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A Yukon wolf stares down the barrel of a camera. The species has lived across this part of the North for as long as 47,000 years, today numbering around 5,000 in the territory.

COVER: NICOLAS DORY, THIS PAGE: COURTESY AUSTRALIAN NATIONAL UNIVERSITY

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BISON BREAKTHROUGH

Watch a video explaining how the Toronto Zoo is using revolutionary techniques to breed wild wood bison.

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COASTAL CARETAKERS

After a disastrous oil spill in 2016 and a near miss in 2017, members of British Columbia's Heiltsuk Nation say more needs to be done to protect coastal waters. Read about their proposal for an Indigenous Marine Response Centre.

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FUTURE FOOD

Insects have been hailed as the food of the future, and for good reason. Read about a Canadian startup that is trying to make cricket-based foods a household staple — and watch *Can Geo* staff try its products.

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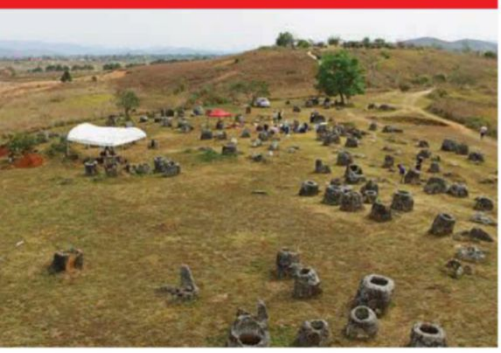

DOUGALD O'REILLY

Now you know

ADMITTEDLY, the statement came with a question mark, but it really caught my attention: "Canada's Indiana Jones?"

That's how writer Bonnie Munday suggested the exploits of Canadian archeologist Dougald O'Reilly could be portrayed in her story pitch. Of course, O'Reilly's never had to run from huge rolling boulder booby-traps or swung across canyons on a whip — at least, I don't think so — but he does lead a somewhat Indiana Jones-esque life (see Munday's feature story on page 46).

His work has taken him to remote parts of war-torn Cambodia and more recently to neighbouring Laos. While the seemingly dangerous aspects of O'Reilly's livelihood captured my imagination, the real draw in Munday's proposal was that a Canadian was the lead archeologist on Laos' Plain of Jars (ABOVE), a megalithic landscape dotted with hundreds of stone "jars," the origins and purposes of which are still being uncovered.

Sharing stories such as this is at the core of what *Canadian Geographic* does best. Prior to Munday's story proposal on the topic, I'd never heard of O'Reilly or the Plain of Jars. I'm betting until you read this, you hadn't either. But Canadians should know both O'Reilly and the amazing work he's doing to help reveal the history and culture of another part of the world. It's just another aspect of our nation we can all take great pride in.

—Aaron Kylie

To comment, please visit cangeo.ca or email editor@canadiangeographic.ca.

For inside details on the magazine and other news, follow editor Aaron Kylie on Twitter (@aaronkylie).

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(416) 360-4151 ext. 380
halldaigle@canadiangeographic.ca

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EDITORIAL OFFICE
1155 Lola Street, Suite 200, Ottawa, ON K1K 4C1
(613) 745-4629 Fax: (613) 744-0947 canadiangeographic.ca

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Lifetime experience #8

'Being in Antarctica is like being on another planet that's just all nature.'

I've done more than 70 expeditions to Antarctica, and people always ask me why I keep returning. There isn't one specific thing that pulls me back, because I've come to realize that every time I go, something different is going to happen. You leave without any idea of what that could be — seeing an amazing iceberg, having an encounter with an elephant seal, getting a glimpse of an emperor penguin — and it's that sense of going into the unknown that makes the whole experience so worthwhile.

I say "unknown" because being in Antarctica is like being on another planet that's just all nature. When you're there, it's as if creation happened and then everything just stopped. And because internet access is limited, you're almost totally cut off, which forces you to be in the moment and connect with nature. As a photographer on these journeys, I work long days, which is physically demanding, but spiritually, my mind gets so much energy from the experience.

One of the great things about One Ocean is that they always include space for scientists and researchers onboard. As a member of the International League of Conservation Photographers, that's important to me. My main goal is to enhance the experience of the guests, of course, but it's also a chance to create ambassadors for conservation. Yes, I can help you take better pictures, but then you go out and show the world what we have in Antarctica and what we risk losing if we don't protect it.

— Daisy Gilardini
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ROSE PINK/CAN GEO

PHOTO BY STEPHEN WILKES

A day of activity — including whales breaching, cruise ships and fishing boats passing, and eagles soaring — in Robson Bight along the northeast coast of British Columbia's Vancouver Island, as captured by the renowned photographer of the *Day to Night* series. Working with the Cetus Research & Conservation Society, a local conservation group, Wilkes created this image of the ecologically important area by combining hundreds of photos taken during a 26-hour period in August 2016.

Read more about the work of the Cetus Research & Conservation Society and how this image was captured at cangeo.ca/ma18/robson.

big picture

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PHOTO BY DAVID HO

Two Atlantic puffins perch on the edge of cliffs near the town of Elliston, N.L. Though numerous seabirds make their home on these seaside precipices, Elliston has made a point of promoting itself as one of the best places in North America to see the distinctive birds, which usually return to the area in May to make their burrows and nest.

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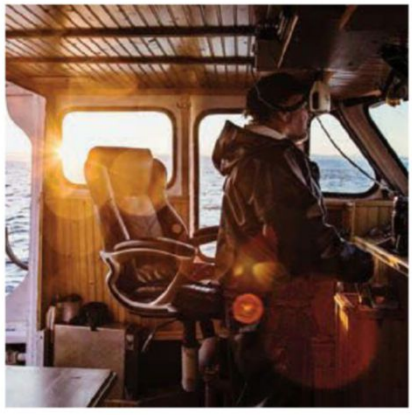
@discover_churchill **Alex de Vries-Magnifico**
Polar bears on ice, Churchill, Man.

@brandonbroderick **Brandon Broderick**
Great grey owl near Terrace, B.C.



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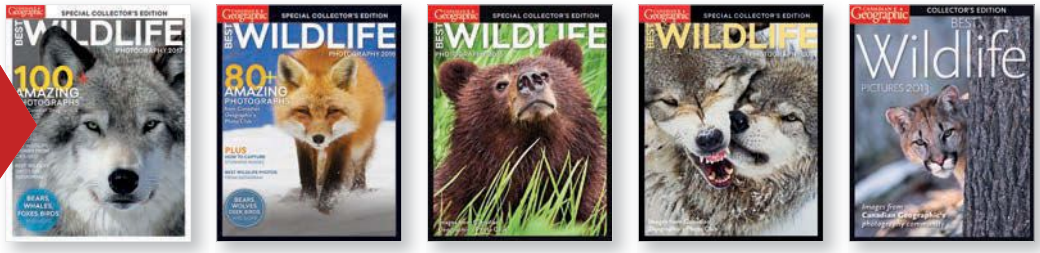

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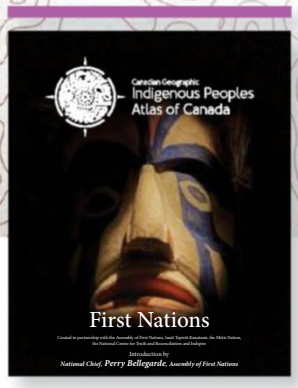
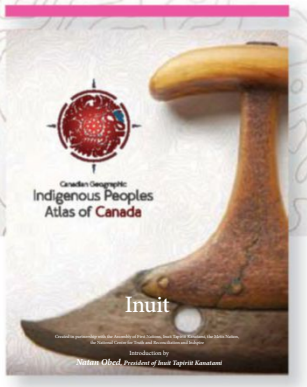
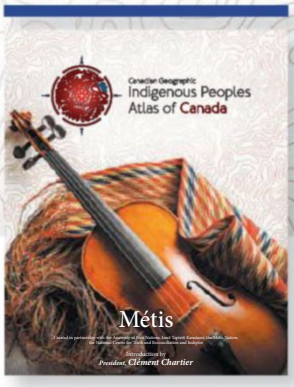
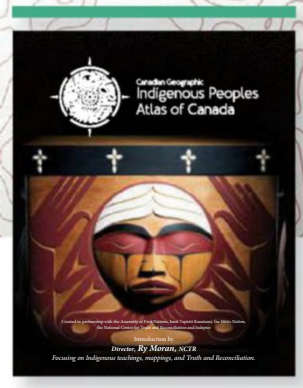
Indigenous Peoples Atlas of Canada









The Royal Canadian Geographical Society is honoured to present the *Indigenous Peoples Atlas of Canada*, a groundbreaking and ambitious new educational resource. This four-book set shares the stories, perspectives and history of the Indigenous Peoples of Canada. The RCGS has partnered with the Assembly of First Nations, Inuit Tapiriit Kanatami, the Métis National Council, the National Centre for Truth and Reconciliation and Indspire to ensure that Indigenous voices are heard and understood. This collection of unique maps and rich narratives offers an opportunity for Canadian classrooms to take an important step on the road to reconciliation.

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Indspire

Dr. Mona Nemer

The nation's new chief science advisor on creating a new science strategy and Canada's potential as a world leader

Science infrastructure, funding and attracting talent are among the things Dr. Mona Nemer will focus on in her new role.

IVY FORTIN (INNOVATION, SCIENCE AND ECONOMIC DEVELOPMENT CANADA)

INTERVIEW BY MICHELA ROSANO

For the first time in nearly a decade, the federal government has appointed a chief science advisor to help support state science, make it available to the public and ensure scientists have a seat at the table when Canada makes important decisions. Dr. Mona Nemer, who is a cardiovascular scientist and the director of the Molecular Genetics and Cardiac Regeneration Laboratory at the University of Ottawa, was named to the position in September 2017, and reports to the prime minister and Kirsty Duncan, the minister of science. Now, a few months into her new role, Nemer discusses some of her priorities and how Canadian science can do better.

On identifying top priorities

We're looking at artificial intelligence and its applications to various sectors, particularly at the intersection of technology and society, as well as its legal and ethical aspects. Clearly, the broad topics of environmental sustainability, clean technology and the Arctic are priorities. I think there's a need for continued Canadian leadership on these fronts, so we must articulate a science and research plan for them over the next few years.

On scientists speaking freely about their work

The government has committed to collaborating with scientists to develop guidelines for communicating with the public about research. I'll be a part of this process. We'll start by looking at what's happening in each department to really understand some of the baselines that need to be put in place. I'm quite hopeful that we're going to make gains on that front and that we'll be able to put together a framework where everyone feels comfortable doing science and speaking about science.

On major science infrastructure

One of the things I'm hoping we'll be able to move on soon is how we manage our large science infrastructure. These are unique facilities that service groups of researchers, who may or may not be physically located there. The Polar Environment Atmospheric Research Laboratory on Ellesmere Island is a good example of a facility that's accessible to researchers from all over the country. Sudbury's SNOLAB is another. We can't have a crisis every few years because major science infrastructure somewhere has run out of funds. We need a strategy, a more systematic approach to these facilities: who pays for them, how we fund them, how often we

review them and how they are governed are all issues of critical importance if we want to maintain our ability to innovate and to do leading-edge science. Even getting a definition of what constitutes a major science facility is something many scientists would find quite helpful.

On criticism of the federal government's funding of science

I have spent many years as a practising scientist, so I understand funding. Canada's Fundamental Science Review [*A comprehensive 2017 report on federal support for fundamental science. —Ed.*] has numerous dimensions, and some items were suggested to be included in my work plan. We need to fund the entire spectrum of research. That starts with basic research, not only for the potential of a discovery, but also for the training it offers to talent. I like to say we "learn by doing," and the best way for a scientist to learn is by conducting research at basic research labs. It's one of the best internships that scientists can have to prepare them for the job market.

Dr. Nemer (right) with a student at the University of Ottawa's Molecular Genetics and Cardiac Regeneration Laboratory.

I think that once we've properly funded basic research, there's nothing wrong with reaping the benefits of studying fields such as stem cell research and artificial intelligence, which are currently well funded. And I think it's perfectly appropriate to continue funding them because they involve multiple fields coming together to better society. There's nothing wrong with making sure that we have the mechanisms and funding schemes to allow this to happen in Canada.

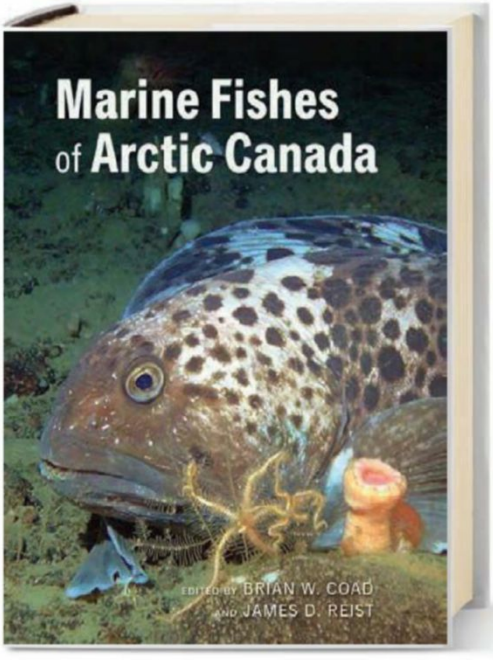
On one of the biggest challenges facing science in Canada

Attracting talent is critical. When I was running my research lab, the most important and time-consuming thing was actually getting talent. Getting the best graduate students, the best technicians, the best collaborators. Of course, you need money to pay them, but money is not the end of things. We have to make sure we keep portraying Canada as a highly competitive and desirable place to come and study, conduct research and innovate, to start innovative companies and so on. Perception is extremely important, but so is reality, because if people come here and are disappointed, then we lose both our credibility and our reputation. "Good" is not good enough. We can be excellent and we should be leaders.

Read an interview with Dr. Molly Shoichet, who was appointed Ontario's first chief scientist in 2017, at cangeo.ca/ma18/shoichet.

DAVE WEATHERALL (UNIVERSITY OF OTTAWA)

Discover the Mysteries of the Deep



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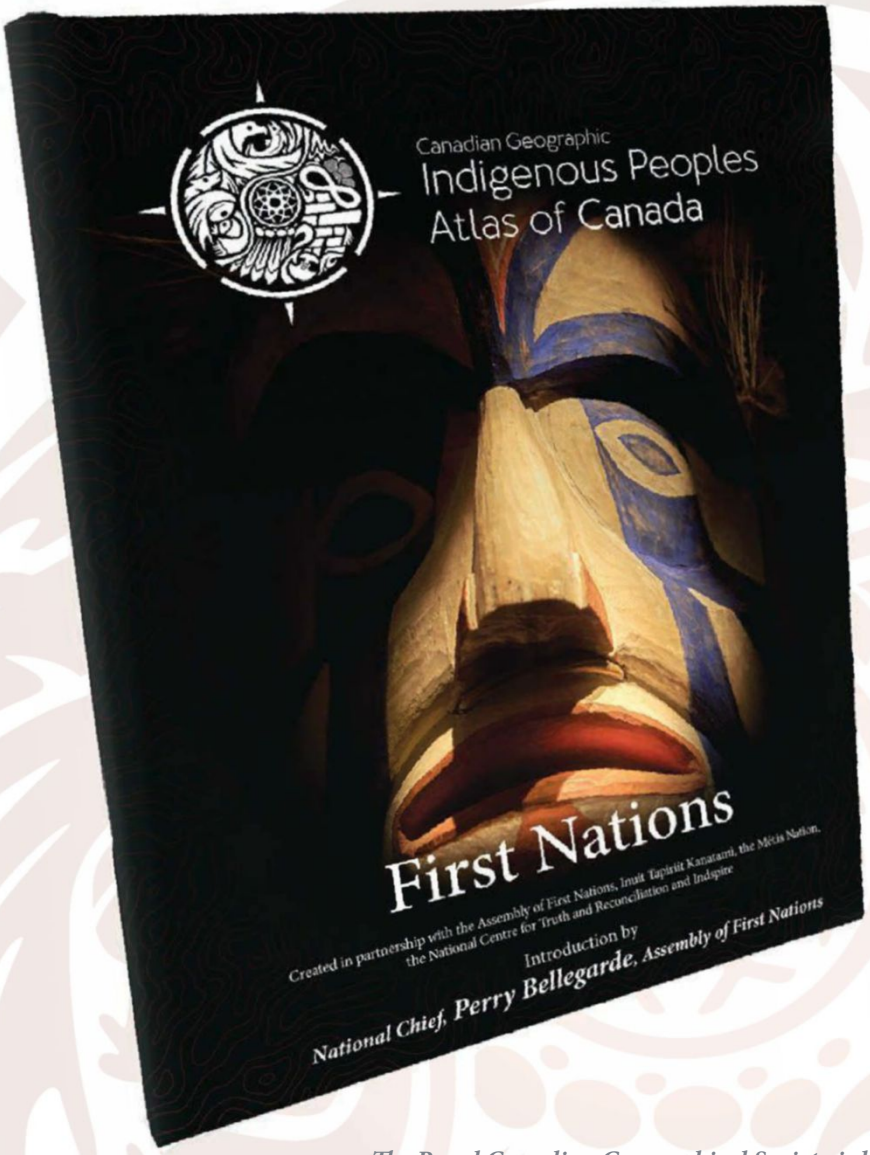

The Royal Canadian Geographical Society is honoured to present this volume as part of a four-book set, sharing the stories, perspectives and history of the Indigenous Peoples of Canada.

> This atlas brings together voices from First Nations, Métis, and Inuit communities, representing the diversity of intellect and profundity of tragedy, comedy and triumph in Indigenous communities from Tkaronto to Tuktoyaktuk and Victoria to Val-d'Or.

— **JULIAN BRAVE NOISECAT,**
Member of the Canim Lake Band Tsq'escen and an award-winning writer

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Inuit Tapiriit Kanatami

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EPIC EXFOLIATION

Canadian scientists have found evidence that bowhead whales in Cumberland Sound, Nunavut, shed their dead skin by rubbing against large rocks. Researchers with the University of British Columbia's Marine Mammal Research Unit who saw the whales engage in the previously undocumented behaviour said that it appears to help the mammals slough off dead skin, along with any accumulated micro-algae and parasites, which in turn may help maintain a healthy appearance and improve skin function by stimulating the growth of new tissue.

