $600,000. Poor weather and safety concerns hindered progress in 2019, health measures due to COVID-19 in 2020 and, through it all, slope erosion beneath the hut continued.

But it was the record high temperatures in 2021 — the infamous "heat dome" — that vanquished what hope remained. The rate of permafrost thaw hastened catastrophically. According to Parks Canada, "approximately 114 cubic meters fell from the slopes under the hut." Structural cracks appeared in the hut's outer masonry. A precipitous gap yawned open beneath the hut's northwest corner.

All mountains erode eventually. Most of the time these changes are incremental and unnoticed. But permafrost and glaciers are the "glue" that holds high mountain slopes together, and when gradual warming and extreme weather events contribute to rapid permafrost thaw and the thinning of glaciers, slope failures can happen very suddenly.

In recent decades, warming temperatures and increased precipitation in western Canada have led to a significant increase in mountain landslides. The latest report from the Intergovernmental Panel on Climate Change concludes, with very high confidence, that 1.5°C warming will further accelerate this trend. Only an immediate reduction in greenhouse gas emissions will curb the most serious consequences for natural systems — and for human infrastructure.

At Abbot Pass, the mean annual temperature has already increased about 1.40 C since the mid-twentieth century, precipitation by over six per cent.

The Swiss guides built their mountain hut in an earlier and more innocent age — one where you could believe that change came slowly to the high alpine. That age is behind us, the demolishment of what was until now a National Historic Site standing witness to the irreparable damage brought about by a rapidly warming planet.

David Hik is a Professor of Biological Sciences at Simon Fraser University and presently Chief Scientist for Polar Canada; Zac Robinson is a historian and Associate Professor at the University of Alberta; and Stephen Slemon is a Professor Emeritus of English Literature at the University of Alberta. The three have collaborated, variously, in mountain-based research and teaching for over twenty years. This essay first appeared in Canadian Geographic magazine Jul/Aug 2022.

Top: The top of the northern slope, just left of the newly constructed hut, in 1922. Photo: Courtesy of the Whyte Museum of the Canadian Rockies, V200-PA-81B

Bottom: The exposed, steep and unstable north slope cutting away underneath the Abbot Pass Hut in 2021. Photo: Parks Canada

1. *Ferrying building materials up from Lake Louise to the base of the Death Trap in 1922. Abbot Pass is the snowy saddle visible in the picture's top right. Photo: Courtesy of the Whyte Museum of the Canadian Rockies (WMCR), M93/V200 PA 68b*
2. *Carrying loads of building material up through the Death Trap to Abbot Pass in 1922. Photo: WMCR M93/V200 PA 72a*
3. *Building the Abbot Pass Hut's foundation with stones quarried on site in 1922. Photo: WMCR M93/V200 PA 78*
4. *Dismantling the roof piece-by-piece before bundles were flown out during unpredictable weather. Photo: Pete Hoang*
5. *Once the main structure was dismantled, the grouting was removed. Photo: Pete Hoang*
6. *A scar of what used to be during the final days of dismantling. Photo: Pete Hoang*
7. *Two walls were partially left intact as a memorial to the building for future visitors. Photo: Pete Hoang*

Accelerated Change in the Glaciated Environments of Western Canada

Figure 1: Mineral exploration camp in northwestern British Columbia. Photo: A. Bevington

Alexandre Bevington and Brian Menounos

Worldwide, glaciers are thinning at accelerating rates.[1] In western Canada, glaciers represent a vital natural freshwater resource that is currently threatened by climate change. The 15,000 or so glaciers of western Canada were last inventoried in 2005, rendering our maps out of date and obsolete. In this article, we summarize recently published research that updates maps of western Canadian glaciers using new automated mapping tools.[2]

Understanding trends in glacier change is important as glaciers have widespread impacts on downstream environments. For example, glaciers impact sea level rise, they moderate stream temperatures, and they provide meltwater for hydroelectric power generation in late summer when runoff from snow is low and power demand is high.

