CONTENTS

	Introduction	1
1	Ice Age Extinction and Migration	16
2	Did Humans Drive Mammoths and Ice Age Animals to Extinction?	42
3	La Brea Tar Pits, “The Death Trap of the Ages”	61
4	Highflyers, Ultramarathoners, and Feathered Vagabonds	77
5	Like Moths to a Flame	101
6	Shift Happens	116
7	Caribou Culture	133
8	A Tale of Two Bears	152
9	Carnivore Connectivity	168
10	Rewilding: Don’t Fence Me In	189
11	Refugia	208
12	Duck Dynasty	223
	Conclusion	237

Acknowledgements 257

Notes 259

Index 271

About the Author 297

Introduction

> Ruled by all-wise laws, every animal fills its appointed place exactly, existing not alone for itself, but forming a necessary part of the vast system of Nature. One class of animals keeps in check certain plants; others prevent the too great increase of these, while those having few enemies are not prolific. Man interferes unwisely, and the border is broken.
>
> —ROBERT KENNICOTT, *QUADRUPEDS OF ILLINOIS, INJURIOUS AND BENEFICIAL TO THE FARMER* (1856)

In the winter of 2020, Inuit hunters in Canada's Central Arctic came across the frozen carcasses of eleven bowhead whales. These enormous marine mammals have made a slow but steady comeback since they were driven to the brink of extinction by late nineteenth- and early twentieth-century whalers. Unsure of what had killed the whales, the hunters contacted officials at Fisheries and Oceans Canada. Marine biologists working for the federal government agency were prevented from flying up because of the COVID quarantine. They instead examined photos and tissue samples the Inuit sent.

There was no smoking gun, according to scientist Jeff Higdon. But everyone agreed that the killers were very likely orcas, relative newcomers to this part of the High Arctic. What made this even more intriguing, according to scientist Steve Ferguson, who headed up the study, was that these killer whales were likely members of a previously unknown, but genetically distinct subspecies that migrated into the Arctic from as far away as Spain. They prey on large mammals rather than fish and seals, like orcas in other parts of the Arctic. If their numbers continue to grow, this new subspecies could upend the food web, affecting Inuit subsistence hunting and threatening endangered whale populations.

FIGURE 0.1. In the winter of 2020, Inuit hunters in Canada's Central Arctic came across the frozen carcasses of eleven bowhead whales that had been attacked by a pod of killer whales. Killer whales had never been seen in this part of the world. Photo courtesy of Lenny Aqigiaq Panigayak.

But that was not the most interesting part of this story.

According to University of Manitoba evolutionary geneticist Colin Garroway, the genetics extracted from the tissues indicate that this "new" subspecies in the Arctic is not actually new. Its origins date back to the last Ice Age, or the last Glacial Period, which occurred between 120,000 and 11,500 years ago. It was the last of multiple periods of glaciation during the so-called Pleistocene epoch (2.6 million to 11,500 million years ago).

"The truth is [the killer whales] were likely always there and looking for an opportunity to get back to places they used to hunt before sea ice prevented them from doing so. They are relics of the last Ice Age that may be trying to go home," Garroway told me when we spoke.

What triggered the movement of these whales? Genetics and environmental factors often compel an animal to move away from its original point of origin and then back to the same place. This must happen over and over again on a seasonal basis to fit the classic definition of migration. Dispersal, on the other

hand, occurs when animals move from one region to another without returning, at least in the short term. Drought, disease, major landscape changes, and warming water in rivers, lakes, and oceans can trigger this kind of movement.

Zugunruhe is a German word that typically applies to the singing, squabbling, flocking, and fighting that take place among migrating birds in spring. This migratory restlessness in birds and other animals is triggered by genes, light, temperature, and large-scale atmospheric disturbances called Rossby waves. Today, this restlessness is being amplified by sea and landscape changes due to a climate that is warming even faster than it did by the end of the last Ice Age when thirty-eight genera (groups of closely related species) of large animals in North America, and many others dwelling on other continents, disappeared. Five smaller species such as *Aztlanolagus agilis*, a two-kilogram rabbit, and *Capromeryx minor*, an antelope that weighed less than a Corgi, did so as well in the American Southwest and Mexico.