Protarctos abstrusus

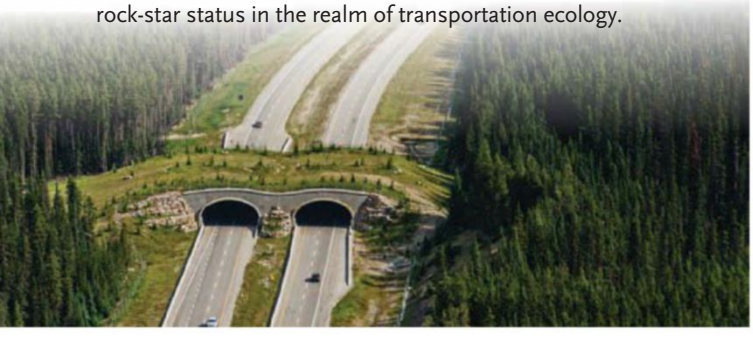
The name of a 3.5-million-year-old species of bear whose fossilized cavity-ridden teeth have prompted scientists to suggest that bears have long adapted to life in cold climates by eating plenty of sugar. Researchers from the Canadian Museum of Nature and the Natural History Museum of Los Angeles County unearthed the fossils in the Canadian High Arctic and theorize that much like its modern-day cousin, the American black bear, *Protarctos abstrusus* probably filled up on berries in the fall to pack on body fat for hibernation.

'This is **definitely** a **good news** story.'

Marcel Gahbauer, co-chair of the Committee on the Status of Endangered Wildlife in Canada's birds specialist subcommittee, reacts after the committee announced that the peregrine falcon is no longer at risk of extinction throughout most of Canada. The bird has been on the endangered species list since 1978 and could be removed from it if the federal government acts on the committee's recommendation.

80%

The amount by which vehicle collisions with wildlife in Banff National Park have been reduced in the 20 years since the first wildlife overpass was built there. Scientists have come from around the world to learn how to adapt and implement similar crossings in their own countries over the past two decades, buoying Banff biologists to rock-star status in the realm of transportation ecology.

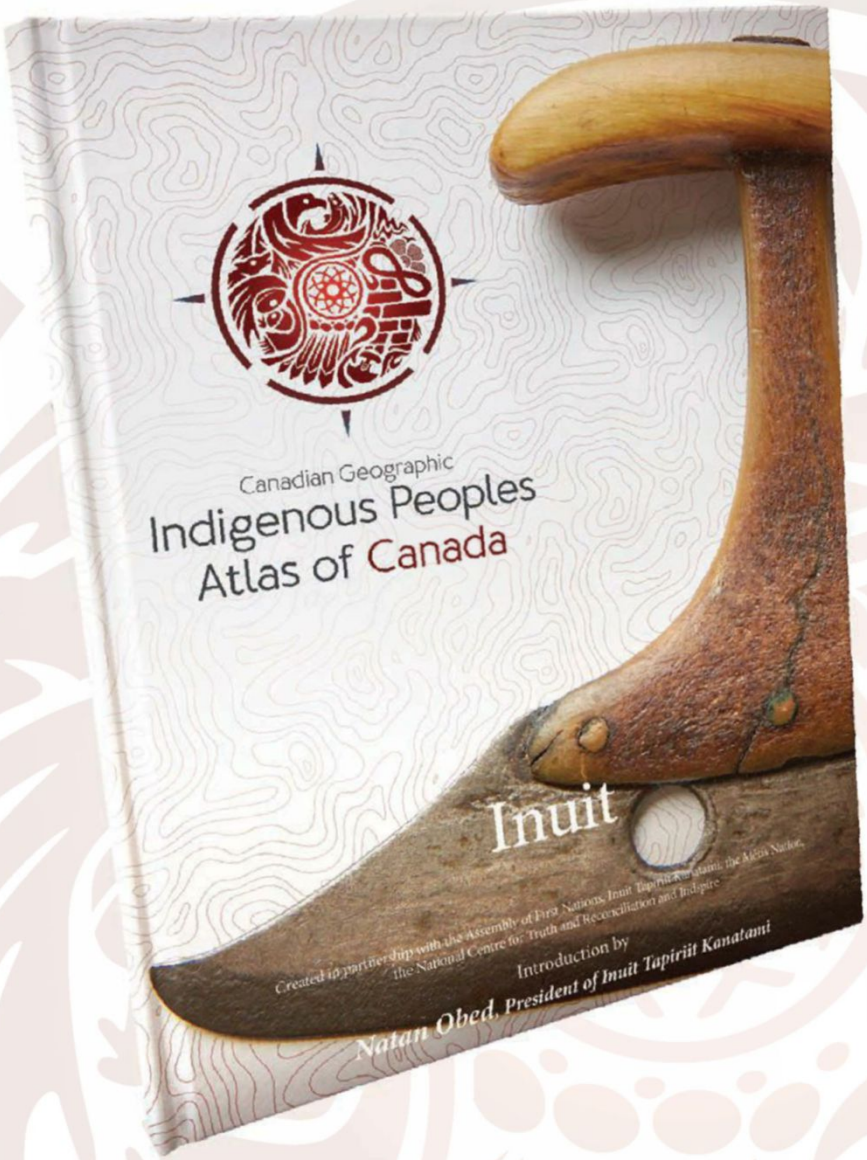


'Tuna have been completely off our radar. We are wired to think of them only as **food**, not **extraordinary wildlife.**'

Canadian filmmaker John Hopkins on the plight of the bluefin tuna, the subject of his recently released documentary film *Bluefin*. Scientists estimate that the number of bluefin tuna has been reduced by as much as 90 per cent oceanwide, largely due to overfishing and declining forage fish stocks.

Read the latest wildlife stories at cangeo.ca/topic/wildlife

CLOCKWISE FROM TOP: VDOS GLOBAL LLC; CHRISTINA ANNE MCCALLUM/CAN GEO PHOTO CLUB; PARKS CANADA; MAURICIO ANTÓN



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> *Nunannguaq* is the Inuit word for map. It means "representation of land." Like other peoples around the world, we have always carried maps in our minds.

— **MICHAEL KUSUGAK,**
Acclaimed children's author and Inuit storyteller

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Indspire

Arctic outposts

How the Joint Arctic Weather Stations program did more than just fill in a blank on the nation's weather map

*By Harry Wilson**

IN ADDITION to possessing thorough technical knowledge of meteorological equipment, applicants must be comfortable with long periods of isolation and cold, and be prepared to live and work in close quarters with a small group of colleagues for a year or more at a time.

OK, so this is an imaginary version of what was required of personnel at the five Joint Arctic Weather Stations active across the Canadian High Arctic from 1947 to 1972, but its take-heed tone about the physical and mental hardships of life in the North probably isn't far off the mark. After all, staffing the stations was serious business for the Canadian and American officials who initiated the project.

They did so to redress an imbalance that for years had left the region covered by Canada's Arctic islands appear as a large blank area on weather maps, as R.W. Rae noted in his story on the stations in a 1951 issue of *Arctic*, the journal of the Arctic Institute of North America. "The need for weather reports from this blind spot was recognized, but the difficulty and expense involved in the establishment and maintenance of communities in these inaccessible regions were prohibitive."

But the Second World War and its aftermath made the Arctic relevant for world powers, and soon after the war ended, the first station was established at Eureka on Ellesmere Island. (The picture above shows Galen Olsen, a station staffer, outside Eureka International Airport in the mid-1950s.) By April 1950, four more stations — Resolute on Cornwallis Island, Isachsen on Ellef Ringnes Island, Mould Bay on Prince Patrick Island and Alert on Ellesmere Island — were operational.

Maps such as the one above, which depicts the Eureka station, part of the east coast of Axel Heiberg Island and part of the west coast of Ellesmere Island, show the region that each station's staff gathered data for by making on-the-ground observations and by using weather balloons to measure temperature, barometric pressure, humidity and wind direction.

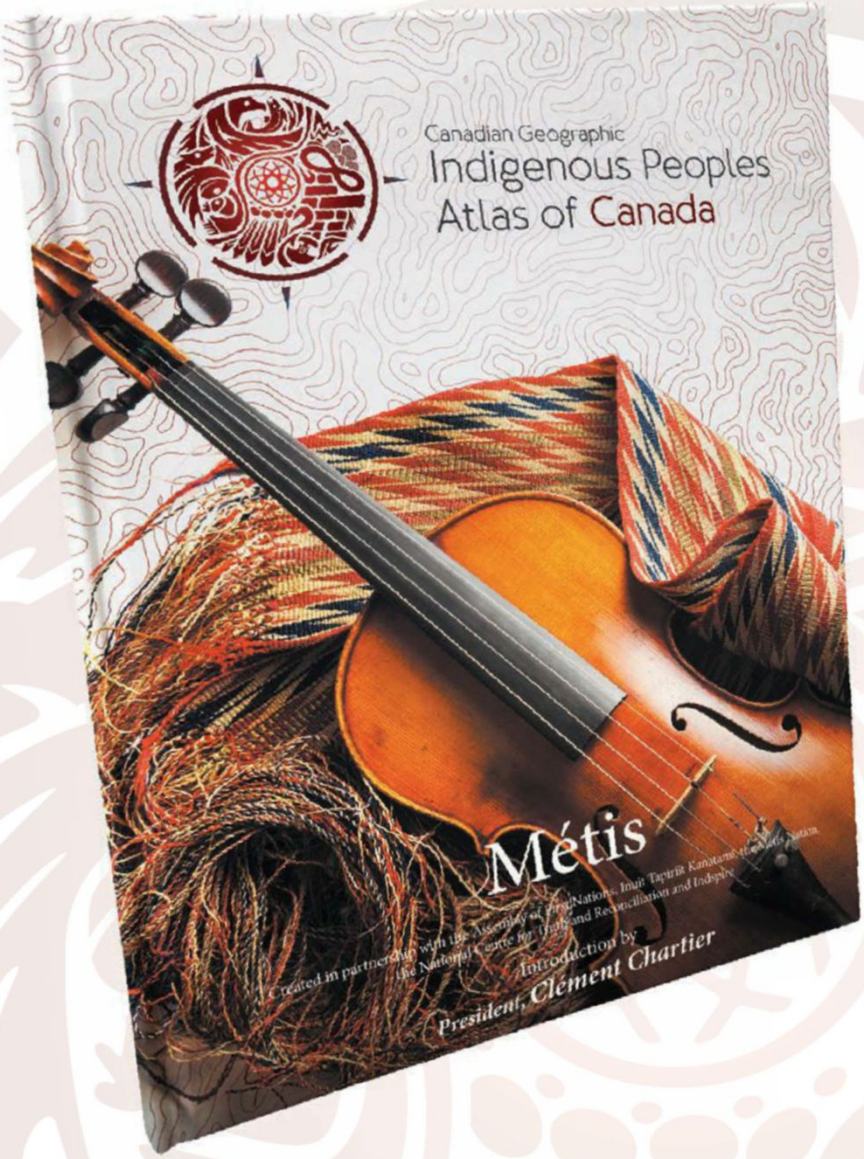
The information was used for more than creating reliable Arctic forecasts, though. "The data these stations gathered," wrote historian Daniel Heidt in a 2015 Network in Canadian History & Environment story about the stations and the "met techs" who worked there, "were crucial to military planning, civilian meteorology, and transatlantic commercial aviation, as well as North America's agriculture and forestry economies."

No pressure, then. It's no wonder, as Rae noted, that great care was "exercised in screening applicants for these posts since one unsuitable individual can disrupt the harmony of the entire station."

**with files from Erika Reinhardt, archivist, Library and Archives Canada*

Read more stories about the maps in Library and Archives Canada's collection at cangeo.ca/topic/map-archive.

MAP: JOINT ARCTIC WEATHER STATIONS, EUREKA, CANADA, EDITION 1, 1970, SURVEYS AND MAPPING BRANCH, DEPARTMENT OF ENERGY, MINES AND RESOURCES, LIBRARY AND ARCHIVES CANADA, E011196844; PHOTO AND EUREKA CREST: COURTESY OF JOHN GILBERT



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> Mapping our spaces, in both contemporary and historical practice, protects Indigenous peoples from imperial erasure.

— **ADAM GAUDRY,**
Métis scholar and professor at the University of Alberta

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Indspire

Golden highway

How Alberta birders-turned-citizen scientists discovered a golden eagle migration route through the Rockies

By Sarah Hewitt

A researcher at Raptor View Research Institute in Montana releases a wing-tagged golden eagle. The tags help spotters easily identify migrating birds.

ON A BRIGHT DAY in early spring, a group of citizen scientists stands in a forest clearing off the Hay Meadow trail in the front range of the Rocky Mountains, about 75 kilometres west of Calgary, binoculars trained skyward. They're scanning for golden eagles, one of the largest raptors in North America. Before long, a speck appears above an unnamed peak. It catches a thermal, circles high and soars overhead as the people below strain to glimpse the band of white across the tail base that differentiates a juvenile from an adult.

In the spring and fall, hundreds of golden eagles stream along the Rockies' eastern ridges on an aerial highway that stretches from Alaska to Mexico. In the Cree lunar calendar, February is known as Eagle Moon, yet scientists didn't know this Alaska-Yukon population of the birds migrated at all until relatively recently.

"It all happened quite accidentally," says Peter Sherrington, an avid birder who for more than two decades has spearheaded a volunteer effort to track the eagles' migration. One March morning in 1992 in Kananaskis Country, Sherrington was watching a pine grosbeak when he saw a golden eagle. Minutes later, two more eagles flew past. By day's end, he'd counted 103 eagles, and over the next four days, the count would rise to 400.

Golden eagles are territorial and have home ranges that can cover as much as 200 square kilometres. They're found throughout the Northern Hemisphere, and the majority of populations studied in Finland and Russia appear to be either year-round residents in their habitat or partial migrants, meaning only the juvenile birds travel far afield. The same was thought about the Alaska-Yukon population. No one suspected they were watching the largest golden eagle migration on the planet. "When you see something that doesn't fit with the known data, you assume it's anomalous, but maybe it's our knowledge that's wrong," Sherrington says.

In the fall of 1992, he began counting eagles in earnest, leaving his oil-industry job to start the non-profit Rocky Mountain Eagle Research Foundation. To date, thousands of volunteers have logged more than 30,000 hours in the field, and recorded sightings of more than 24,000 golden eagles. They've been able to identify not only the migration route along the Rocky Mountain front, but also, working with researchers in Alaska and Montana, a secondary migration corridor farther west through the Rocky Mountain trench.

"This whole thing is just the result of me saying 'This is interesting, I wonder what's happening here,' and then pursuing it," Sherrington says of his citizen science experience. "It's a case of looking up and wondering what's out there."

Read an extended version of this story, including more on how Peter Sherrington's data is helping conserve golden eagles, at cangeo.ca/ma18/eagles.

ROB DOMENECH/RAPTOR VIEW RESEARCH INSTITUTE; MAP: CHRIS BRACKLEY/CAN GEO

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A new way to heat Hinton

Accessing geothermal water via abandoned oil and gas wells

By Sabrina Doyle

Transforming abandoned oil and gas wells in Alberta into the key components of a first-of-its-kind geothermal heating system in Canada might seem like an implausible transformation — but that's exactly what could happen in fewer than two years in Hinton. The town of about 10,000 just outside of Jasper National Park sits atop reservoirs of water that at 140 C and five kilometres below the surface are some of the hottest and deepest in the province. And although it's not uncommon in Canada to use geo-exchange systems (a type of ground-source heat pump) to heat and cool individual buildings, Hinton wants to tap into that thermal energy on a much wider scale by implementing a district geothermal heating system that uses heat recovered from disused oil and gas wells.

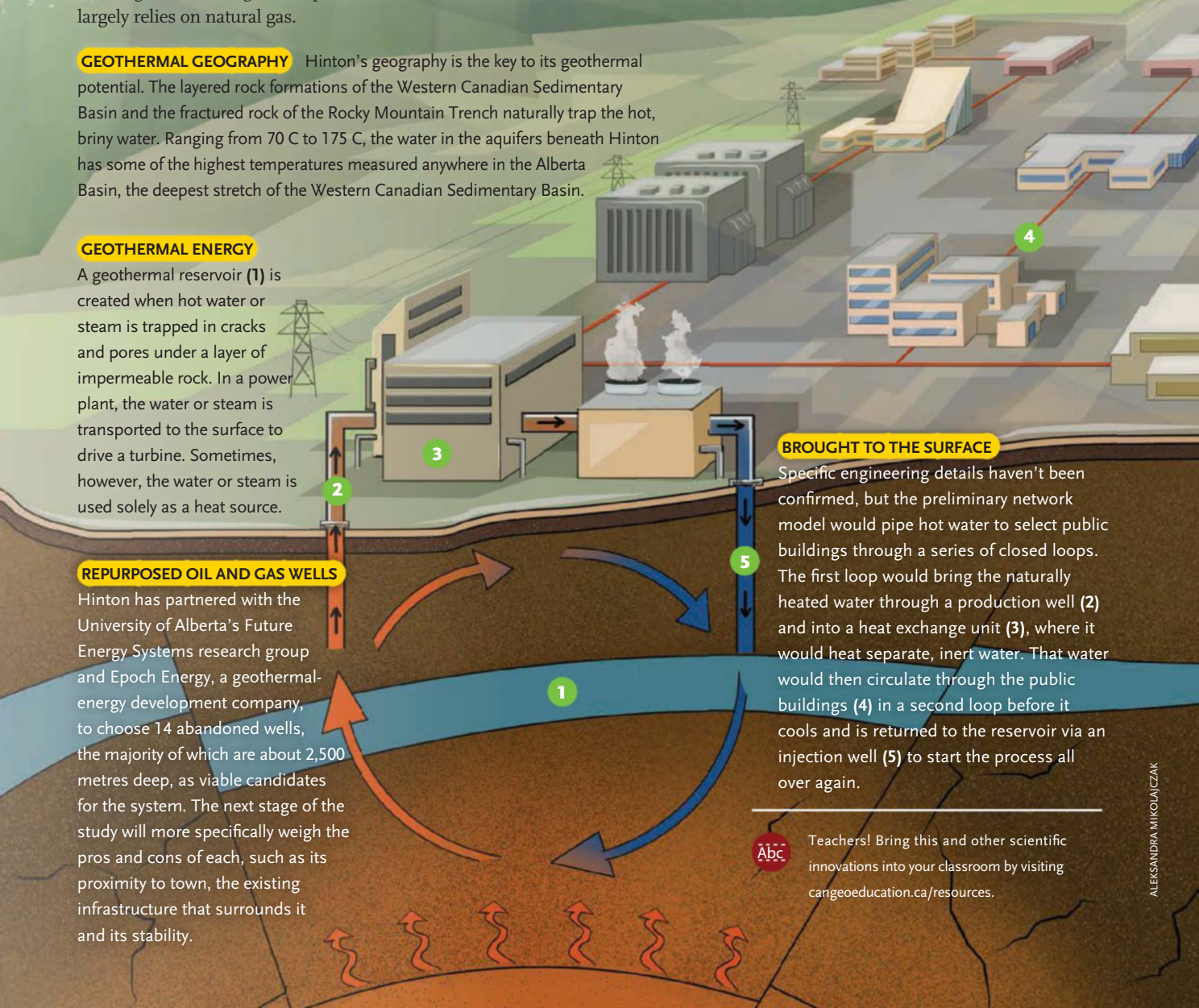
Funding isn't completely in place and regulatory frameworks have yet to be determined, but work could begin by 2019 on the system, which would heat public buildings — including the hospital, the RCMP station and two schools — in a town that largely relies on natural gas.