Figure 2: Glacier road over the Knipple Glacier in northwest British Columbia that leads to the Brucejack Mine. Photo: A. Bevington

Ongoing glacier retreat can also elevate the likelihood of landslides in some mountain catchments, as detailed in Brent Ward's contribution to the ACC's 2020 *State of the Mountains Report*.[3] Glacier retreat also exposes previously hidden geology that is of great interest to mineral exploration companies.

Most glaciers in western Canada are nourished by winter snowfall and undergo melt during summer. When summed over a year, these inputs and losses determine whether a glacier is gaining or losing mass. The duration and depth of winter snow cover has decreased in the last several decades, and summers – particularly recently – have been getting longer and hotter, with clear links to human impacts on climate.

When mountain glaciers retreat, remaining ice occupies higher elevations in steep north-facing locations where local meteorological factors (shade, loading of snow by wind or avalanches) favour their presence. Deglaciation also exposes terrain susceptible to rapid change, including the growth of alpine plants and shrubs, formation of new lakes, and slope instability.

To update glacier maps, the traditional method of tracing over aerial or satellite images is out of date. These days, with tens of thousands of satellite images at our disposal, we are developing automated methods to monitor our changing glaciers. Remote sensing technologies for glacier monitoring were well summarized in the 2021 *State of the Mountains Report* for the curious reader.[4]

The Landsat Program, perhaps the most well-known earth observation platform, has been systematically acquiring images of our glaciers since the mid-1980s. These images provide a rich archive that allows us to detail how each glacier in western Canada changed over the last forty years. Landsat records visible and infrared wavelengths are used in automatic mapping methods. Nearly two decades ago, the United States Geological Survey made the entire archive of Landsat images freely available to all. These open datasets change the way scientists can document environmental change over time.

Google Earth Engine, a free online tool for satellite data processing, has become a household name in the scientific community.[5] The tool allows for the processing of enormous amounts of satellite data by anyone, including Landsat images. Earth Engine helped us map the glaciers of western Canada using over 12,000 Landsat images. To purchase this amount of Landsat data before the open data policy came into effect would have cost about sixty million dollars.

The last systematic inventory of glaciers in western Canada was completed in a 2010 study, led by Tobias Bolch, using Landsat images from 2005.[6] That study found that western Canada was losing about 166 square-kilometres of ice per year since 1985, and lost about 300 glaciers over that period.

In our recently published research,[7] we remap the same glaciers as Bolch *et al* using a fully automated method from 1984 to 2020. Unlike the previous study, our results yield annual changes in each glacier. The technique also allows us to detail trends in glacier area change and a notable acceleration of area loss since about 2011. We have since then added the glacier outlines for 2021 to the database.[8]

Western Canada lost 340 square-kilometres of glacier ice per year since 2011, which is seven times faster than rates of area loss for the period 1984-2010. In some areas, the acceleration is much greater. The few glaciers that remain on Vancouver Island, for example, saw a 32-fold acceleration in glacier area loss in our study. We report errors of about five per cent on the automated glacier outlines.[9]

We also found that glaciers are fragmenting into smaller pieces over time, which provides more surface area for melt to occur and likely contributes to the accelerated loss. Proglacial lake area growth accelerated from ten square-kilometres per year to fifty square-kilometres per year in the region. These lakes are important to map and understand as they represent not only an important water storage factor in the water cycle, but they also represent a hazard for downstream communities.

Any spaceborne glacier mapping program needs to identify a lower threshold for contiguous snow and ice-covered pixels to be mapped as a glacier. In our work, we set a lower limit of detectability to 0.05 km2 (or about four city blocks). We found that 1,141 glaciers fell below our detection limit and ultimately disappeared from our database, representing a loss of eight per cent.

Our study is accompanied by mixed emotions. On the one hand, we are in awe of these spectacular landscapes, and we are grateful for their presence on the landscape. While on the other hand, we are documenting their last moments. Most of our southern glaciers will be lost by the end of this century, which will fundamentally change the character of our mountains and how we travel through them. This deglaciation will also have widespread impacts on downstream communities, fish and wildlife, hydroelectric power, freshwater availability, and more. Policies are required to dramatically reduce our impact on climate to ensure that at least the larger glaciers can survive.