Most migrating species are either staking out new territory, altering their migrations, or simply returning to their old Ice Age habitat—as those killer whales may be doing.

It's not exactly new. Animals have been on the move since the last Ice Age, dispersing to new places or altering their migrations when surging glaciers, sea ice retreat, predators, vegetation changes, wildfires, or weather made the normal routes either too challenging or impossible.

The more opportunistic sometimes venture into new territory. The barred owl, not a typical migrant, has done just that over the past century and a half, as forests replaced grasslands following the near extinction of the plains bison and the rise of wildfire suppression, which allowed trees to take over. The big owl, often referred to as the "hoot owl" because of its "Who cooks for you? Who cooks for you?" call, first showed up in the Yellowstone region in the 1870s, likely coming from the American Midwest before moving into northern Montana around the turn of the century, west to Idaho, Oregon, and Washington in the 1970s, and then north to Alaska and the Northwest Territories.

Even more rare are long-distance dispersals, where a so-called vagrant appears well outside of its normal geographical range. This often happens to nocturnal migrants, usually inexperienced juvenile birds, that might lose sight of landmarks such as shorelines. It can also occur when variations in the earth's magnetic field disorient a bird that uses magnetoreception along with vision to know which direction to fly. Canadian national park biologist Mark Bradley has documented several examples of these unexpected visits in Jasper National Park in the Rocky Mountains of Canada. The most surprising was a crested caracara,

a medium-sized raptor rarely seen north of the Mexican border, that showed in 2015. It was not the bird's only visit to Canada. Another crested caracara was spotted in northern Ontario a decade later. The closely related yellow-headed caracara, which dwells farther south from Panama to Uruguay, does not even appear in North American field guides. It is also on the move showing up recently in states like Florida and Texas and as far north as Delaware.

Occasionally, vagrants manage to colonize new territory. For instance, 90 percent of all elegant terns nest in a single colony on Isla Rasa in the Gulf of California (Sea of Cortez), Mexico. "Screaming masses" of these birds are rarely found away from their range in the eastern North Pacific, but some colonies have been recorded along Atlantic shores in recent years, nesting in Spain and France on rare occasions.

While migrations and dispersals like these have been ongoing for millennia, what's been happening since the turn of the century is much more profound. *Zugunruhe* is playing out at warp speed as former ranges shift or diminish and as new ones open up. In places like the Arctic, warmer temperatures and less sea ice make the region more hospitable for many insects, fish, birds, and other animals.

I caught a glimpse of this in the High Arctic in the summer of 2000 when I was participating in a survey of raptors nesting on the tundra in Aulavik National Park on Banks Island. It was a year after the peregrine falcon had been taken off the endangered species list in both Canada and the United States. Parks Canada, the Canadian park service, was interested in knowing how many peregrines might be nesting there, so that a baseline for future monitoring could be established.

There were far more peregrines, as well as rough-legged hawks, snowy owls, and other birds than we expected to see. We found forty-eight species in all, and there were likely many more that we did not see. Not included on our list were the robins that were spotted on the southwest corner of the island. The Inuit had never seen them before in this area. The biggest surprise was short-eared owls nesting for the first time on Arctic islands.

As impressive as this was, the strange sightings continued. On the way home, I stopped to visit family in the Yukon. The discovery of a dead cougar and the fresh tracks of another earlier in the year confirmed reports of the big cat's unlikely arrival in the territory. It was not a one-off visit. Andy Williams, a pilot who has been ferrying scientists in and out of the mountains in Kluane National Park area for decades, told me he had seen one on a glacier—not hanging around, he joked, but clearly intent on finding a better place to be.

More surprises followed in the coming years with cougars moving east from Alberta and Montana into northern Ontario and Minnesota, testing the limits of their boundaries all the way to Connecticut in one remarkable case. The opportune sighting of a giant black witch, a moth rarely seen north of Texas, on the west coast of Hudson Bay in 2006, was so mind-bending that entomologist Chris Schmidt never fails to mention it to his students. The discovery occurred right around the time and not far away from where I was hanging precariously on a cliffside counting peregrine falcon eggs when I was attacked by yellowjacket wasps, another animal that one would not expect to see in this part of the Arctic.