GEOTHERMAL GEOGRAPHY Hinton's geography is the key to its geothermal potential. The layered rock formations of the Western Canadian Sedimentary Basin and the fractured rock of the Rocky Mountain Trench naturally trap the hot, briny water. Ranging from 70 C to 175 C, the water in the aquifers beneath Hinton has some of the highest temperatures measured anywhere in the Alberta Basin, the deepest stretch of the Western Canadian Sedimentary Basin.

GEOTHERMAL ENERGY
A geothermal reservoir **(1)** is created when hot water or steam is trapped in cracks and pores under a layer of impermeable rock. In a power plant, the water or steam is transported to the surface to drive a turbine. Sometimes, however, the water or steam is used solely as a heat source.

REPURPOSED OIL AND GAS WELLS
Hinton has partnered with the University of Alberta's Future Energy Systems research group and Epoch Energy, a geothermal-energy development company, to choose 14 abandoned wells, the majority of which are about 2,500 metres deep, as viable candidates for the system. The next stage of the study will more specifically weigh the pros and cons of each, such as its proximity to town, the existing infrastructure that surrounds it and its stability.

THE BENEFITS Resurrecting abandoned wells for geothermal use would reduce greenhouse gas emissions and help protect people from the costs associated with an unpredictable energy commodities market. The typical Canadian home uses about 120 gigajoules per year, but Hinton's system could provide between 60,000 and 100,000 gigajoules per year, enough to heat between 500 and 800 homes.



BROUGHT TO THE SURFACE
Specific engineering details haven't been confirmed, but the preliminary network model would pipe hot water to select public buildings through a series of closed loops. The first loop would bring the naturally heated water through a production well **(2)** and into a heat exchange unit **(3)**, where it would heat separate, inert water. That water would then circulate through the public buildings **(4)** in a second loop before it cools and is returned to the reservoir via an injection well **(5)** to start the process all over again.

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Sea change

INUIT HUNTERS AND SCIENTISTS ARE COLLABORATING TO RECORD ALARMING SHIFTS IN HUDSON BAY SEA ICE

BY JOHN BENNETT

Hunters Peter Kattuk (left) and Daniel Qavvik, part of a research collective recording environmental changes on Hudson Bay, search for belugas near Sanikiluaq, Nunavut.

JOEL HEATH/ARCTIC EIDER SOCIETY

INUIT HUNTERS from eastern Hudson Bay are working with scientists to document the changing environment. Keen observers who travel widely on the bay year-round, the hunters first noted unusual changes in the sea ice in the 1970s, when massive hydroelectric projects on Quebec rivers altered the flow of fresh water into James and Hudson bays. By the 1990s, they were sharing observations related to the changing climate. Megan Sheremata, a PhD student in the department of physical and environmental sciences at the University of Toronto Scarborough and recipient of the 2017 Polar Knowledge Canada Scholarship, is helping to document that knowledge.

Sheremata's research is part of a broad collaboration that includes hunters, scientists and the Arctic Eider Society, which works with communities on Hudson Bay on sea ice research and education. So far, she has interviewed nearly 40 experts from Kuujjuarapik, Umiujaq and Inukjuak, in Arctic Quebec, and Sanikiluaq, on Nunavut's Belcher Islands.

"Our goal," she says, "is to understand the cumulative impacts of hydro and climate change on the sea ice and water, and their effects on wildlife and on Inuit land use, lives and livelihoods."

Before the hydroelectric projects, the greatest flow of fresh water into James Bay (and then north into Hudson Bay) occurred during the spring melt. When the dams began operating, the maximum flow moved to mid-winter, when demand for electricity in Southern Canada and the northeastern United States is highest, and more water is directed through the generating stations.

"Hunters immediately noticed the ice was more brittle [freshwater ice is less flexible than saltwater ice], and some described seeing it literally break behind their snowmobiles," says Sheremata. "Seals, which normally float when killed in seawater and can be retrieved, were less buoyant in water with reduced salinity, and began sinking out of reach."

Hunters' more recent observations of the changing climate include thinner ice and reduced sea ice area, cooler summers and warmer winters, and higher and less predictable winds. "People say that 15 or 20 years ago, winds of 150 km/h or more would occur only in the fall," says Sheremata. "Now you can have windstorms at any time of year. That's a concern for hunters travelling by snowmobile or boat and for communities, where high winds can damage buildings and services."

The hunters' knowledge complements the physical sciences used to monitor salinity and sea ice in eastern Hudson Bay, says Sheremata. "Together, we can understand what these changes mean for the land, sea and wildlife that Inuit depend on."

Polar Knowledge Canada Savoir polaire Canada

CANADIAN Geographic

This is the latest in a blog series on polar issues and research (cangeo.ca/blog/polarblog) presented by *Canadian Geographic* and Polar Knowledge Canada, a Government of Canada agency with a mandate to advance Canada's knowledge of the Arctic and strengthen Canadian leadership in polar science and technology. Learn more at canada.ca/en/polar-knowledge.

on the map

EXPLORING CARTOGRAPHY

Route revisions

New bird-tracking technologies are leading to startling discoveries and helping revise migration pathways

BY BRIAN BANKS

It's been a mystery since the study of bird migrations began: while scientists understand a great deal about where birds breed, they know less about where they spend other times and, sometimes, nothing about their travel routes.

Over the last decade, though, researchers have started unlocking many of these unknowns using an array of evolving tracking technologies. The result: a stream of revelations about migratory birds' journeys, their capabilities and critical destinations and hazards en route — essential information for conservation work.

"There are some surprising findings," says Darroch Whitaker, an ecosystem scientist with Parks Canada, in Rocky Harbour, N.L. "A lot of these birds are making astonishing non-stop movements."

Take Connecticut and blackpoll warblers, combined as one of six examples of such discoveries depicted on this map. These small songbirds, which weigh about as much as a triple-A battery, spend summer in Canada's boreal forest and winter in South America. But in 2014 and 2016, researchers found that instead of flying south over land in the fall, they undertake a non-stop transatlantic marathon — upward of 2,500 kilometres — from the East Coast of the United States to various Caribbean islands before reaching their final destination.

These conclusions emerge from light-sensing geolocators attached to the birds, one of the few devices small enough to be carried by birds this size. There are similar lightweight tags that record a bird's GPS coordinates at pre-set intervals. Birds must be recaptured to collect this data.

Other sensors, however, supply data that can be downloaded remotely, sometimes in real time. For example, slightly larger GPS tags can send location information when they're in range of a receiver. Others link directly to satellites. Scientists using a third option, the Canadian-created Motus tracking system, fit birds with tiny nanotag transmitters that emit a radio signal detected by more than 350 ground-based tracking stations throughout North and South America whenever a tagged bird passes nearby.

As the accompanying examples show, all of these methods — coupled with breakthroughs in DNA and isotope analysis that further pinpoint individual bird origins — are yielding remarkable results.

"Migratory birds have always faced dangerous and daunting journeys, but human impacts have made such marathon flights all the more amazing," says Bridget Stutchbury, a biology professor and Canada research chair in ecology and conservation biology at Toronto's York University. "New technologies are important for advancing basic migration science, but also give us hope that population declines may someday be reversed."

Check out a mesmerizing animated map of a year of bird migrations in North America at cangeo.ca/ma18/migration.

Whimbrel

Whimbrels were among the first birds to show the power of migratory tracking technology. In 2008 and again in 2012, whimbrels fitted with satellite transmitter tags were tracked continuously between summer breeding grounds in Alaska and the Northwest Territories and wintering sites in Brazil. Often, the birds spent days aloft.

Wilson's warbler

There are five known breeding regions for this species in Canada, and birds born in each carry distinctive genetic markers. In 2014, scientists used DNA to match birds in various wintering areas in Mexico to their areas of origin.

Grey-cheeked thrush

In 2015 and 2016, dozens of these boreal breeders were tagged with tiny radio transmitters at overwintering grounds in Colombia. Researchers then logged segments of their springtime moves north with the Motus tracking system, revealing links between migration speeds — the fastest bird went 3,200 kilometres in a little more than three days, while some took weeks — and fuel availability at stopover sites.

THIS PAGE, FROM TOP: JOE AUSTIN PHOTOGRAPHY/ALAMY/ALL CANADA PHOTOS; ETHAN MELEG; GERALD A. DEBOER/SHUTTERSTOCK. OPPOSITE PAGE, FROM LEFT: RICK & NORA BOWERS/ALAMY/ALL CANADA PHOTOS; RANDY MEHOVES/ALAMY/ALL CANADA PHOTOS; SEVENTHDAYPHOTOGRAPHY/ISTOCK; MORTEZA NEMATI/SHUTTERSTOCK; MAP: CHRIS BRACKLEY/CAN GEO

Atlantic puffin

This winter range is based on an eight-year tracking study, using light-level geolocators, published in 2017 of 270 Atlantic puffins from 13 colony groups. Travel distances from breeding colonies range from under 250 kilometres to more than 1,700. Birds flying shorter distances, such as the Canadian population, were healthier and more productive.

Connecticut warbler/Blackpoll warbler

These tiny songbirds make mighty non-stop transatlantic fall migrations from Canada's East Coast and the Northern United States to Hispaniola and other Caribbean islands. Scientists suspected this, but confirmed it with data gathered by light-sensing geolocators fitted on a handful of each species in 2014 and 2016. Curiously, the birds take predominantly overland routes when returning in spring.

Northern wheatear

In 2012, scientists used light-sensing geolocators to track the epic flights of wheatears from Alaska and Nunavut to sub-Saharan Africa for the first time. Results revealed Canadian birds take a 7,500-kilometre easterly route to winter in Western Africa, while Alaskan birds go to Eastern Africa via Asia.

'THEY'RE *out there*'

After decades of conflict between humans and wolves, the Yukon is finding its balance with the top predator, which is thriving across the territory

BY EVA HOLLAND
WITH PHOTOGRAPHY BY PETER MATHER

A Yukon wolf, the female alpha of her pack, emerges from the boreal forest near Dezadeash Lake, in southern Yukon.

IT'S A RARE THING to spot a wolf in the Yukon wild. While grizzlies and black bears forage on the hillsides above the highway, and moose stand knobby-knee-deep in the murky ponds below, putting themselves on easy display for passersby, the territory's wolves play hard to get, offering only glimpses and hints: a dark flash on the riverbank as you're paddling, a set of oversized paw prints on the snow-covered surface of a frozen lake.

But they're out there. There are an estimated 5,000 wolves in the Yukon — that's roughly one wolf per seven human residents, or one wolf for every 96 square kilometres. Their range spans almost the entire territory, from the boreal forest to the alpine and Arctic tundra; only the vast Kluane icefield is wolf-free. While wolves have been driven out and exterminated in many parts of North America and only slowly, painfully, reintroduced in some, in the Yukon they're still thriving.

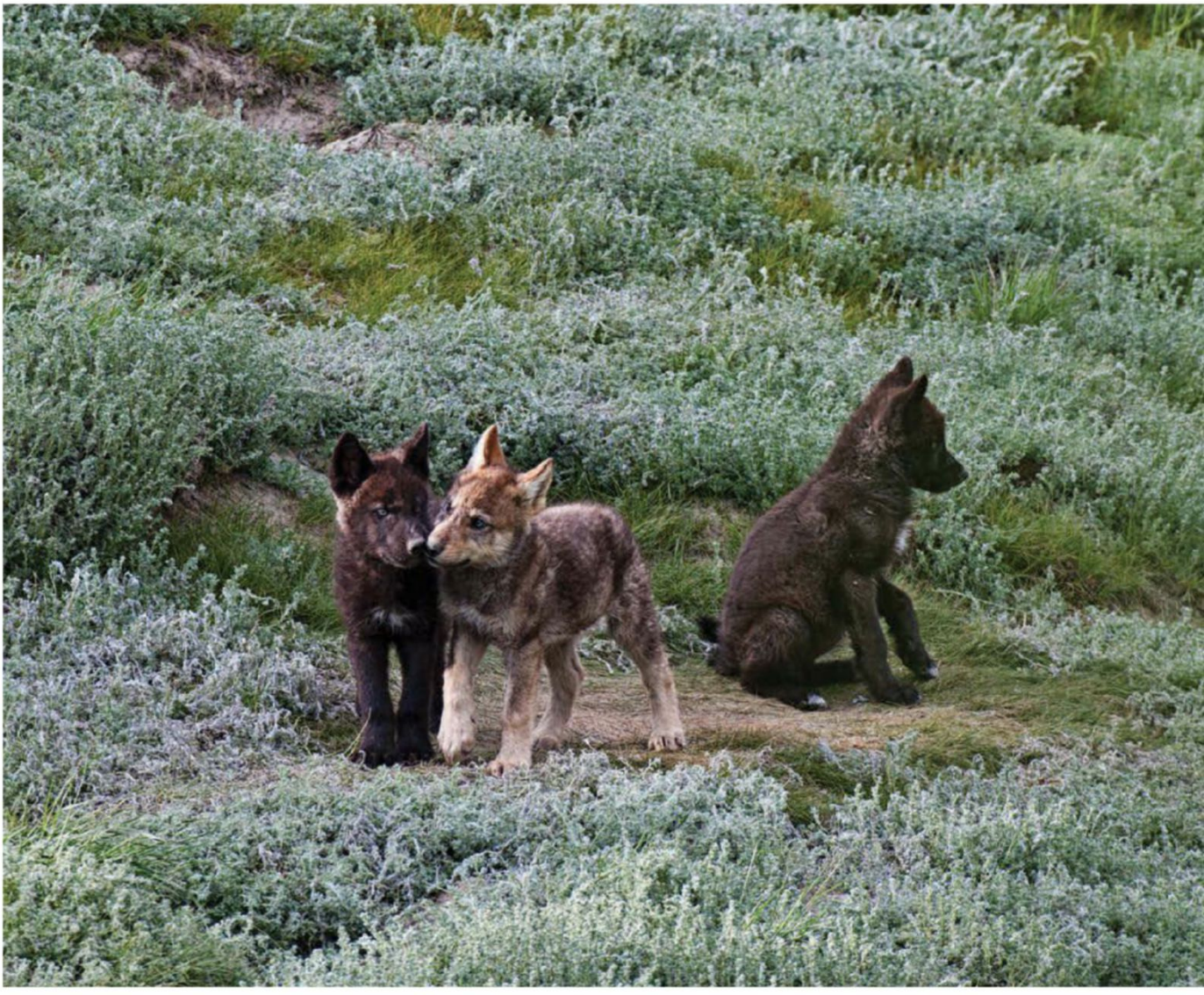
WHAT'S DIFFERENT ABOUT THESE WOLVES IS THEIR SURROUNDINGS: THE ECOSYSTEM THEY MOVE THROUGH SO INVISIBLY IS INTACT.

There's nothing special or unique about the biology or physiology of the wolves in the territory — they're grey wolves, *Canis lupus*, like the ones you might find in any number of wild areas. What's different, though, is their surroundings: the ecosystem they move through so invisibly is intact. "What's really unique is that they're completely naturally regulated," says Bob Hayes, author of *Wolves of the Yukon*. Mark O'Donoghue, a northern regional biologist for the Yukon government, agrees. "We have a natural predator-prey system," he says. The wolves and their ungulate meals — moose, primarily, and caribou and mountain sheep to a lesser extent — are largely in balance.

Humans, of course, haven't always been content to leave that balance alone.

Wolves existed in the Yukon as many as 47,000 years ago, according to

Clockwise from ABOVE: Prime wolf territory in central Yukon's Ogilvie Mountains; a paw print on the bank of the Snake River; moose are a top food source for wolves; pups outside their den in the territory's southwest corner.



A wolf on the hunt for caribou in northern Yukon's Barn Mountains (OPPOSITE) is interrupted by a northern harrier protecting its nest. Siblings socialize near their den (ABOVE).

archeological records — since the time when extinct giant mammals such as the woolly mammoth roamed the grasslands of what we now call Beringia, during the Pleistocene Epoch. But like the mammoths, the Beringia wolves vanished sometime during the transition from the Pleistocene to the Holocene, 12,000 to 6,000 years ago. Modern wolves, *Canis lupus*, subsequently migrated up to the territory from southern North America as the ice sheets receded, clearing the way.

Wolves, a source of both fear and respect for Indigenous Peoples in the region, were often featured in imagery and stories. (Many First Nations people today, particularly in southern Yukon, belong to the Wolf Clan.) Wolf-human conflict did not become a major issue in the territory until the 20th century, after the Klondike Gold Rush brought thousands of newcomers to the area. After the gold rush, trappers in a booming and busting fur industry began to complain that wolves were harming their business; a growing number of sport and subsistence hunters blamed the wolves for the shrinking herds of ungulates, too. In the 1920s, trappers were authorized to set out poisonous strychnine baits for wolves, and a system of wolf bounties was set up.

WOLF-HUMAN CONFLICT DID NOT BECOME A MAJOR ISSUE UNTIL THE KLONDIKE GOLD RUSH BROUGHT THOUSANDS OF NEWCOMERS TO THE AREA.