Alex Bevington is a PhD candidate at the University of Northern British Columbia and a Research Hydrologist with the Ministry of Forests of British Columbia. Alex has spent a lot of time on glaciers for both work and pleasure and is interested in

Any spaceborne glacier mapping program needs to identify a lower threshold for contiguous snow and ice-covered pixels to be mapped as a glacier.

Figure 3: Knipple Glacier in northwest British Columbia. The glacier has a 12-kilometre road on it that allows for access to the Brucejack Mine. The dark horizontal streak through the glacier is the glacier road. Photo: A. Bevington

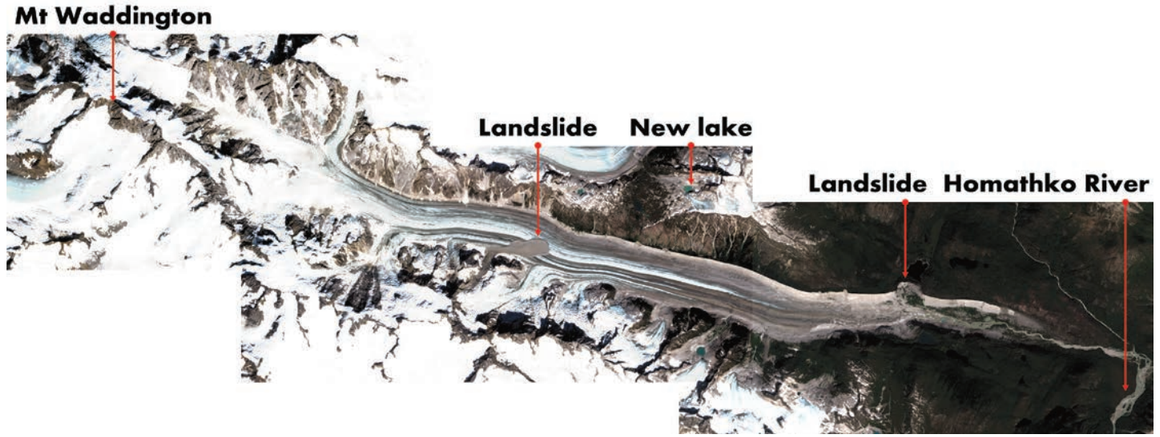
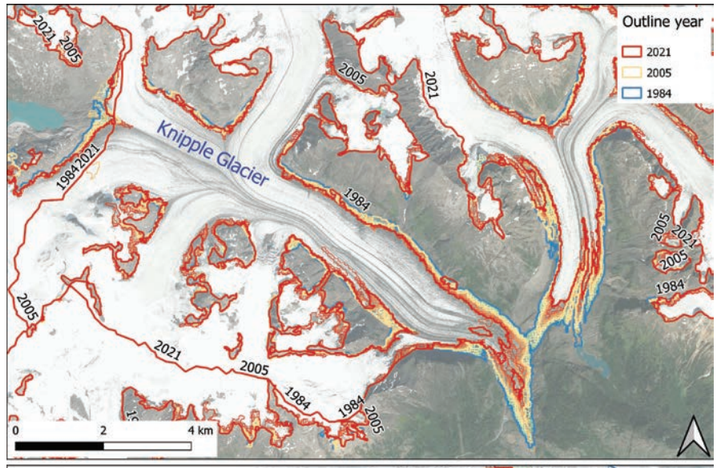


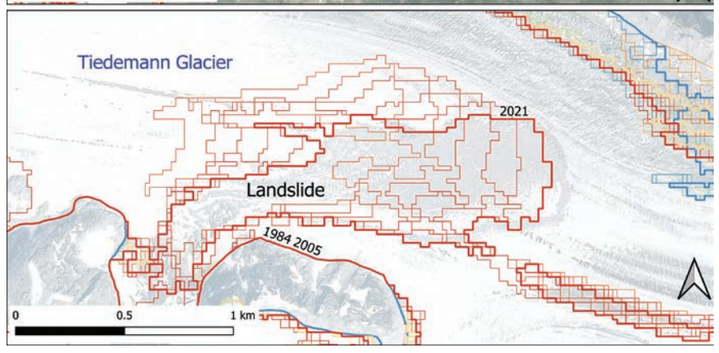
Figure 4: Mt Waddington and the Tiedemann Glacier as seen from space. Notable landslides and new lakes are labelled, as is the Homathko River, which drains into Bute Inlet.