With each year that passed, there was something new to marvel at: grizzly bears mating with polars bears and producing hybrids, such as the one that was shot off the coast of Banks Island in 2006; the gray whale in the North Pacific that somehow migrated east through the Northwest Passage before being spotted off the coast of Israel in 2010; the muskox that was found in Alberta in 2012. No one on record had ever seen one south of the 60th parallel.

Later that same summer, my companions and I sailed into the Inuit community of Arctic Bay looking to purchase fresh Arctic char. The Inuit there were not netting char, however, as I wrote in my book *Future Arctic* (2015). They were netting Pacific salmon, a fish previously foreign to the region. I thought I'd seen it all until a few years later when I saw a grizzly bear denning in the High Arctic and beavers venturing from the northern edge of the boreal forest onto the tundra in the western Arctic, building dams with thin branches of willow instead of spruce, pine, and aspen.

When I learned about the killer whales in the central Arctic, it was still a surprise, but it was no longer so shocking. I finally realized that these sightings were all part of a larger trend: the ranges of many animals were shifting.

In 2020, scientists from more than a hundred universities from seventeen countries began compiling three decades of terrestrial and marine animal tracking studies. This ongoing study makes it clear that at least ninety-six Arctic and sub-Arctic species are responding dramatically to warmer winters, earlier spring snowmelt and profound landscape changes by migrating earlier, farther afield, and in different directions.[1]

These new migrations, especially those over long distances, may not be providing the same benefits as migrations have in the past. Biologist Myrna Pearman has learned through decades of observations that the mountain bluebird has advanced the timing of its migration north by almost three weeks in

the past sixty years, arriving on the summer nesting sites when there is often still snow on the ground.[2] Clearly, there was no advantage in arriving early.

Geoff Holroyd, another biologist I have spent some time with over the past thirty years, reports that the least flycatcher in central Alberta is flying south two weeks earlier than it did three decades ago. Several biologists have confirmed that the migration routes of critically endangered southern mountain caribou herds have contracted or diminished over the past thirty-five years.[3]

Twenty-five studies conducted by another group of scientists identified some common themes related to these and other long-distance migrations: the journeys didn't always lead to more food as predictably as they had done in the past; they exposed the animals to more parasites and pathogens and put them at greater risk of predation than ever before; and they happened at a time when critical resting stopover sites like the Salton Sea and Owens Lake in Southern California were being badly degraded by drought and human developments.[4]

The current movement of these and many other animals throughout the world rivals those that occurred during the ice ages, the last of which ended about 11,500 years ago. During these periods, sea levels dropped by up to 360 feet, exposing a land bridge between Chukotka (eastern Russia) and Alaska. It allowed animals like woolly mammoths, steppe bison, the giant Yukon camel, and Beringian wolves to move from one continent to another in a vast ice-free refugia that came to be known as Beringia, the boundaries of which extended from Siberia and Chukotka into Alaska, the Yukon, and the Mackenzie Valley, and as far north as Banks Island. It was as big a game changer in evolution and biodiversity as the formation of the Isthmus of Panama three million years ago, which created a corridor for animals to migrate between South America into North America.

One might assume that the rapid spread of ice sheets that covered most of North America and other parts of the world would have been hard on these animals and the humans who hunted them. They often were. But Grant Zazula, a Yukon government paleontologist who knows as much about Ice Age animals as anyone, is quick to point out that during the peak of the last Ice Age between 27,000 and 19,000 years ago, not all was a "glacial hell" as most people assume. There was more biodiversity in Beringia than there is now. There were six large carnivores living there at this time: American lions, scimitar cats, cheetahs, Beringian wolves, grizzlies, and giant short-faced bears hunting mammoths, steppe bison, Saiga antelope, caribou, helmeted muskoxen, horses, and woolly rhinoceros, which migrated as far east as Chukotka 14,000 years ago and may have reached Alaska before it went extinct. Ancient black-footed