Eventually, the government took control of the strychnine programs, rather than allowing trappers to freelance the process, and efforts to poison the wolves into submission continued for decades. In his book, Hayes describes arriving by helicopter on the scene of a strychnine bait site in 1985: "There was a sow grizzly bear crumpled in the trees, two wolves, 10 ravens and

The Wind River runs through pristine Yukon wolf habitat in the territory's northeastern Peel Watershed.

six magpies. There were hundreds of dead chickadees everywhere I looked — on the ground and in the willow branches, their tiny white feathers scattered like a dusting of fresh snow."

Strychnine use was restricted in 1972, but according to Hayes, its use continued illegally in some quarters for several years, including at the site he visited in 1985 (no one was ever charged in that case). Hayes, a biology grad who had dreamed of being able to study wolves someday, arrived in the territory during those years. He wound up working on birds, but was offered the position of wolf biologist for the Yukon government in 1982. The job fell into his lap — he remembers a supervisor casually asking, "Do you want to start working on wolves?" The carnivores were a hot topic at the time, with Whitehorse residents concerned about incursions into their yards and subdivisions, and hunters in the Southern Lakes region of the territory upset about low moose numbers.

'PERIODIC, BROAD-SCALE WOLF CONTROL HAS LIMITED BENEFIT TO PREY POPULATIONS, DOES NOT LAST, AND SHOULD BE RELEGATED TO THE PAST.'

Hayes took the job and kept it for 18 years. He wound up being the face of Yukon government wolf policy during an extremely fraught and turbulent time. He'd been on the job for a decade when, in 1992, the government launched a new wolf management plan. The 1992 plan included some progressive and pro-wolf elements: for instance, it asserted that wolves had an inherent value in and of themselves — beyond their influence, positive or negative, on human concerns such as game availability or the safety of neighbourhood pets. But it also legalized aerial wolf control as a means to protect ungulate populations for human hunting.

In the lead-up to the new plan, public consultations were held around the territory to determine the future of Yukon wolves, and tempers flared. One speaker at a public meeting had his tires slashed. After the 1992 plan was adopted, a large-scale aerial wolf-kill program was launched in the Aishihik region, near Kluane National Park and Reserve and the town of Haines Junction. Hayes, as the government's lead wolf biologist, was responsible for overseeing the program. Dozens of wolves were shot from

Eva Holland (@evaholland) has written for The Walrus, AFAR, Grantland *and more. Peter Mather (petermather.com) is a widely published Fellow of the International League of Conservation Photographers.*

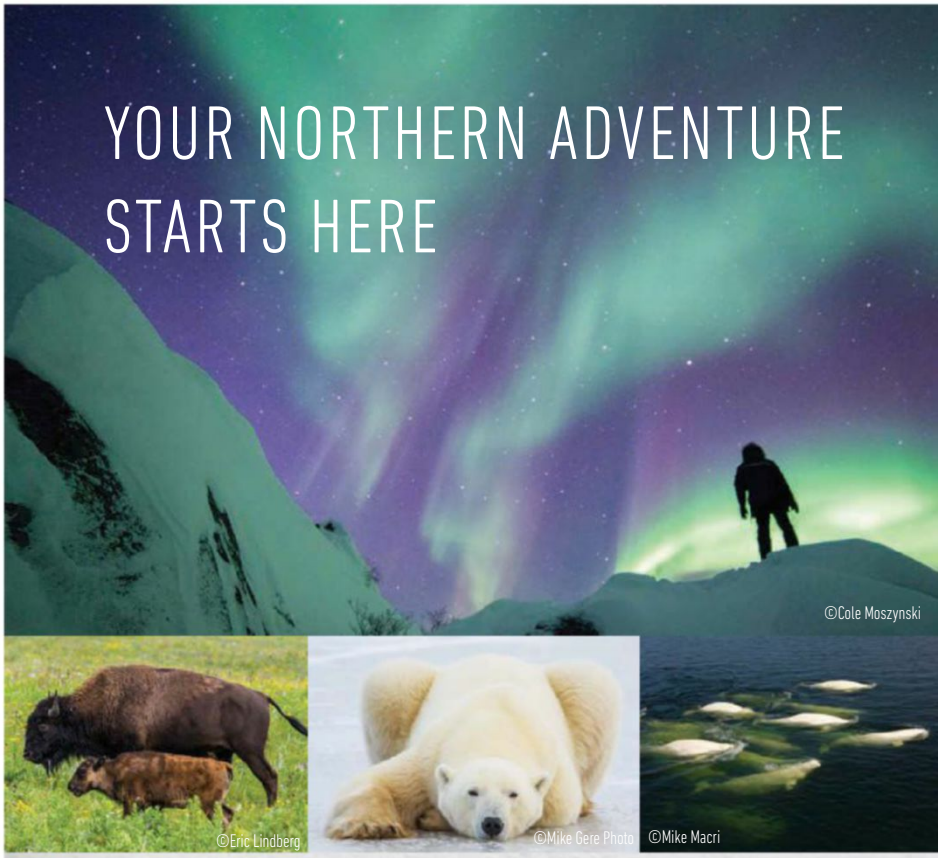
A female wolf peers over willow bushes in the southern Yukon (OPPOSITE). In northerly Vuntut National Park (RIGHT), a young wolf lopes across a snowy landscape.

helicopters. Activists from outside the Yukon migrated north, chained themselves to the doors of the Yukon legislature, held protests on the highway, and trailed Hayes from his work to his home and back again, viewing him as Wolf Enemy No. 1.

The debate over wolves got personal. In a 2011 story in *Up Here* magazine, "Wolves in our blood," Whitehorse-based writer Peter Jickling looked back on his own family's involvement in the territory's wolf wars. His father was a leading activist for wolf conservation, and a member of the committee that produced the 1992 plan. He was also a close friend of Hayes, and the younger Jickling wrote about growing up alongside the Hayes family: "The Hayeses and Jicklings were an entwined unit." But the Aishihik wolf kill ended the friendship permanently. "One month the Hayes clan was there, the next month, they weren't," Jickling wrote. "It was tough for an 11-year-old to understand."

Since the 1990s, the furor over the Yukon's wolves has mostly died down. Hayes left his post in 2000, and eventually became a potent voice against aerial wolf kills and other lethal wolf-management methods. Hayes was convincing: he'd studied the methods even as he deployed them, and he argued that killing wolves was, simply, ineffective in addition to being potentially immoral and cruel. His research found that while large-scale wolf kills did temporarily increase the stock of moose in a given area, allowing hunters better chances at game, wolf populations rebounded quickly as soon as the killing stopped. "It only lasts as long as you kill wolves," Hayes says. The result is an expensive and bloody cycle with limited benefits to hunters.

"I believe science has answered the question of the periodic, broad-scale wolf



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control," Hayes wrote in *Wolves of the Yukon*, published in 2010. "It has limited benefit to prey populations, it does not last, and should be relegated to the past along with poison and bounties."

In 2012, the Yukon government released a new wolf management plan that put an end to government-run wolf-kill programs. And this time, the plan and the process leading up to its release were relatively uncontroversial.

Territorial biologist Mark O'Donoghue was one of the authors of the new plan. "We went to every community in the Yukon," he says, "and I think that was one of the real consistencies we found — and it was a little bit surprising that everybody pretty much said, 'We don't want to see any more of these big helicopter wolf-control programs.' " The change in public sentiment was based on a mixture of ethical considerations and concerns over the programs' high costs and low efficacy. "People did not want to see government doing this." Now, if there are strong concerns about wolf and ungulate populations in a given area, that sub-region's trapping and hunting quotas are altered accordingly — a less blunt instrument.

There is no expiry on the 2012 plan, no firm date on when it will be reopened for public debate. For now, says O'Donoghue, the plan is working and the wolf population is healthy.

It's hard to say what the future holds. Bob Hayes thinks that some of the impacts of climate change could benefit wolves, at least temporarily: some of the territory's tundra is gradually becoming taiga, moose habitat, and moose density is increasing in northern Yukon. That's good news for moose-eaters.

Writing in the conclusion of *Wolves of the Yukon*, Hayes noted that "There are many wolves ranging through the Yukon today as there were a hundred years ago, a thousand years ago, five thousand years ago."

A lone hiker along the Wind River (TOP), where visitors are often serenaded by a pack that dens nearby. A large black wolf stalks the boreal forest (ABOVE).

"They live everywhere around us," he added. Even if we rarely see them.

Learn how Peter Mather captured these amazing photos of Yukon wolves at cangeo.ca/ma18/wolves.

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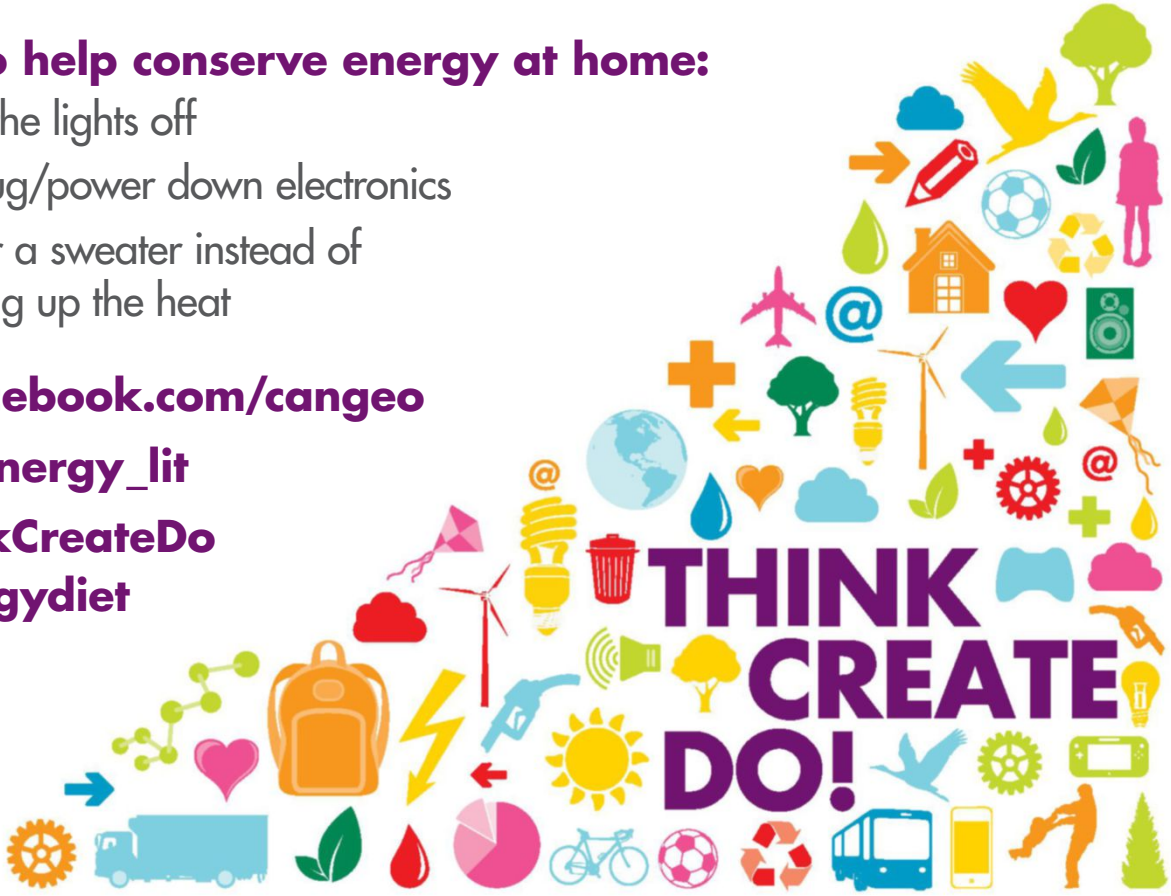

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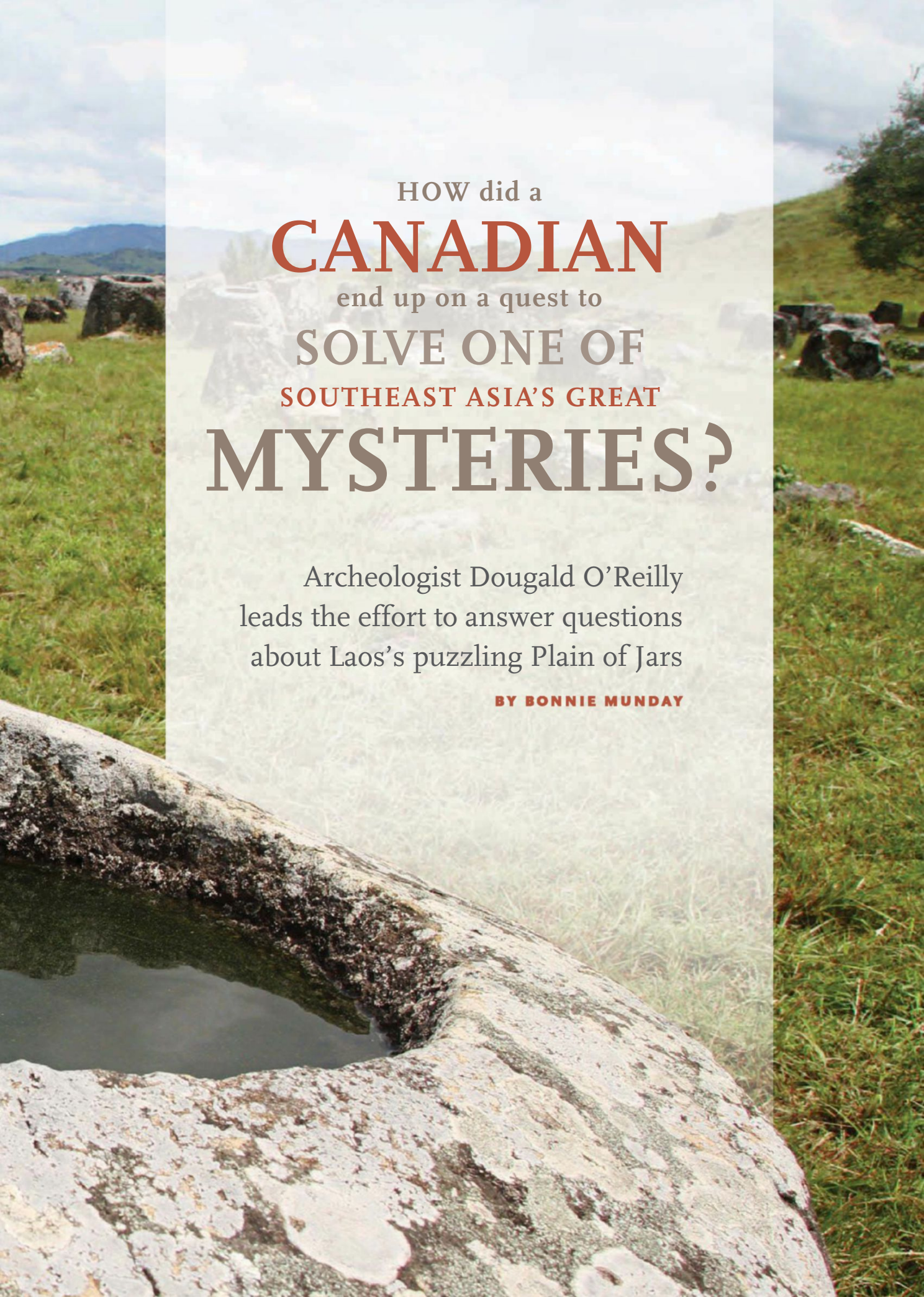

HOW did a CANADIAN end up on a quest to SOLVE ONE OF SOUTHEAST ASIA'S GREAT MYSTERIES?

Archeologist Dougald O'Reilly leads the effort to answer questions about Laos's puzzling Plain of Jars

BY BONNIE MUNDAY

SHAFTS OF SUNLIGHT struggle to penetrate mist hanging over mixed forest on a mountaintop in the northern reaches of the Annamite range in Laos. It's a cold day in February 2017 and a metal pot of coffee simmers on a fire. Nearby, Canadian archeologist Dougald O'Reilly, in a canvas Australian stockman hat and army pants, black puffer jacket and Grateful Dead T-shirt, is crouched in a precisely cut four-by-four-metre trench. At its edge is an oval stone disk roughly one metre across. It's lying flat near a huge stone "jar."

This is Site 52 of the Plain of Jars, so named for the plateau where the best-known group of jars, Site 1, is situated, near the city of Phonsavan. From Phonsavan, Site 52 is an hour's drive on a highway, then another 45 minutes up a precipitous dirt track. Scattered all around this forest floor are some 400 stone vessels, one to three metres tall, some lying on their sides. A number of the jars are broken, with trees growing through them; a few disks, some of them likely lids, can be seen too. The jars are empty except for stagnant rainwater and spiders.

O'Reilly, 51, is an assistant professor at Canberra's Australian National University and chief investigator on this three-week field project that's part of a five-year effort — the first of its scale in some 80 years — to solve the mystery of the jars. "The two most common questions I get are, 'What were the jars for and how old are they?'" says the dark-haired, blue-eyed Oakville, Ont., native. "That's what we're trying to find out."

Site 1 of the Plain of Jars (ABOVE and PREVIOUS PAGES) is the best known grouping of the megaliths that archeologist Dougald O'Reilly (BELOW) is investigating.

He's well positioned to do just that. "Dougald O'Reilly is one of the main players in advancing our understanding of Southeast Asian prehistory," says Charles Higham, an archeologist at the University of Otago in Dunedin, New Zealand. "He's been a success story from the word go." Higham, who himself has long been considered the "rock star" of archeology in this part of the world, credits his former student with making an exceptional contribution in Cambodia, both in excavating key sites and in his initiatives to protect cultural heritage. (See sidebar, "Heritage Watch: Preserving Cambodia's Past.")

As for Laos, says Higham, "Dougald has pioneered fieldwork there by opening this major Plain of Jars project." One of the team's main goals is to map the sites, and the jars themselves, for the first time with remote sensing and GIS. O'Reilly says this is crucial for the Laos government's bid, now underway, for UNESCO World Heritage status for the jar sites. Such status would benefit Laos, one of the world's poorest countries, since it boosts tourism and can help preserve the sites.