Figure 5: Examples of our automated glacier inventory for the Knipple Glacier and Tiedemann Glacier. The landslide on Tiedemann is slowly being transported downhill as the glacier flows over time.

improving our understanding of how the mountain cryosphere impacts downstream environments.

Brian Menounos is a Professor of Earth Science and the Canada Research Chair in Glacier Change at the University of Northern British Columbia. In 1987, he fell in love with mountains during an exchange year in Germany and has been studying them ever since. Brian is a Hakai Affiliate and Chief Scientist of the Airborne Coastal Observatory.





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8 Glacier polygons available here: https://zenodo.org/record/5900363#.YpkbDqAieUk

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A New Mount Logan Ice Core

Alison Criscitiello

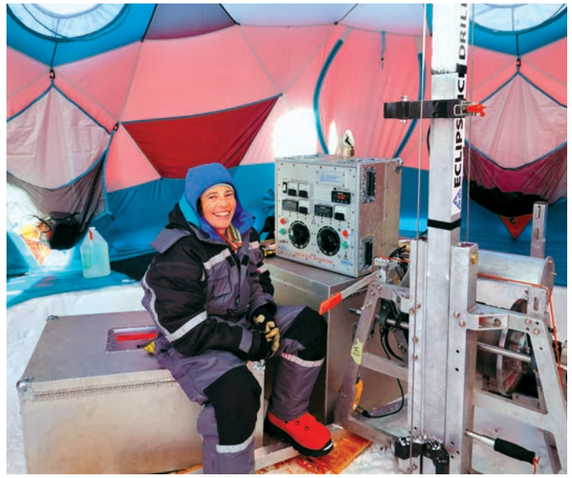
The author on her way to Prospector's Col from the team's Camp 3 high on the King Trench Route.
Photo: Rebecca Haspel

In the spring of 2022, after four protracted years of planning, multiple head-spinning pandemic-induced delays, and a successful-but-hasty reconnaissance in 2021, we drilled and retrieved a 327-metre deep ice core from Mount Logan's brutal summit plateau. The highs were high (a record-breaking high-altitude ice core offering tens of thousands of years' worth of climate insights) and the lows were devastating (only half of our starting team made it to the end). It took eleven days of drilling at high-altitude, fourteen hours-a-day, with near-impossible logistics to accomplish our goal. But let's start at the beginning.

Drilling an ice core on Logan's summit plateau required climbing the mountain first so the drilling team was safely acclimatized to live and work above 5,300 metres at high latitudes. We flew into base camp on May 2 and climbed the King Trench Route to access the summit plateau in ten days. Due to its high northern latitude, Logan's altitude is heavily felt by the body. We double-carried our way up the mountain, climbing every section twice, and finding the same crux as we did the previous year – the King Col Icefall. The icefall, which has historically been a fairly straight-forward ski, has in recent years become an exposed and mobile maze of seracs.[1] We carefully picked our way through it twice (once on our carry to Camp 3, and then on our move-up the following day), only to say good riddance weeks later on the final ski descent. On May 15, after a night of >80km/hr winds at our Camp 3 below Prospector's Col, we skied up and over the high saddle to our summit plateau High Camp.

Climbing Logan is no small effort, but in this case arriving on the summit plateau was the true beginning. Though we had completed a radar survey the previous May on the plateau allowing us to locate the ideal drill site, we did a final radar survey on May 18 this year to narrow down on the final drilling location. The drill itself – a Canadian

Climbing Logan is no small effort, but in this case arriving on the summit plateau was the true beginning.