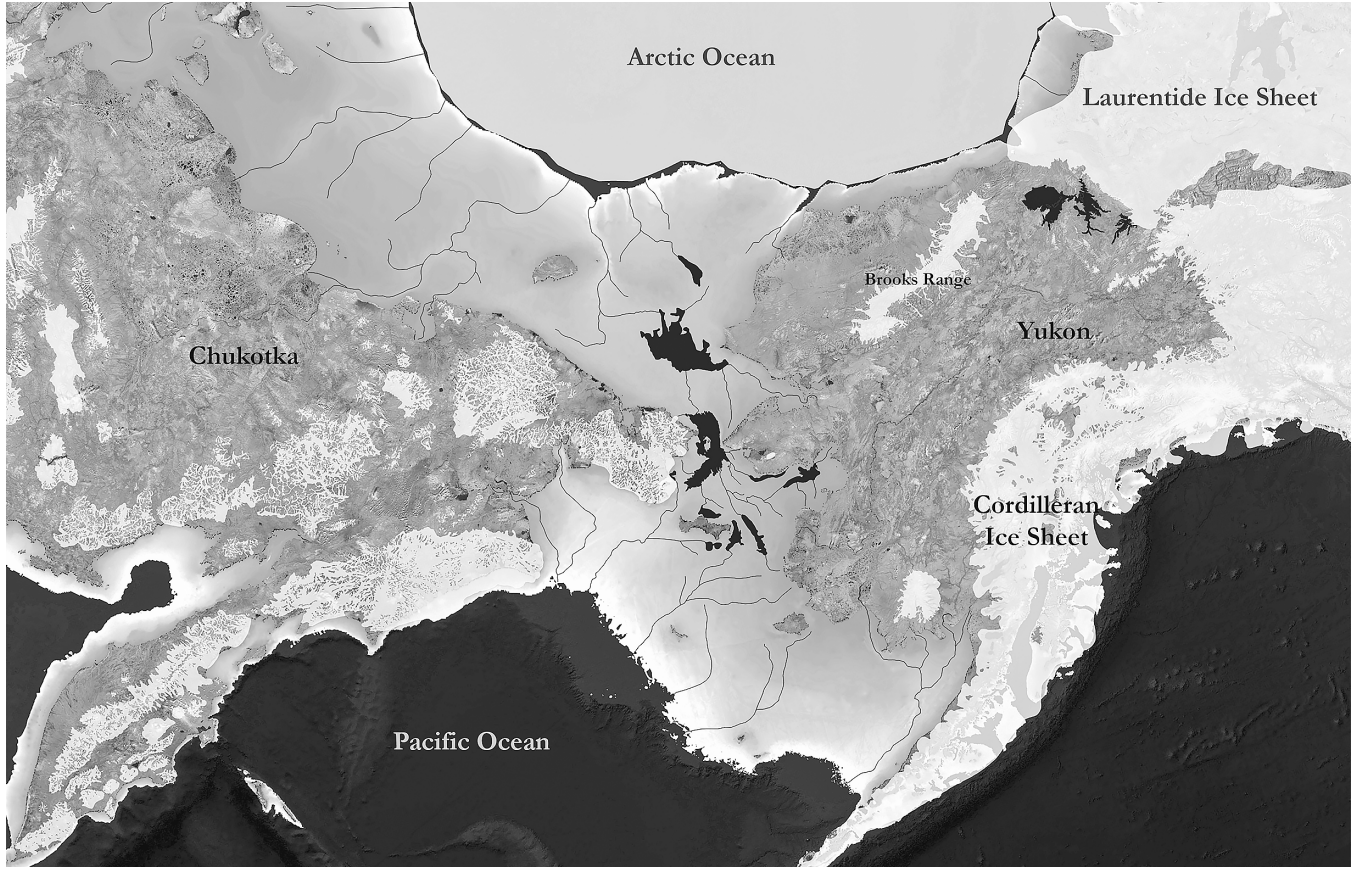

FIGURE 0.2. Map of Beringia. Courtesy of the Yukon Geological Survey, Government of the Yukon Territory and Jeffrey Bond.

FIGURE 0.3. *Beringia Winter Scene* by Rinaldino, © Government of Yukon, 1997. Original artwork by George "Rinaldino" Teichmann—Rinaldino Art Studios. Published by permission of Government of Yukon, Department of Tourism and Culture—Yukon Beringia Interpretive Centre, www.beringia.com.

ferrets, one of Zazula's obsessions, did not hunt prairie dogs as they do now. They hunted ground squirrels, which were plentiful at the time.