If successful, the government will have O'Reilly and his project partner, archeologist Louise Shewan of the University of Melbourne, to thank: the pair approached Laos's heritage department back in 2012 to propose this research. "The fact that too little was known about the jars had been one of the hurdles they'd been facing in gaining World Heritage status," says O'Reilly. The archeologists got their permission and were awarded a grant from the Australian Research Council, and began work on Site 1 in 2016.

LITTLE IS KNOWN about the megaliths, thought to have been made a couple of thousand years ago. There are some 80 jar sites scattered around northeast Laos,

PLAIN OF JARS

and a handful in remote eastern India, thousands of kilometres away. Many were quarried a few kilometres from where they sit, further adding to the Stonehenge-like mystery: Weighing as much as 10 metric tons apiece, how did they even get here from the quarries? Were they transported on log rollers, dragged by elephants, or somehow rolled to the sites? O'Reilly calls his search for the answers "invigorating."

No major excavation has been done since the 1930s, when famed French archeologist Madeleine Colani first studied these jars in what was then part of French Indochina. Then came civil war starting in the 1940s, and later the Vietnam War, during which the U.S. bombed Laos for a decade. (It's said Laos is the most heavily bombed country per capita in history.) About 30 per cent of the 260 million bombs dropped never detonated, so the unexploded ordinance, or "UXO," has been a deadly obstacle — not just for archeological work, but for anything from road-building to farming. The British non-profit Mines Advisory Group has been in Laos since the mid-1990s to remedy that. It's slow, painstaking work, but the group has now cleared UXO from various locations for a total of about 60 square kilometres, indicating cleared areas by embedding the ground with bricks engraved "MAG." It has helped keep about one million people safe.

'O'Reilly has pioneered fieldwork in Laos by opening this Plain of Jars project…' mapping the sites for the first time with remote sensing and GIS.

Site 1 was declared clear about 10 years ago. During their 2016 excavations of the bomb-cratered plateau that's home to some 300 jars, O'Reilly, Shewan and Laotian archeologists found human bones in smaller ceramic vessels buried underneath flat stone disks beside the jars.

The theory is that the jars were for mortuary practice. "The people of perhaps the Iron Age — 2,000 years ago — might have used them to rot their dead, then later transferred the bones to the smaller vessels for burial," says O'Reilly. Archeologists including Colani (whom O'Reilly admires so much he named his now four-year-old daughter, Madeleine, after her) and Julie Van Den Bergh, a Belgian who mapped some of the jar sites in the early 2000s, believed this. "But until we get lab results from samples we've taken, that remains unproven," says O'Reilly. So far there aren't really any other plausible theories. (A fanciful one: Some villagers believe the jars were used to store rice wine for a mythical giant.)

Back at Site 52 (which had no UXO, only machine-gun shells), eight of O'Reilly's team members have been using pickaxe-like tools called mattocks to dig the trench into the crumbly red soil beside the oval disk. They want to see what's underneath; O'Reilly suspects

PREVIOUS SPREAD: VALERY SHANIN/SHUTTERSTOCK. THIS SPREAD, TOP: NUWATPHOTO/SHUTTERSTOCK; BOTTOM: COURTESY AUSTRALIAN NATIONAL UNIVERSITY. MAP: CHRIS BRACKLEY/CAN GEO

Members of O'Reilly's research team at Site 52, where jars have been marked with orange tags for the project's inventory.

human bones, as at Site 1. But the disk is thicker than expected — about 25 centimetres — and too heavy to lift without the help of levers. O'Reilly walks off into the forest with his machete, cuts a couple of tree limbs and drags them over.

As they use the levers to lift the lid, the moment of truth reveals ... nothing. They take a few more hours to dig down another third of a metre or so — and still nothing.

'The people of the Iron Age might have used the jars to rot their dead, then later transferred the bones to the smaller vessels for burial.'

"Oh, that's *very* interesting," remarks O'Reilly dryly, rubbing his chin in faux contemplation. Sure, he's disappointed, as is the team, but "sometimes you find things, sometimes you don't," he says with a shrug. "Even when what you're hoping for isn't there, in this case anthropogenic material, it's still about gathering information. And you just keep going."

SO HOW DID a Canadian end up on a quest to solve this mystery of Southeast Asia? O'Reilly's fascination with archeology goes way back; he still has a drawing he made at age five of himself digging with a shovel next to the Sphinx. His parents nurtured the interest. "Dougald used to love it when I told him stories of the Celts in Ireland, heroes like Brian Boru, Cú Chulainn," says his dad, Joe, in his lilting Irish accent. When Dougald's parents took him to his mom's ancestral home of Scotland, they visited a cemetery. "We were standing at the gravestone of someone named MacGregor, I think," says Joe. "Dougald knew clans were identified by their tartans — and he asked if we could dig up this grave to see what tartan the man was wearing! It was outlandish, but perfectly logical to him."

Joe says his son drifted academically through his teens, and Dougald recalls that when he graduated from Ottawa's Carleton University at age 21, he felt his career options with a history degree were limited. So he put off job decisions and travelled for a year on a round-the-world ticket with his best mate. In particular, O'Reilly was struck by Thailand, and it was on his travels there that his passion for archeology was rekindled, and he decided he'd study that part of the world. "Archeologically, Southeast Asia was poorly understood," he explains. "I decided to put all my eggs in one basket, and work my tail off to achieve my goal."

He eventually got his BA in classical archeology at Brock University in Ontario, then his master's and PhD in New Zealand under Charles Higham (O'Reilly had been determined to study under the leading authority on Southeast Asian prehistory). During those studies, the pair worked on projects in Cambodia and Thailand.

In 2000, after getting his PhD, O'Reilly moved to Phnom Penh, the Cambodian capital, where he was a UNESCO lecturer at the Royal University of Fine Arts. It was a time of constant change in Cambodia, a country finally free of the Khmer Rouge, who were responsible for some two million deaths from execution or starvation — mainly in the 1970s, though they were active until the 1990s. "When I was there, there were people from around the world working on important projects such as disarmament, wildlife protection and schools for disadvantaged children," says O'Reilly.

In 2010 came a dream job: leading an excavation inside Angkor Wat. "When I was a kid, *National Geographic* dedicated an issue to Angkor Wat, and I was in awe," recalls O'Reilly. The 12th-century temple, dedicated to the Hindu deity Vishnu, covers 208 hectares and is the world's largest religious complex. O'Reilly led the 2010 excavation after ground-penetrating radar had revealed anomalies indicating another temple underneath. Sure enough, they discovered such remains. It was a major find in the world of archeology when the research was published. O'Reilly went on to author the digital book *An Interactive Guide to Angkor*. Yet, he says, as intimately familiar as he is with Angkor, "every time I drive through its gates I still have a feeling of awe."

Bonnie Munday (@bonnie_munday) has written for Canadian Geographic Travel, Reader's Digest International, TravelLife *and* The Walrus.

DOUGALD O'REILLY

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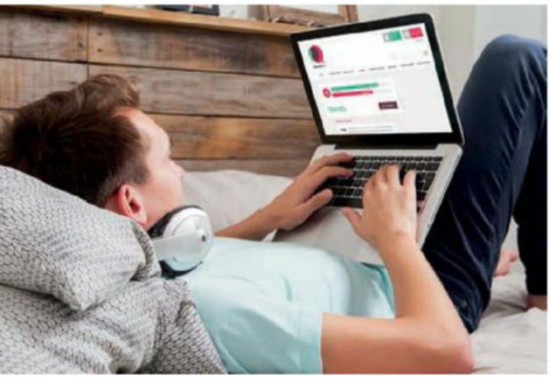

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O'Reilly has done extensive work in Cambodia, too, including documenting burial finds at Prei Khmeng, site of a Hindu temple built atop a prehistoric cemetery.

OVER THREE WEEKS at Site 52, the team never did find bones but, significantly, they found four previously unknown quarry sites. They also tried a new type of testing. In simple terms, says Shewan, stone can't be dated, "so we took core samples from the bottoms of the jars for 'optically stimulated luminescence' testing." They hope it will reveal when the jar bottoms were last exposed to sunlight — therefore, when they were placed on the ground where they sit. The process of taking those stone samples was tricky, as no light can be present: black lightproof tarps were tented over the extraction site, and O'Reilly held a flashlight covered in a red filter while he used a drill to extract the core.

> **'The fact that too little was known about the jars** had been one of the hurdles they'd been facing in gaining World Heritage status'

The team heads to Assam, India, this year to see how jars there compare to what they've found in Laos. Meantime, they can "visit" Laos any time they like from their base in Australia, at the CAVE2 3D facility at Monash University in Melbourne. Drone photos gathered in 2016 have been used to create a virtual Site 1. (They collected drone photos at Site 52 and will soon be able to revisit it in 3D, too.) CAVE2 is the world's largest virtual reality facility of its kind — no VR goggles required. "We can 'return' to our excavations to do things like take measurements and interpret data," says O'Reilly. And thanks to drones, they'll have a safe way to check out jar sites that may not yet be clear of UXO. "Of course, you can't excavate without being there, but you can gather a lot of information on site location and the surrounding landscape."

It could be a year until the team has results from soil and other physical samples — including a human tooth — that they gathered at Site 52, and up to two years for the optically stimulated luminescence results. But O'Reilly hopes the data will finally provide some answers about these massive megaliths on remote mist-shrouded mountaintops. "Archeology," says O'Reilly, "is largely about untangling mysteries, and the Plain of Jars is one of the world's enigmas."

Get a closer look at the Plain of Jars by watching spectacular drone footage of the site at cangeo.ca/ma18/jars.

PRESERVING CAMBODIA'S PAST

HERITAGE WATCH was founded by Dougald O'Reilly in 2003 after he witnessed widespread looting of ancient antiquities in Cambodia. The non-profit aims to preserve prehistoric sites there. "I felt the looting was an incredible tragedy," says O'Reilly. "One can't blame folks for digging around their homes to find anything of value, since poverty is what drives looters. But these sites give us clues to the rise of civilizations, about which little is known."

He had ideas for how to reduce the destruction, so he set up an office in his Phnom Penh apartment and mobilized some of his former students, paying them with his own money and taking no salary himself. "We began with small-scale projects, such as village training sessions, to educate locals on the importance of preserving the past."

Heritage Watch, which O'Reilly believes is the first organization of its kind, also promotes responsible tourism: visitors are discouraged from buying antiquities, businesses are certified as "heritage-friendly" with stickers or signage to help travellers identify ethical companies, and locals are employed to work on excavations. And now Heritage for Kids is in play, to educate children about preserving heritage and the environment. "We have a pilot program in schools in northwest Cambodia involving some 600 kids," says O'Reilly. "The schools love it, the government loves it, and the kids love it."

In 2009, O'Reilly won the prestigious Archaeological Institute of America's Conservation and Heritage Management Award for his work leading the non-profit.

DOUGALD O'REILLY

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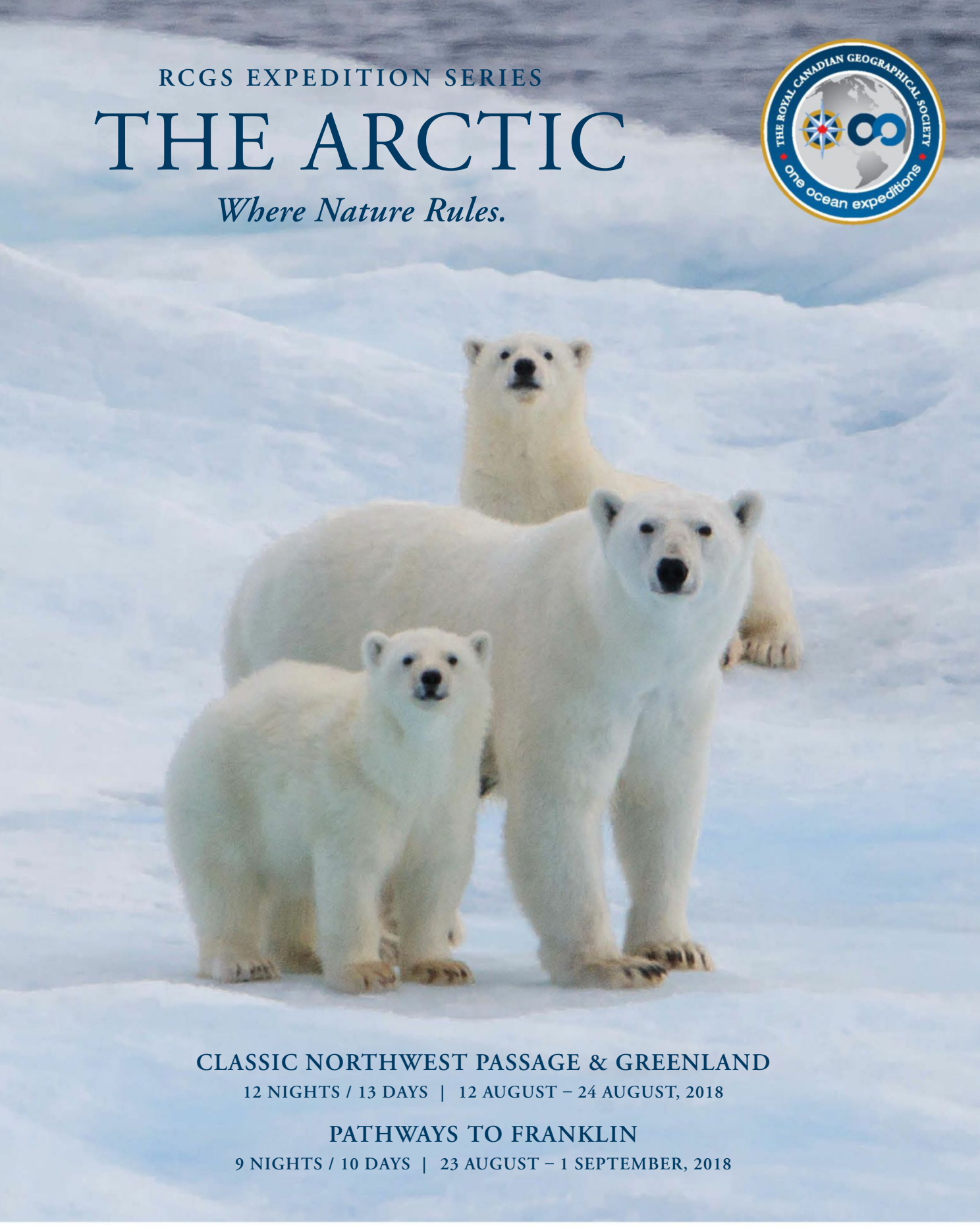

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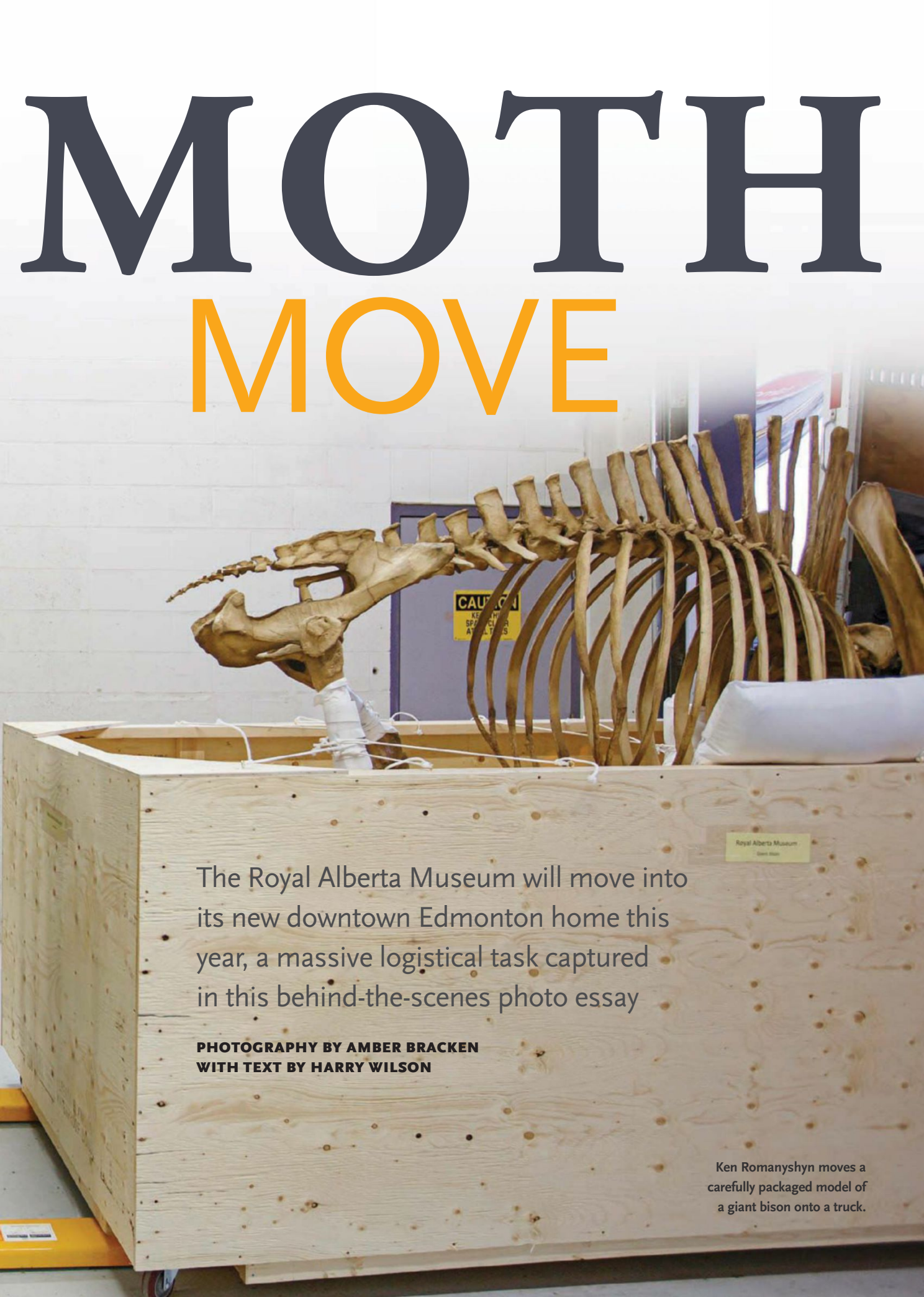


The Royal Alberta Museum will move into its new downtown Edmonton home this year, a massive logistical task captured in this behind-the-scenes photo essay

PHOTOGRAPHY BY AMBER BRACKEN
WITH TEXT BY HARRY WILSON

Ken Romanyshyn moves a carefully packaged model of a giant bison onto a truck.