Top: The author drilling with the Canadian Eclipse drill on Logan's summit plateau. Photo: Rebecca Haspel

Middle: An "after" shot of the 2022 National Geographic and Rolex Perpetual Planet Mount Logan Expedition members near Kluane Lake. Left to right: Dominic Winski, Etienne Gros, Steve Andrews (film crew), Rebecca Haspel, Alison Criscitiello, Greg Hill (film crew support), Bradley Markle, Leo Hoorn (film crew). Photo: Kristina Miller

Bottom: Rebecca Haspel and Alison Criscitiello happy atop Prospector's Col after replacing the wind sensor on North America's highest weather station. Photo: Leo Hoorn

Eclipse drill – and all other ice coring equipment and supplies, was heli-slung up to the plateau in 300-pound loads by a pilot on oxygen. In one day, we had set up the drill and camp, and the race to the bottom was on. On Day 1, we drilled sixty metres of ice, but as work progressed, that daily rate would decrease due to the increased travel time of the drill – up and down – in the borehole. By Day 11, for instance, we only drilled twenty-three metres. While one team member had to descend during the climb up, two others had to descend while working up on the summit plateau – all related to the altitude's toll on the body.

Other than three distinct volcanic layers, the cores came up one after the other, day after day, ad nauseum. We settled on a shift schedule that allowed us to keep the drill running fourteen hours a day, while also allowing us all to get some rest during the day as we slowly deteriorated living and working that high. We drilled the core without drilling fluid (unusual for cores deeper than ~100 metres), and I feared that we might pay a cost in the core's quality at depth. That fear surprisingly remained unfounded, as even the deepest ice when pulled up to the surface was not very fractured. On May 30, we drilled our last metre of core to 327 metres, and immediately started packing up the drill and drill camp. Now, the race was on to get down as quickly as possible, down to oxygen and warmth.

We had taken advantage of all good weather windows while up on the summit plateau, flying ice off at every occasion when several loads staged. As a result, the day after we drilled our final meter of ice core, we were able to fly the last of it off the plateau, and ski ourselves all the way to base camp – luckily flying out that very evening. The slow day-in day-out monotony had suddenly revved to a sprint.

After being heli-slung off the plateau, the ice was flown directly to a freezer sea-can staged at Silver City, the landing strip in Kluane National Park and Reserve used for most flying into the St. Elias and the Icefield Ranges. The freezer unit sat there for the duration of our time on the plateau receiving ice loads, with spare parts to every component of the precious freezer and a technician on-site. When the last load reached the freezer sea-can, it was trucked south to the Canadian Ice Core Lab (CICL) in Edmonton, Alberta, nearly beating me back home. With the ice safely here at CICL, and a whole lot of processing and analyzing ahead, there are many more questions than answers for now about what discoveries are contained within the ice, and how long this record actually is.

There are non-scientific questions, too, that I've found myself pondering – questions that the ice, in an indirect way, has already answered. What keeps us going when our bodies want to stop suffering and get down low? When our team is reduced to half by the brutal reality of being too long too high? What keeps us working hard in thin air for a common cause that, over time, seems impossible? It's the people we surround ourselves with, and a dream that's bigger than all of us.

Alison Criscitiello is an ice core scientist and high-altitude mountaineer. She is Director of the Canadian Ice Core Lab (CICL) at the University of Alberta. The National Geographic and Rolex Perpetual Planet Mount Logan Expedition comprised of Alison Criscitiello, Rebecca Haspel, Etienne Gros, Dominic Winski, Bradley Markle, Seth Campbell, and Kirk Mauthner.

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Participants and staff at the ACC's 2021 Mount Mummery General Mountaineering Camp. Photo: Mary Sanseverino

Glacier fresh: Surface runoff on the Mummery Glacier, 2021.
Photo: Mary Sanseverino

The State of the Mountains Report

Canada's diverse mountains define much of the country. Mountains provide critical natural and economic resources like water, biodiversity, forests and recreational opportunities. They're also home for many people living in small and remote communities. But both local and global changes influence these places in ways that are still not well understood. The ACC's State of the Mountains Report is a contribution to compiling and sharing the best available knowledge about Canada's mountains, from coast to coast to coast.

www.stateofthemountains.ca

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