Most large Ice Age animals, like the woolly mammoth, steppe bison, scimitar cat, caribou, and giant short-faced bear persevered through the many violent swings in climate that occurred over the past 115,000 years. Some, like bighorn sheep, bison, and elk decreased in size through the last Ice Age.[5] Curiously, many others did not undergo the rapid physical changes that modern animals like the Galapagos finch and the hermit thrush have been undergoing in response to drought and higher temperatures.[6]

Most of those animals that went extinct or began to decline before and after the last Ice Age ended with variations in the amount of sunlight that reached the northern hemisphere. These small variations, which are driven by changes in the geometry of the earth's axis, triggered feedback loops that amplified the warming. Sea ice retreated and snow melted earlier, reducing the amount of sunlight that was reflected back into the atmosphere. As sea ice melted, the oceans warmed and released dissolved carbon dioxide, which trapped even more heat. As temperatures rose from 3 degrees to perhaps as much as 8

degrees Celsius (5–15 degrees Fahrenheit), permafrost thawed, releasing greenhouse gases that had been frozen in peat. In relatively short order, ecosystems were transformed by wildfire, floods, and by rising temperatures and a wetter climate that favored the growth of some trees and shrubs over the vegetation that thrived in drier, colder conditions.

Now that it is heating up even faster than it did at the end of the last Ice Age, there's good reason to believe that something as catastrophic will happen again.

Pinpointing the cause of these extinctions could provide vital clues into what might happen in the future as species continue to move, interact, and evolve in novel ways, and as the climate continues to warm dramatically. But that has been challenging because the fossil record of animals living and migrating during the Ice Age is scant and confined to a handful of treasure troves such as the Upward Sun River site in interior Alaska, Old Crow Flats and the Klondike gold fields in the Yukon, Fossil Lake in Oregon, the La Brea Tar Pits in Southern California, Pucuncho Basin in Peru, and Monte Verde in Chile. Some of the richest fossil sites are likely in coastal areas that are now underwater.

Ice Age science has historically suffered from neglect. The Pleistocene, the Ice Age period that began around 2.5 million years ago has been overshadowed in science and pop culture by the Triassic, Jurassic, and Cretaceous periods when dinosaurs ruled. Up until very recently, we knew more about T-rex than we did about the short-faced bears, American camels, and flat-headed peccaries (Ice Age pigs) that lived in the Beringian world. The existence of the Beringian Land Bridge connecting Siberia to Alaska was not firmly established until the mid 1960s, when humans knew enough about the Moon to plan and eventually land on it in 1969. A decent map of what Beringia looked like wasn't forthcoming until 2019, when the geography of many parts of the planet Mars had already been mapped in better detail.

Many other questions remain about Ice Age extinctions. For a long time, many scientists believed that humans were the main cause for these mass extinctions. Some still do.[7] Others point to vegetation changes that came so quickly because of a rapidly warming climate to which many animals didn't have time to adapt. Disease has been implicated, as has wildfires that burned bigger and more often in some places. Flooding of biblical portions that followed the retreat of glaciers would not have helped those dwelling on the fringes. It may have also cooled the warming oceans. A few continue to believe that an asteroid may have caused these extinctions. It may well be that

rain-on-snow events like those occurring more often today made it impossible for some animals to dig through an icy surface to get to food below.

Paradox prevails in our understanding of this past for a number of reasons. We tend to think of humans as always having been at the top of the food chain, instead of hunter-gatherers who may have relied more on scavenging injured animals or animals killed by giant short-faced bears, American lions, and other Ice Age carnivores. We also assume that plants and animals thrive in a stable environment. Many do. But the genetic diversity most animals need for long-term survival depends in part on instability. All nature is at war, as Darwin liked to say. Instability that comes with war triggers migrations and dispersals, which, in turn allow animals to develop traits that help them to breed more successfully.