FORGET ABOUT the tables and chairs. And the microscopes. And the 14,000 bird eggs in the ornithology collections. And the 60-plus live invertebrates that crawl, scuttle and buzz in the Bug Room gallery.

Those are — relatively speaking — easy to move.

What the Royal Alberta Museum really needed to worry about was the mammoth skeleton.

How was the institution going to get the ancient tusked behemoth out the low doorways of the venerable old building it had outgrown just west of downtown Edmonton and into its glittering new $375.5-million home that occupies 38,000 square metres of prime real estate in the more central Arts District?

By taking off its head, naturally. Six museum staffers detached the approximately 36-kilogram skull, lowered it to the ground with a scissor lift and ... moved on to the next item.

Logistical problems such as this one come with the territory when a museum decides to move, of course, but the sheer scale of the entire exercise can be hard for the public to wrap their minds around.

"We've got 2.4 million pieces in our collection and we're moving about two million of them to the new location," says Chris Robinson, the museum's executive director. "How do you move two million pieces? You do it carefully and you do it once."

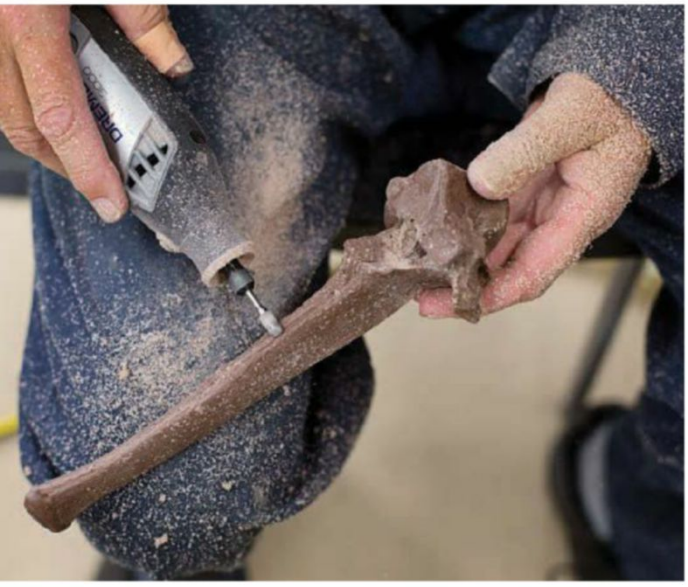
To that end, the museum is using a barcode system to keep track of what's gone out the old doors and in the new ones, which are expected to open to the public sometime in 2018. As of mid-January, about 71,000 bar codes — "That's 1.6 kilometres long," says Robinson — had been applied to the approximately 422,000 artifacts and specimens relocated so far.

Displaying and storing those millions of artifacts is going to be much easier in the new museum than it was in the old one, which despite expanding almost continuously through the late 1960s and '70s after opening as the Provincial Museum of Alberta in December 1967 was still not big enough to house most of its collection. In the new building, for example, the amount of permanent gallery space has more than doubled, while the storage areas have 2½ times the capacity compared with the old building.

Robinson believes all that space will help future-proof the museum, the collections of which will only keep growing. "History doesn't stand still," he says. "And neither does the museum."

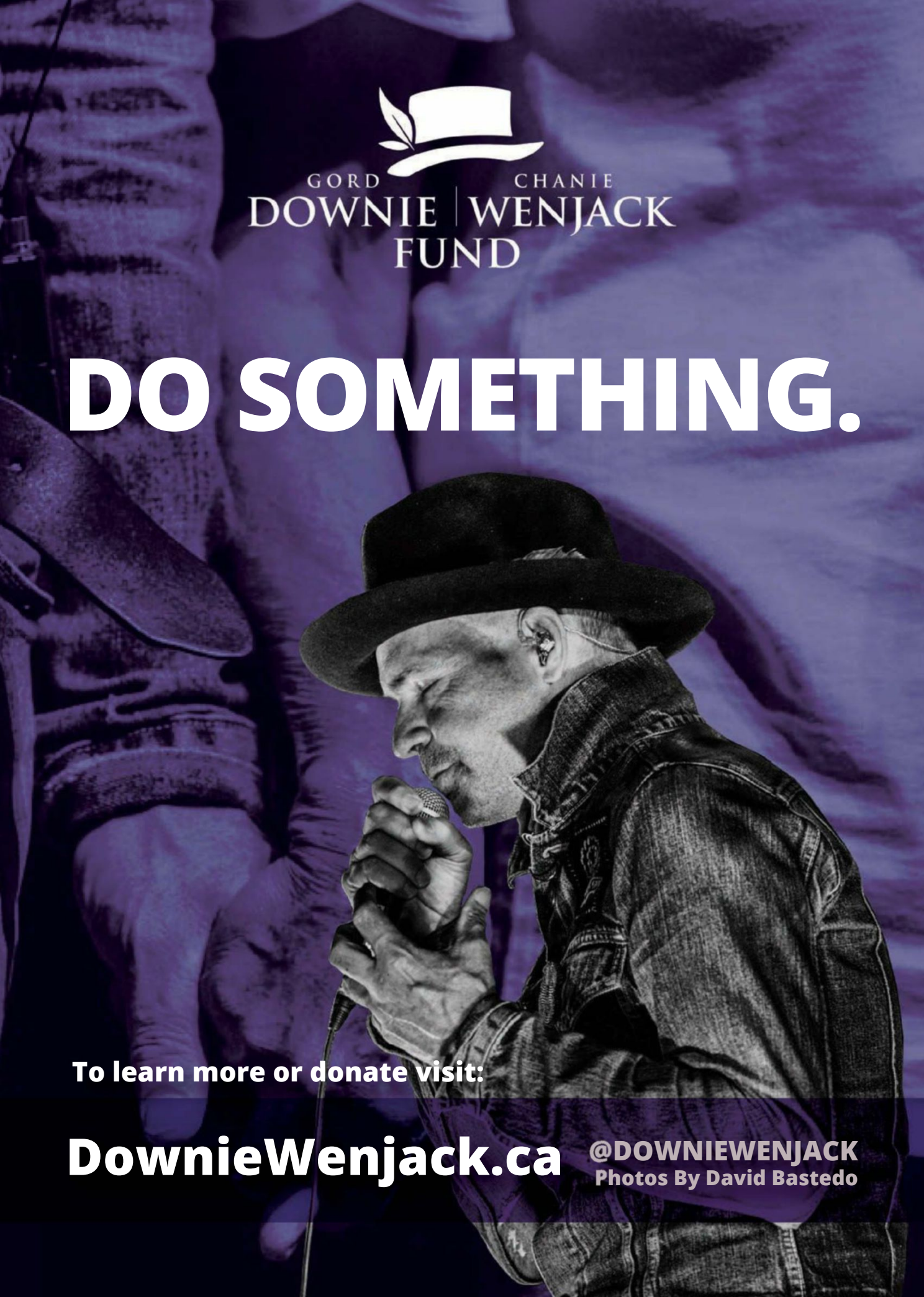
Clockwise from ABOVE: Paleontology exhibit specialist Peter Milot articulates a horse skeleton before packing it; a giant bison skull awaits its box; ladders and part of a custom-made crate; museum mascot Moe the mammoth at a museum goodbye party.

ERTA



Clockwise from TOP LEFT: Peter Milot files away extra material from a cast of a bone before packing it; Milot prepares a tray of specimens for shipping; boxes ready to be moved flank unpacked items in a museum storage room; a carefully arranged array of bone fragments ready to be boxed.

Amber Bracken (@Amber-Bracken) shoots regularly for the Globe and Mail, Maclean's *and* Reuters. *Harry Wilson (@MrWilsonH) is* Canadian Geographic*'s senior editor.*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Photos By David Bastedo

Clockwise from TOP: Head of conservation Carmen Li installs an exhibit at the new museum; embroidered mittens get a light-sensitivity test, part of the exhibit-planning process; protected clothing awaits display.

Learn more about what the future could hold for the old Royal Alberta Museum building at cangeo.ca/ma18/ram.

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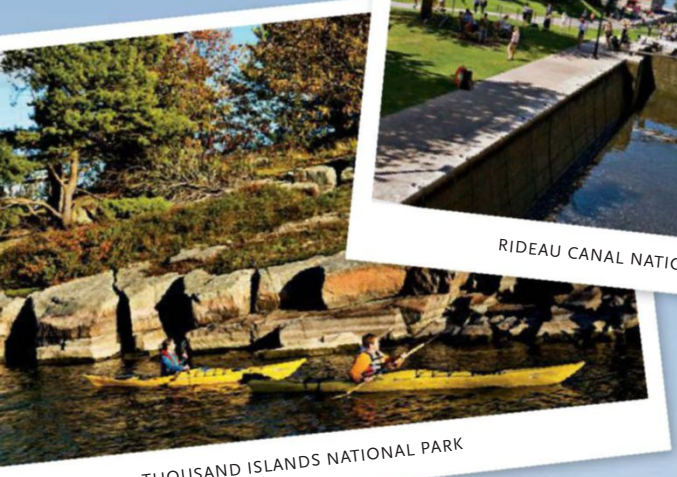
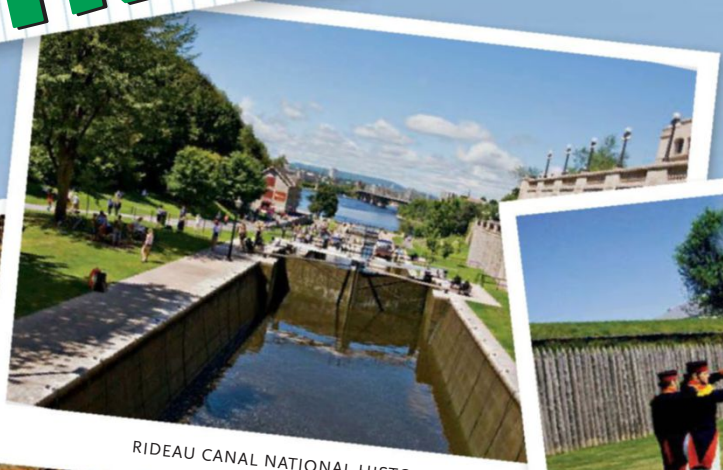


THOUSAND ISLANDS NATIONAL PARK



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The class that wins the **grand prize** will head on an all-expenses paid trip to Parks Canada places in and around Ottawa.

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TRACING THE NILE

This August will mark the 160th anniversary of John Speke's claim to have found the source of the world's longest river, an assertion that created one of the great myths and legacies of Victorian-era exploration

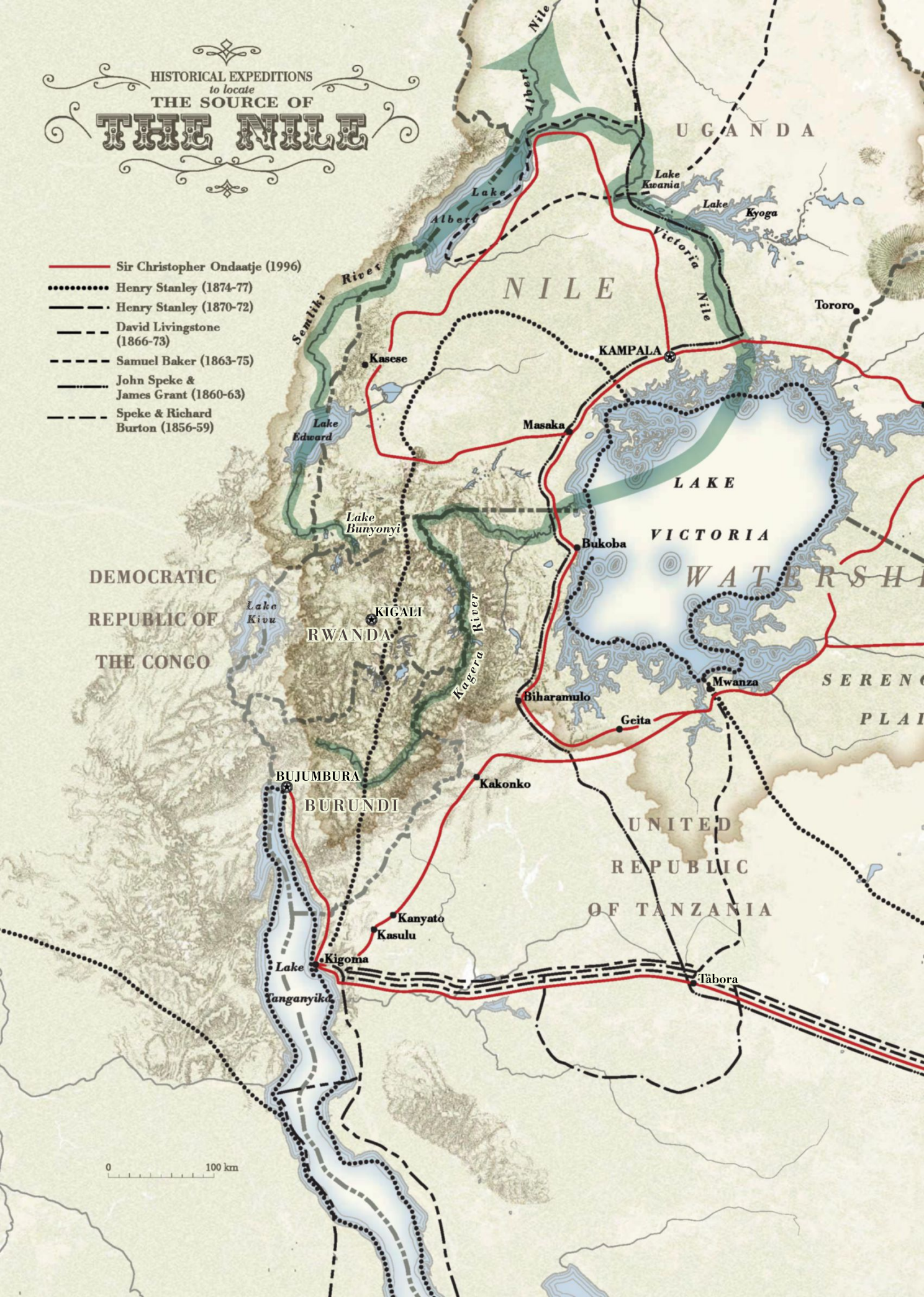
BY SIR CHRISTOPHER ONDAATJE

"The caravan, after quitting Isamiro, began winding up a long but gradually inclined hill ... until it reached its summit, when the vast expanse of the pale-blue waters of the Nyanza burst suddenly upon my gaze ... I no longer felt any doubt that the lake at my feet gave birth to that interesting river, the source of which has been the subject of so much speculation, and the object of so many explorers."

— John Hanning Speke, "Captain J.H. Speke's Discovery of the Victoria Nyanza Lake, the supposed source of the Nile. From his journal," *Blackwood's Edinburgh Magazine*, October 1859.

[illegible] HANNIN[illegible]PEKE, the English explorer who clai[illegible]ave discovered [illegible] source of the Nile just 15 months bef[illegible]ords above were [illegible]ublished, actually do so?

I [illegible]rs before me hav[illegible] long believed he did not, a conclusio[illegible]ut by my expedi[illegible]on to Africa to follow in the footste[illegible]orers such as Sp[illegible]ke, Richard Burton, James Grant, Sar[illegible]er, David Living[illegible]one and Henry Stanley, a story I told in my 1998 book *Journey to the Source of the Nile*. As is now [illegible]owledged, the Nile is sourced by not one lake, as


HISTORICAL EXPEDITIONS
to locate
THE SOURCE OF
THE NILE
Sir Christopher Ondaatje (1996)
Henry Stanley (1874-77)
Henry Stanley (1870-72)
David Livingstone (1866-73)
Samuel Baker (1863-75)
John Speke & James Grant (1860-63)
Speke & Richard Burton (1856-59)
UGANDA
Albert Nile
Lake Albert
Lake Kwania
Lake Kyoga
Victoria Nile
NILE
Semliki River
Tororo
KAMPALA
Kasese
Masaka
Lake Edward
LAKE
VICTORIA
WATERSHED
Lake Bunyonyi
Bukoba
DEMOCRATIC
REPUBLIC OF
THE CONGO
Lake Kivu
KIGALI
RWANDA
Kagera River
Mwanza
SERENGETI
PLAIN
Biharamulo
Geita
BUJUMBURA
BURUNDI
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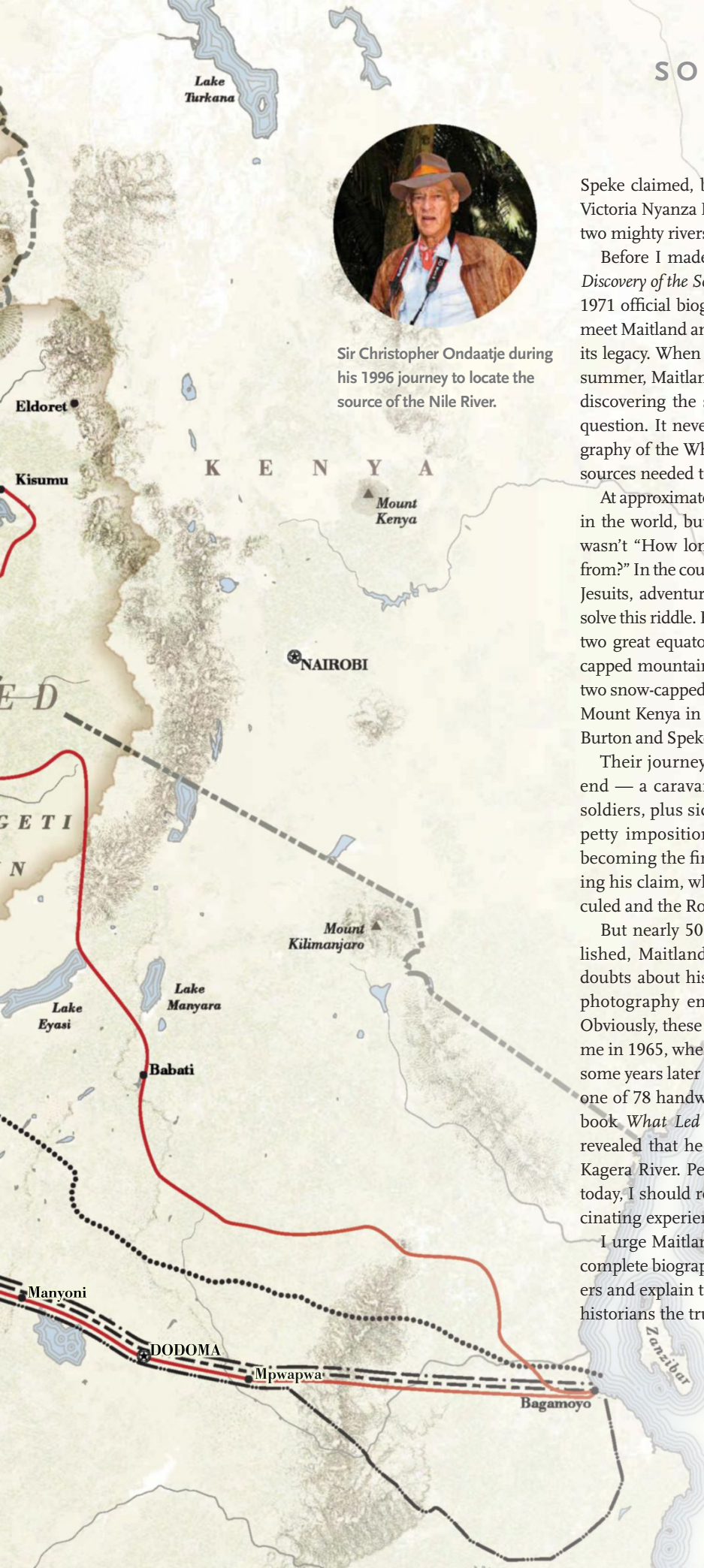

Sir Christopher Ondaatje during his 1996 journey to locate the source of the Nile River.