This may explain why mammoths, mastodons, and short-faced bears failed to endure in rapidly changing landscape while muskoxen, caribou, and cougars survived. Muskoxen, caribou, and cougars may have been better equipped to develop the traits needed to persevere through periods of instability like the one that ended the last Ice Age. It may also explain why butterflies, beetles, spiders, bees, and other insects demonstrated a remarkable degree of stability throughout the many climatic oscillations of the Ice Age.[8]

We still have a lot to learn about animal migrations, both in the deep past and today. Early on, our understanding was constrained by Greek myths, religious beliefs, and then later by the refusal to embrace Darwin's theory of evolution. Because there was no way of tracking animals and dating fossils from the prehistoric past up until the 1950s, scientists preoccupied themselves with the chronology of human and animal migration.

Still, a great deal has been learned about the Ice Age and modern-day animal as well as human migration in recent years thanks new tools such as environmental DNA, genetic material collected from samples of soil or other substrates. There has been an explosion of animal migration and movement studies in the twenty-first century. When I conducted a search of the Web of Science on February 28, 2026, for the words "animal migration," more than fifteen thousand open access entries were revealed. More than a third of the entries had been made since 2020.

We now know that with the advent of the last Ice Age many bird species were forced to abandon their northerly migrations or cut them short for thousands of years. Ice Age animals like the woolly mammoth traveled as much as seventy thousand kilometers in a lifetime searching for food in a harsh Beringian landscape where resources were likely scarce.[9] Woolly mammoths may have staked

their claim in the northern half of the continent while the Columbian mammoth was content to dwell in the south from the Pacific to the Atlantic Oceans. And there now appears to be a third mammoth that inhabited Mexico.

Migrating animals refine their behavior as they get older and with each generation, suggesting that experiential learning is an important part of successful migration. It's as much cultural in some cases as it is genetic. Animals are moving distances two to three times shorter in areas disturbed by humans than in the wilderness. Many migrating animals have genes that appear to trigger their seasonal movements.

Despite many intriguing advances in science, the migration and movement of many animals remain a mystery for a variety of reasons.

As with all science, our knowledge is limited by our values and priorities. There is a strong bias in favor of tracking huntable and endangered species at the expense of those considered to be of least concern or undervalued. Studies of animal movement tend to focus on understanding "typical" movement patterns rather than understanding variation in movement.[10] Long-term tracking of most animals has been spotty at best because of funding issues.

Even when we would like to track a species, we are sometimes limited by technology: tracking songbirds and insects was virtually impossible until recently because tracking devices were too cumbersome for them to carry. The elusive nature of some animals, such as birds like the yellow rail, poses a challenge because they are hard to find. I have heard but never seen one. Then there are those animals like the muskox, as quintessential an Ice Age survivor as there is, that have gotten little attention until recently because of massive die-offs. The number on Banks Island and Victoria Island in the High Arctic, where a majority of the world's muskoxen live, has dropped from nearly 100,000 in the 1990s to 16,500 in the 2020s.

It can also be challenging to study migration and movement amid all the other issues impacting animals. Identifying and opening up corridors that facilitate the movement of animals is problematic when there are so many people and so much industry on the landscape getting in the way. We are also just beginning to understand how wildfires and the massive plumes of smoke that come with them affect migration and dispersal, and how migration may spread disease from one species to another.

Even when we know a lot the about migration of some animals like the northern saw-whet owl, which has been banded and tracked for more than century, they and many other animals continue to surprise us, as rufous hummingbirds do in making a three-thousand-mile flight from Mexico to Alaska each year. In

FIGURE 0.4. Muskoxen are quintessential survivors of the last Ice Age. Photo by Edward Struzik.

2018, an Arctic fox traveled more than two thousand miles from Norway to the Canadian Arctic in three weeks, crossing the frozen ocean and the Greenland Ice Cap along the way. In 2014, a female grizzly named Ethyl stumped everyone involved in tracking her when she set off on a long journey through Montana and Idaho over mountains, along and across many busy highways, through landfills, and people's backyards. Polar bears, we know, stubbornly stick to their territory in twenty areas of the circumpolar world even when receding sea ice makes it difficult for them to put on the energy reserves they need to survive and reproduce. But every once in a while, a polar bear ventures off on a long-distance journey, as one did for 798 days in the spring of 2009, traveling 11,686 kilometers from northern Canada to Arctic Russia and back.

The beginnings and endings of animal dynasties are complex and not well understood as the scant fossil records of the Ice Age demonstrates. What we do know is that if one species is removed, another sometimes takes its

place in larger numbers. We are seeing this happen today when bees, moths, butterflies, and other specialists are dying off, leaving less competent pollinators to take over. When that happens, fewer seeds fall, and fewer seedlings spread. In the end, herbivores decline, and their predators begin dying away soon after. We are seeing this at the top levels of the food chain, also, with killer whales moving into once-unreachable parts of the Arctic, such as those that killed bowhead whales in the Central Arctic in 2020. With sea ice receding, the polar bear may no longer be the only king of this polar world. In southerly locales such as western and southern Hudson Bay, it may disappear.

There's a lesson here for humans. Where animals went, humans followed, as they did during the midst of the Ice Age 45,000 years ago when they began populating Europe. Many of them persevered even as temperatures fell and the ice sheets spread to their maximum coverage between 27,000 and 19,000 years ago. Through many generations, some of them followed the animals that crossed the Bering Land Bridge all the way to the tip of South America. Not all of them persevered. Some cultures collapsed with the mass extinction of so many Ice Age animals. Indigenous people in the Arctic fear that another mass extinction will put an end to their way of life.

Most scientists are justifiably concerned about another mass extinction looming. With temperatures rising by 3.2 degrees Celsius, geographic range losses of more than 50 percent are projected in about 49 percent of insects, 44 percent of plants, and 26 percent of vertebrates. It won't be as catastrophic if we can find a way of controlling greenhouse gas emissions. At 2 degrees Celsius, projected range losses fall to 18 percent of insects, 16 percent of plants, and 8 percent of vertebrates. At 1.5 degrees Celsius, they fall to 6 percent of insects, 8 percent of plants, and 4 percent of vertebrates.[11]

Migrating animals are the most vulnerable. Among the 577 animal species that migrate north into Canada from the United States and other more southerly wintering grounds, a quarter are considered to be at risk of extinction. Slightly more than 20 percent of the planet's migratory animals face similar extinction threats.

But hidden in the rising mountain of sobering data are animals that continue to surprise us: cougars and grizzly bears are expanding their range, salmon and killer whales are returning to the Arctic, non-migratory Anna's hummingbirds are overwintering in Alaska, and the North American waterfowl population has remained relatively stable over the past half century in spite of climate change, drought, and the systematic degradation of wetlands.

Taking the long view, Grant Zazula believes there is much we can learn from the past. Extinction, he says, is often critical for evolution to be possible. Climate change contributes to evolution in many ways, be it during periods of intense cold or periods of rapid warmth. Chaos can lead to more genetic diversity.

At the risk of giving the movie *Jurassic Park* too much credit, there is one Darwinian line in it that rings true: "If there is one thing the history of evolution has taught us, it's that life will not be contained. Life breaks free. It expands to new territories, and crashes through barriers, painfully, maybe even dangerously."

There will always be winners that break free, expanding into new territories, and losers that stay put and allow nature to select them for extinction. Animals that survive do it either through adaptions they acquire genetically from natural selection or through phenotypic plasticity, the ability to change behavior or physiology in response to novel circumstances. It may be the reason why there is an increasing number of migrants that are becoming *synurbic*, choosing to live where we do, or staying put instead of migrating, as the springbok, black wildebeest, kulan, scimitar horned oryx, and birds like the Canada goose are doing. This is not necessarily a good thing. Human activity and urbanization can rapidly alter the ecology and evolution of animals. Since coyotes began settling into the urban environment of the Greater Los Angeles area, for example, gene flow has been reduced, and genetic diversity has been eroded in ways that could undermine their health.[12]

The difference between what is happening now and what happened during and after the last Ice Age is that the world is warming a lot faster. This is coming at a time when, at least from a geological timeline, we should be entering another ice age. Humans are largely responsible for this warming by burning fossils fuels that produce greenhouse gases. Humans are also no longer hunting with spears and bow and arrows. They have guns and snowmobiles, motor-powered boats and fish finders that do away with the need to know where and why fish go to feed. Humans are building roads to mine sites and drilling for oil and gas on land and offshore. They are shipping these resources through narrow strait like the Bering Sea and moving from one place to another in numbers never seen before in human history. They are triggering wildfires that are burning bigger and hotter and lasting much longer.