Speke claimed, but two — Lake Victoria (the aforementioned Victoria Nyanza Lake) and Lake Albert, which are in turn fed by two mighty rivers, the Kagera and the Semliki.

Before I made my Nile trip in 1996, I'd read *Speke and the Discovery of the Source of the Nile*, Alexander Maitland's gripping 1971 official biography of Speke, which had made me want to meet Maitland and discuss Speke's source-of-the-Nile claim and its legacy. When I finally had the chance to do so at length last summer, Maitland told me that, "In the 1960s, Speke's claim to discovering the source of the Nile was still accepted without question. It never occurred to me at that time that the hydrography of the White Nile [a tributary of the Nile proper] and its sources needed to be re-investigated."

At approximately 6,700 kilometres, the Nile is the longest river in the world, but before 1858 the great geographical question wasn't "How long is it?" but "Where does all its water come from?" In the course of centuries, Roman legionaries, Portuguese Jesuits, adventurous Scots and erudite Frenchmen all tried to solve this riddle. Herodotus quoted a story that the Nile rose from two great equatorial lakes that in turn were fed by two snow-capped mountains. Thus, following the European discovery of two snow-capped mountains — Mount Kilimanjaro in 1848 and Mount Kenya in 1849 — the Royal Geographical Society chose Burton and Speke to lead an expedition to find the Nile's source.

Their journey is the stuff of Victorian-era exploration legend — a caravan of about 20 porters and an escort of local soldiers, plus sickness, desertion, arguments and seemingly petty impositions by chiefs — but it did result in Speke becoming the first European to reach Lake Victoria and making his claim, which many of his peers disputed, Burton ridiculed and the Royal Geographical Society eventually accepted.

But nearly 50 years after his biography of Speke was published, Maitland wonders whether the explorer had private doubts about his own claim. "Today, technology and satellite photography enable us to view the region in great detail. Obviously, these weren't available to Speke in the 1860s, nor to me in 1965, when I began my research for his biography. Only some years later was my attention drawn to an intriguing note, one of 78 handwritten corrections in Speke's own copy of his book *What Led to the Discovery of the Source of the Nile*. It revealed that he had wondered about the significance of the Kagera River. Perhaps with all the knowledge available to me today, I should rewrite Speke's biography — it would be a fascinating experience."

I urge Maitland to do this. It would allow him to present a complete biography of one of the Victorian era's greatest explorers and explain to a whole new generation of geographers and historians the true mystery of the source of the Nile.

Explore an interactive version of the map that appears on these pages at cangeo.ca/ma18/nile.

PHOTO FINISH

CANADIAN LANDSCAPES | WINNER

Ramtin Kazemi
Snow clouds diffuse the early morning light over (left to right) Haddo Peak, Saddle Mountain and Fairview Mountain in Banff National Park, Alta.

CANADIAN GEOGRAPHIC PRESENTS THE WINNERS OF ITS **32ND ANNUAL PHOTO COMPETITION**

Brilliant auroras on a night when the forecast called for clouds. The patient gaze of a bighorn sheep as you round a bend in a mountain trail. A perfectly timed lightning bolt. These are the moments photographers live for, the ones that get them out of bed before dawn, keep them out long past sunset and compel them to drive and hike hundreds of kilometres every year in search of the perfect shot. And while the unexpected and serendipitous seemed to be a unifying theme among the images favoured by our judges — *Canadian Geographic*'s creative director Javier Frutos, *Canadian Geographic* Photographer-in-Residence Michelle Valberg and Ottawa-based travel and lifestyle photographer Julia Weber — the five winning photos are also a testament to the skill and determination of the photographers. We are once again proud to present the winners of our Annual Photo Competition.

See the honourable mentions from the 32nd Annual Photo Competition at annual17.canadiangeographic.ca

CANADIAN LANDSCAPES | RUNNER-UP

James Anderson
Clouds over Cascade Mountain in Banff National Park, Alta., are tinged orange at sunset.

FLORA AND FAUNA | RUNNER-UP

Stuart Clark
A female humpback whale breaches in the Strait of Georgia near Read Island, B.C.

FLORA AND FAUNA | WINNER

Ron Good
A bighorn sheep stands on a mountainside west of the Kootenay Plains natural area in western Alberta.

ACTIVE OUTDOORS | WINNER

Eric Poulin
The aurora borealis dances over a campsite on Mount Sproatt near Whistler, B.C.

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is either a
daring
ADVENTURE
or nothing
Helen Keller

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URBAN CANADA | WINNER

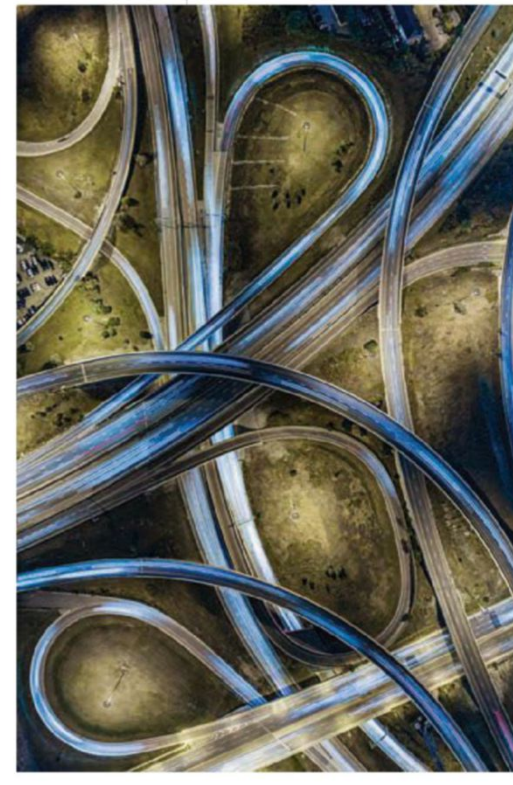
Marianna Armata
A man is reflected in a puddle while walking in Montreal's Parc René-Lévesque on a foggy winter evening.

URBAN CANADA | RUNNER-UP

Gary Cummins
From above, the Queen Elizabeth II Highway west of Toronto is an intriguing tangle of interchanges.

ACTIVE OUTDOORS | RUNNER-UP

Ray Majoran
Cottagers jump in for an early morning swim in Clearwater Lake, Port Sydney, Ont.



ADVENTURES

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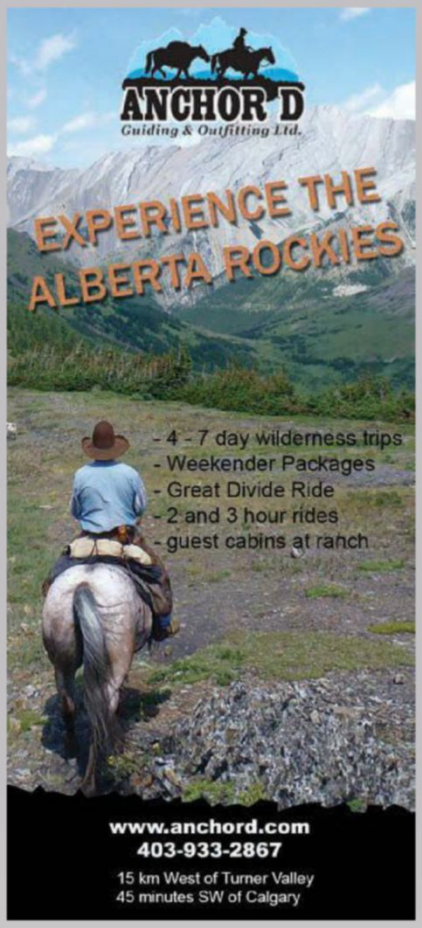

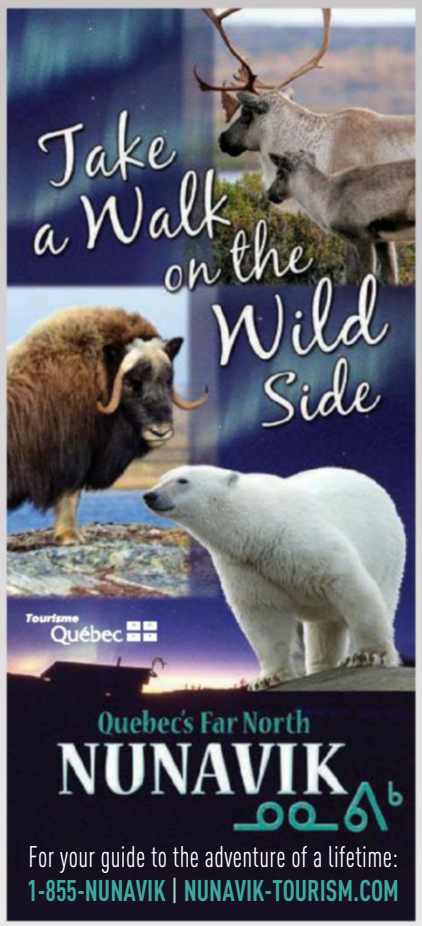

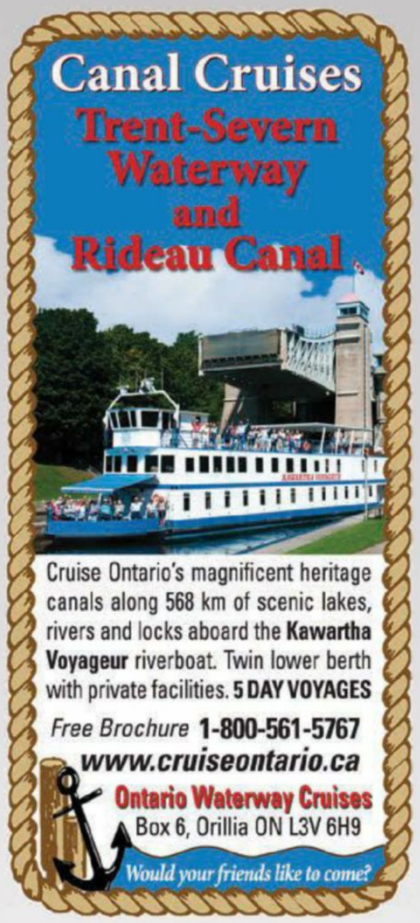

WILD WEATHER | WINNER

Ryan Wunsch
Lightning strikes near a grain elevator during a summer thunderstorm in Leader, Sask.

WILD WEATHER | RUNNER-UP

Mark Jinks
Mammatus clouds sweep over an open field near Pine Lake, Alta., after a severe thunderstorm.

A word about our prize sponsors

It took more than the talents of our readers to make the 32nd *Canadian Geographic* Annual Photo Competition a success. We appreciate the generous support of our prize sponsors and thank them for their participation.

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COMMENT

Your feedback

Great Trail tales

I love this issue (January/February). So many beautiful photos. And so many fun memories of this past summer as my family and I travelled the #LakeSuperiorWaterway.

—@lauradeeves

I appreciate the wonderful work done by Gordon Macdonald and his team ("The man who saved the Kinsol Trestle," cangeo.ca), but I consider Cowichan Valley historian T.W. Paterson to be the man who saved it. It was his 10 years of dedicated work that made the rebuilding of the trestle even an option.

Dira McClintock
Duncan, B.C.

Interesting article about the restoration of the Kinsol Trestle. It should be mentioned that the trestle is in Shawnigan Lake and that the museum there is the place to go for information about the trestle. Lori Treloar, who is the museum's curator, and her husband Grant have created school programs where children assemble models of the trestle's vertical supports and participate in other trestle-related activities before they visit the structure.

Sally Davies
—via cangeo.ca

I commend you on your spirit of adventure, Dianne ("500 Days in the Wild," facebook.com/cangeo), and sharing your love of this land and our people. Safe travels on The Great Trail! Oh Canada!

Bill Franz
Red Deer, Alta.

Wow — you did this alone! Amazing. You go girl!

Audrey Hollasch
Richmond Hill, Ont.

Residential Schools reflection

Thank you for the hard work that went into the Indigenous-themed issue (November/December 2017). I know that many Canadians still do not know the truth about residential schools. I truly appreciate and honour the strength of the members of the Survivors Circle that you shared with all Canadians.

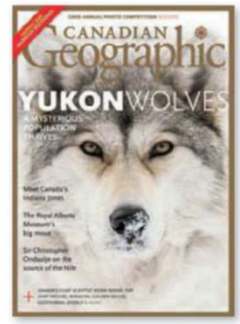
Tara Muir
Oshawa, Ont.

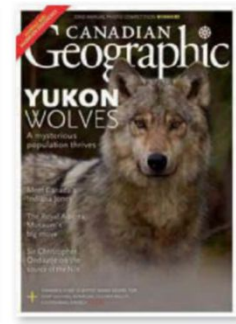
Correction:

On page 22 of the January/February 2018 issue, details about a new park on Vancouver Island park were incorrect. The park should have been referred to as the Sooke Hills Wilderness Regional Park, not the Sooke Hills Wilderness Park Reserve. The park had been in "park reserve" status for 20 years before opening to the public in June 2017.

COVER VOTE

How we chose this issue's cover





Well, this was unexpected. Option one in the cover vote for the March/April 2018 issue of *Canadian Geographic*, the close-up shot of the subject above, took 64 per cent of the tally, clearly winning the competition. But in fact checking the information that had been provided to us, it turned out that the subject was not a Yukon wolf in a sanctuary, but a wolf dog. That disqualified it. Enter option three, a verified Yukon wolf, which had finished second in the tally with 22 per cent (option two earned just 14 per cent), to claim the coveted spot. Creative director Javier Frutos then integrated the gold frame and text treatments — as recommended by newsstand consultant Scott Bullock to help the cover image pop — with an eye toward including some of the features likely responsible for option one's initial success. Here's hoping the gold was what really won the hearts of voters, and that it will have the same impact on the newsstands.

Not already receiving our cover vote email? Visit cangeo.ca/newsletter and sign up for the *Canadian Geographic* newsletter to get in on the action.

CONTACT US

1155 Lola Street, Suite 200,
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Comments may be edited for length and clarity.

THIS PAGE, COVERS, LEFT TO RIGHT: SHARIF GALAL; JOE BISHOP; NICOLAS DORY.
OPPOSITE PAGE, LEFT: ROYAL ALBERTA MUSEUM; RIGHT: COURTESY FORT EDMONTON PARK

WHAT'S THIS?

Recognize this mystery object and how it relates to Canadian geography and history?

- Visit cangeo.ca/whatsthis for a hint, to enter your guess and for a chance to win one of three copies of *The Ultimate Canadian Geography Quiz* special issue.* Follow us on (@CanGeo) for more hints.
- The deadline is April 16, 2018.
- The correct answer will appear in the May/June 2018 issue.

*Three winners will be randomly selected from all correct responses.

Canadian Geographic and the Canadian Heritage Information Network have partnered to showcase important artifacts from Canadian history and geography. Each object comes from one of the museums in CHIN's national network.

LAST ISSUE'S OBJECT: Red River cart

Red River carts were used by Métis people of the Red River Settlement, located on the Red and Assiniboine rivers in what is now Manitoba, and were a key mode of transportation for travellers going west during the fur trade and settlement eras. Red River carts were constructed without any metal, so repairs could be made easily while travelling in the wilderness, and were usually pulled by oxen, although horses were used for longer trips. This reproduction cart housed at Fort Edmonton Park along Edmonton's river valley was crafted by Indigenous students at the city's Amiskwaciy Academy.

With files from Fort Edmonton Park. Learn more about this artifact and others by visiting fortedmontonpark.ca.

Explore more stories from Canada's past through cangeo.ca/whatsthis.

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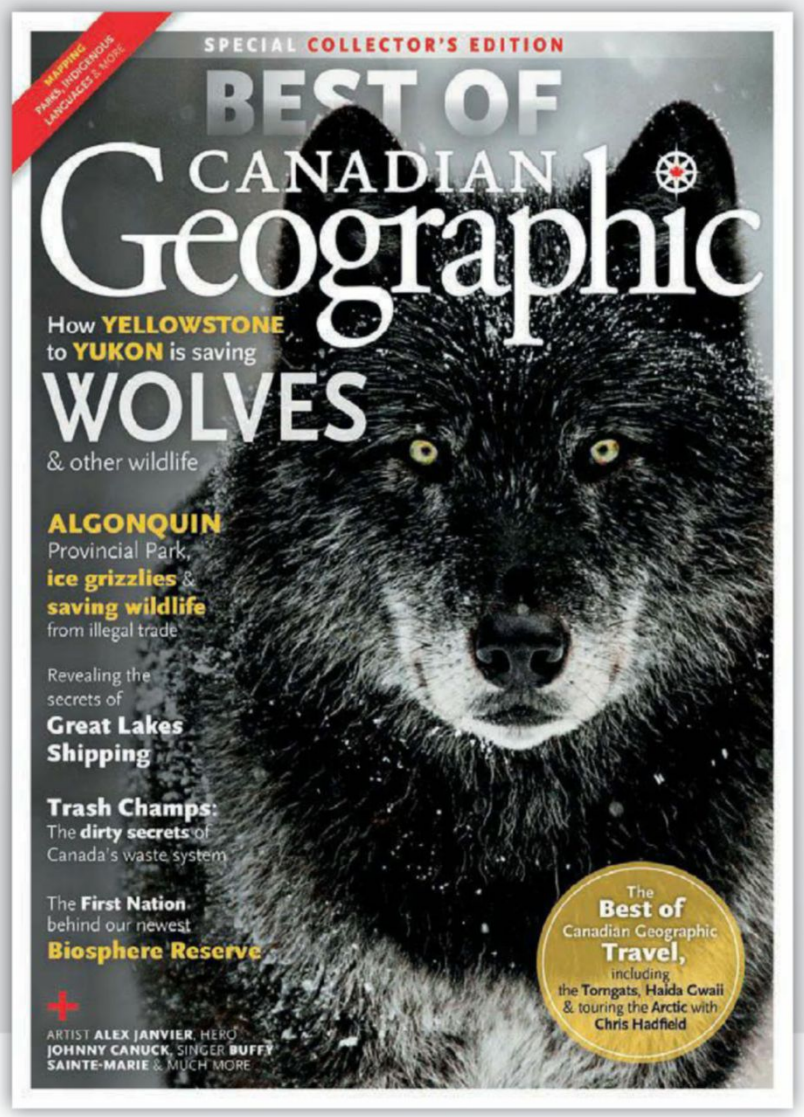

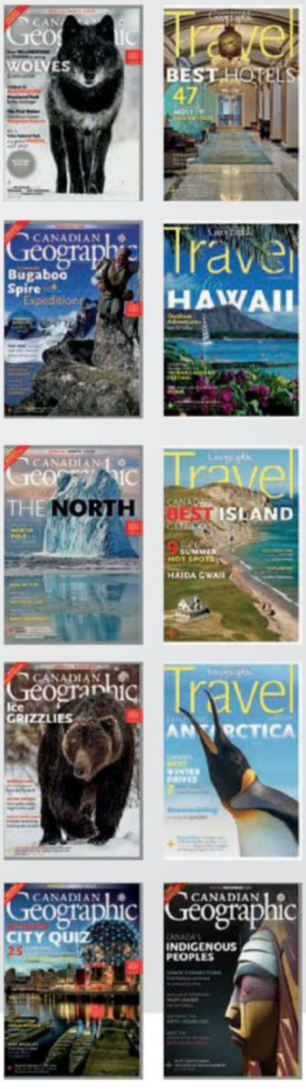

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YOUR SOCIETY

NEWS FROM THE ROYAL CANADIAN GEOGRAPHICAL SOCIETY

THE INAUGURAL VOYAGE OF RCGS *RESOLUTE*

For its first voyage as an RCGS-flagged vessel, One Ocean Expeditions' RCGS *Resolute* is turning south to explore the White Continent. Antarctica Off the Beaten Track, a 13-day expedition from the southernmost tip of South America to explore the west coast and islands of the Antarctic Peninsula, departs on Nov. 16.

"With one of the highest ice-class ratings of any passenger vessel, RCGS *Resolute* is ideally suited to begin her voyages in Antarctica," says Andrew Prossin, founder and managing director of One Ocean Expeditions. "The region is very close to our hearts, and where our programming began over 10 years ago." For more information, visit oneoceanexpeditions.com/antarctica.

—Nick Walker

A GEOGRAPHICAL MOU WITH SCOTLAND

It's a transatlantic handshake between societies with rich histories and common ground. Signed in Ottawa in late 2017, the MOU opens the door to collaboration between the Royal Scottish Geographical Society and RCGS. "There are so many links between Scotland and Canada," says RSGS CEO Mike Robinson (ABOVE, left), "and a great willingness to forge greater friendships still." Go to cangeo.ca/ma18/rsgs for more.

—N.W.

RCGS-SPONSORED BISARO ANIMA CAVE EXPEDITION SETS RECORD

On Jan. 1, 2018, Kathleen Graham descended 670 metres into the Bisaro Anima Cave, near Fernie, B.C., establishing a new record for the deepest cave in the country. She and her eight team members made the discovery during the latest expedition of the multi-year Bisaro Plateau Caves Project, which is supported by the Alberta Speleological Society and this year received funding from The Royal Canadian Geographical Society. The team expects further exploration to take them even deeper. To read more, visit cangeo.ca/ma18/bisaro.

—Michela Rosano

MAPPING CANADA'S HISTORY OF RESIDENTIAL SCHOOLS

With the support of the National Centre for Truth and Reconciliation, Canadian Geographic Education recently became the first Canadian organization to launch a story with Google Earth Voyager. *Canada's Residential Schools* addresses a dark chapter in our history, weaving photographs and videos with first-hand accounts from survivors. It aims to help educate all Canadians about these schools and to inspire Indigenous and non-Indigenous people to work together toward reconciliation. Go to cangeo.ca/ma18/voyager to explore the Google Voyager story.

—Tanya Kirnishni

CLOCKWISE FROM TOP LEFT: JAVIER FRUTOS/CAN GEO; JARED HABIAK/BISARO PLATEAU CAVES PROJECT; LIBRARY AND ARCHIVES CANADA, MIKAN: 3191693; BEN POWLESS/CAN GEO

FEATURED FELLOW: MERIC GERTLER

Meric Gertler has been president of the University of Toronto since 2013.

University of Toronto president Meric Gertler is a world leader in urban theory, focusing on the geography of innovation, creativity and culture in city centres as economic drivers. Besides authoring, editing and co-editing several influential books and dozens of academic publications, he has been an advisor to North American and European governments, to the European Union and the Organisation for Economic Co-operation and Development, in Paris. Here, he discusses leveraging U of T's urban location and reimagining education in that light.

On the benefits of the urban location

As an urban geographer, it seemed obvious that one of U of T's greatest assets was that it has three major campuses in the middle of one of the world's most dynamic and diverse metropolitan regions. There are all kinds of opportunities on our doorstep, real-life problems that not just our faculty but also our students, in programs such as architecture, geography, urban studies or civil engineering, can and do work on. In the process, they're not only deriving fantastic experience, they're helping improve our communities and working with our partners.

On the challenge of student commutes

Collectively, Toronto's four universities (U of T, York, Ryerson and OCAD University) have about 180,000 students enrolled, the vast majority of whom commute to and from their campuses. And we knew, anecdotally, that they've been spending *a lot* of time commuting, which means less time for studies and otherwise engaging with life, on or off campus.

So I "enticed" the other universities' presidents to collaborate with us to help tackle this. We jointly commissioned, funded and implemented the first-ever study of daily travel patterns of university students in the GTA. We now have a fantastic database that we've shared with the City, Toronto Transportation Commission and MetroLinks to help inform planning.

On the university's part in the wider city

You can think of U of T, both figuratively and literally, as a city-building organization. We have about a billion dollars' worth of capital projects underway. As we build new buildings or renovate old historic properties, we're thinking a lot more systematically about how that can improve the quality of the built environment and the experience of Torontonians. We also recruit about half our faculty and a quarter of our students from around the world, so the more we do to make this city itself a draw, the more we help ourselves.

On the flip side: international experience

I think that the more Canadians who can travel and engage with the rest of the world directly, the better. And U of T isn't doing too badly in that regard: we reckon that 15 to 16 per cent of our undergraduates will have some kind of international experience while they're here. But we would love to double or triple that. We are leveraging our global connections, deepening partnerships with other great universities around the world to facilitate more international, experiential opportunities for our students.

—Interview by Nick Walker

LISA SAKULENSKY/UNIVERSITY OF TORONTO

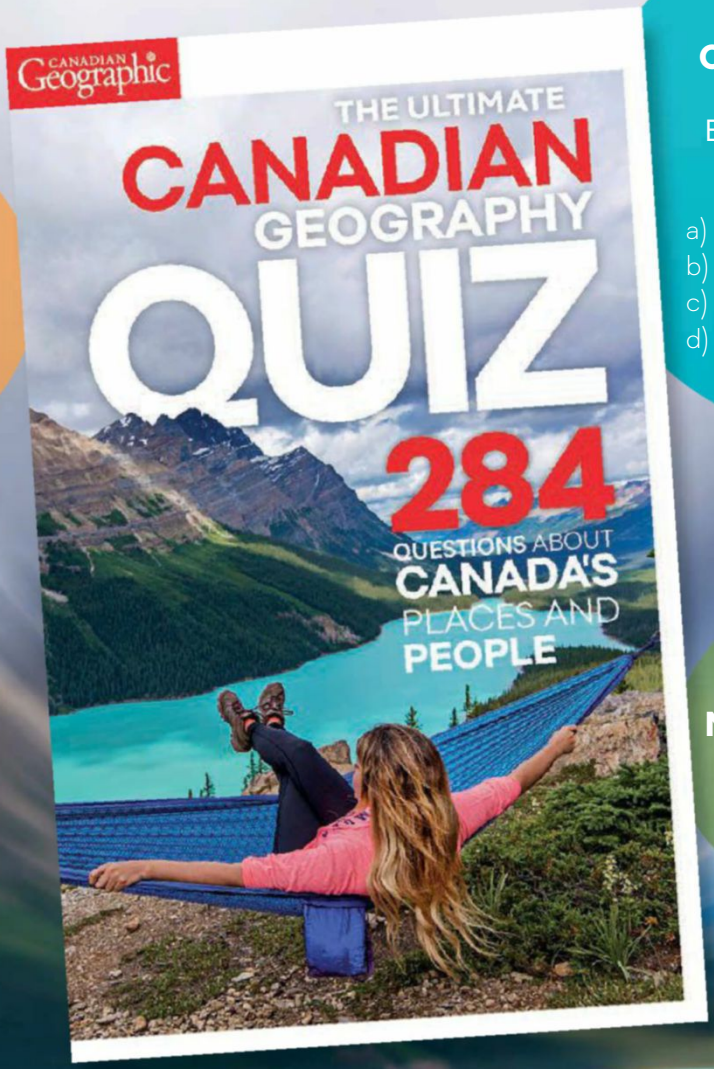
ARE YOU A

GEO GENIUS?

TUKTOYAKTUK is a **small Inuvialuit hamlet** located in which territory?

What was the **ORIGINAL NAME OF LAKE LOUISE,** Banff National Park's most photographed lake?

a) Jade Lake
b) Blue Lake
c) Turquoise Lake
d) Emerald Lake



IS A MUMMICHOG a bird, fish, seal or mollusc?

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MAY/JUNE 2018

Canadian Geographic dives into expeditions

Members of the Enduring Ice expedition make their way across Arctic sea ice near Ellesmere Island (TOP). Adam Shoalts paddles the Mackenzie River during his Trans-Canadian Arctic expedition (ABOVE).

Trapped. Days in tent
Wind screaming like angry wraith
Wish I had a book

This simple haiku published on the Enduring Ice project's expedition log marked the sixth excruciating day that an extreme windstorm had trapped members of The Royal Canadian Geographical Society's 2017 Expedition of the Year at the north end of the Kennedy Channel on eastern Ellesmere Island.

In desperation, Stephen Smith, Diana Kushner, Christopher Horvat, Michael Dillon and Bryce Dillon, who were just days from finishing their 33-day scientific research and documentary film project, made an attempt at escaping "Arctic jail" that evening. They paddled their kayaks into fierce headwinds for an hour and had made it just two kilometres when powerful gusts whipped swells of black water into frothy whitecaps. Faced with a losing battle against the wind, the team surrendered and set up camp in a nearby river valley.

That hardship paled in comparison to the environmental threats revealed by the unstable ice pack that expedition members encountered every step of the way. Read their compelling story about dramatic changes in Arctic sea ice and the epic tales of the five other expeditions funded by the Society in 2017 in the upcoming May/June issue: RCGS Explorer-in-Residence Jill Heinerth's sub-zero dives along the coasts of Baffin Island, Labrador and Newfoundland; Adam Shoalts' solo trek along the Arctic Circle; John Dunn's 70-day skiing and hiking marathon across the Boothia Peninsula and Somerset Island; Dianne Whelan's cross-Canada traverse of the entire 24,410-kilometre Great Trail; and Dave Pearson's source-to-saltwater voyage from British Columbia's Monarch Icefield to the Pacific Ocean, 100 kilometres downriver.

It's an adventure-filled issue sure to spark your own explorations this summer.

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The May/June 2018 issue hits newsstands in April.

TOP: ENDURING ICE; BOTTOM: ADAM SHOALTS

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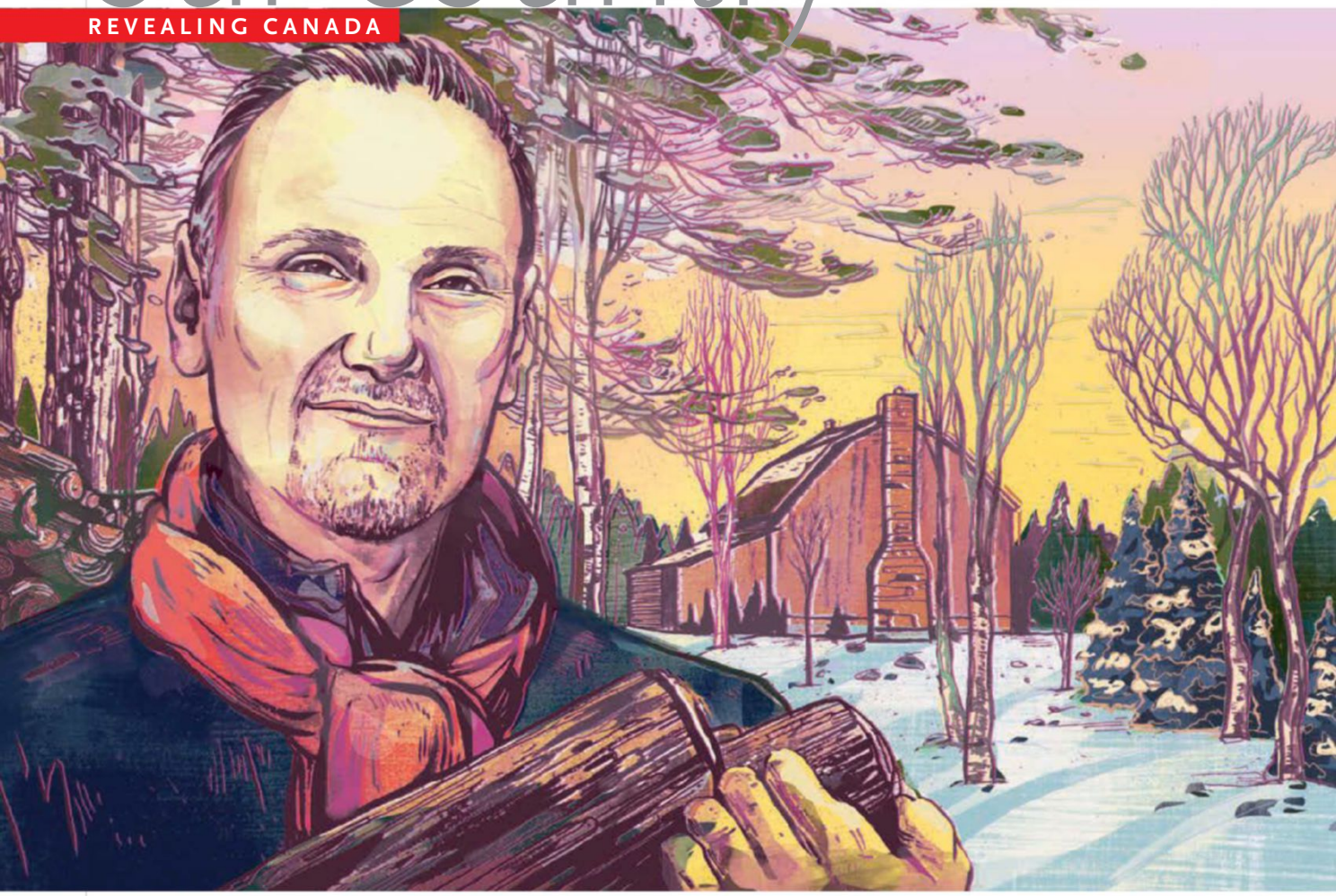

Michael Bonacini

The celebrity chef and *MasterChef Canada* judge reminisces about escaping to rural living in Caledon, Ont.

I have a country home in the bucolic hills of Caledon, Ont., about 60 kilometres northwest of Toronto. I really connect with the beauty here and what it has to offer, like the quirky and wonderful people I've made friends with. It really is a great part of the world. I love coming up, as do my wife and son. Going there is really about getting back into the countryside, where things move at a slightly slower pace and the air seems fresher, the trees greener, the wildlife more plentiful.

I've never been the kind of guy to sit for too long on the back deck with a beer or a book. I always have a job going. And here it's the kind of jobs I can't do in the city. Cutting the grass, planting trees, building a stone wall, tidying up the barn. Just these outdoor jobs that I love to do. Splitting firewood, stacking firewood and making a fire when it starts to get chilly … there is nothing more satisfying and gratifying. They're all sort of rituals that I don't find chores. I actually look forward to them.

I also have wonderful neighbours. A neighbour farmer friend taught me how to plow. I have a local beekeeper who comes to see me. I hike with a group of guys weekly. I feel very much a part of this community and I feel welcome here. The group of friends we hang out with in Caledon have a favourite little cidery down the road and a coffee shop in the village, a bakery we stop at when we're on our cycling tours, a friendly neighbourhood pub. It's unique little destinations like these that make it extra special. I never tire of coming here.

—As told to Aaron Kylie

What's your favourite Canadian place? Tell us on Twitter (@CanGeo) using the hashtag #ShareCanGeo.

Or share it with us on Facebook (facebook.com/cangeo).

JACQUI OAKLEY/CAN GEO

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