Realistically, there is no way we are going to be able to stop sea ice from melting, oceans from rising, and permafrost from thawing. At least not in the short term. Wildfires will continue to burn hotter and more often and move

faster, even in wetlands like the Yukon/Kuskokwim Delta and on the tundra of the North Slope of Alaska. Flooding will increase as the jet stream continues to weaken and fail to move rain-soaking low-pressure systems from west to east.

What we can do is learn more about extinctions of the past to make better decisions in the future. We may be able to mitigate the impacts of extinctions or facilitate animal recoveries. We've done this before, just as we did when the peregrine falcon, whooping crane, and plains bison were on the brink of extinction. If we don't, those species that are now on track for extinction will be gone or critically endangered in the coming decades. It will be far worse than what happened when the world warmed so rapidly during the last Ice Age.

In the chapters that follow, we'll begin with an exploration of all we've learned about the migration and movement of animals during the last Ice Age, including how humans have reshaped the world to disrupt animal migration. We'll then carry these lessons forward into the present day to see how animals are altering their migrations on a changing planet. This book is as much about survivors as it about those animals that can no longer be found alive. It's also about solutions, both new and old, that can stave off future losses.

Exploring and learning more about the Ice Age past to better understand the future is in some ways a mystery story, which writer Arthur Conan Doyle once described being as filled with obvious things that nobody by chance ever observes. A new breed of scientist earnest in looking for clues is increasingly relying on the help of the public (citizen science) and the wisdom of Indigenous people to solve this cold case. This is a story of visionaries who have come up with ways to prevent environmental crimes and misdemeanors from happening again. There are many red herrings and skeptical scientists that divert attention away from the main characters trying to piece together the puzzle. New tools such environmental DNA, stable isotopic fingerprinting, environmental game theory, and statistical methods like phylogenetic regression come into play in good, fascinating, and sometimes misguided ways.

Although we've learned a lot, not all these mysteries have been solved. But we do have clues pointing us in the right direction. Many of our approaches to wildlife were designed decades ago, when the climate was more stable, as it was 27,000 to 19,000 years ago in Beringia. We need to change our strategies as fast as the climate is changing. The end of the last Ice Age is proof of that.

INDEX

Page numbers in italics indicate images

Abbey, Edward, 168
Aberdeen, England, 89
Abernaki people, 57
Achurch, Maxine, 178–79, 181
Acorn, Benny, 102
Acosta, José de, 29–30
Acoustic Division of the Natural Sounds Program, 242
acoustic technology, 97
Adamowicz, Vic, 203
adaptation, 87, 112, 115, 121. *See also specific species*
Adirondack Mountains, 74
Afognak Island, 194
African American population, 213
Agassiz, Louis, 61
agriculture, 86, 106, 211, 232, 233–34, 235
Agriculture Canada, 197
Akpaqarvik Migratory Bird Sanctuary (Prince Leopold Island Migratory Bird Sanctuary), 78, 248, 249
Alabama, 83
Alaska: Chukotka, Russia and, 6, 106; conditions of, 24; Ducks Unlimited and, 230; hunting in, 235; Ice Age animals discoveries in, 16; Ice Age in, 34; migration from, 98; oxide minerals and, 254; reintroduction of muskoxen to, 206; transportation in, 240. *See also specific locations; specific species*
Alaska Commercial Company, 241
Alaska Highway, 240
Alberta, Canada, 110, 112, 186, 197. *See also specific locations; specific species*
alder flycatcher, 70
Aleutian Islands, 34
Alfred Wegener Institute, 132
algae, 71, 102
Allard, Charles, Sr., 195
Allison, Leanne, 182
Alpine Club of America, 30
Alvarez, Alejandro, 20
amber, 190–91, 192
Ambrose, Skip, 238, 240, 242, 243, 244, 245–46, 248
American cheetahs *(Miracinonyx trumani)*, 170–71
American Game Conference, 227
American Game Protective Association, 227
American horses, 26
American lions, 6, 16, 36, 64, 138, 171
American Museum of Natural History, 21–22, 26, 35
American robin, 70
amphipods, 117
Amstrup, Steve, 158–59, 161, 166
Amundsen, Roald, 241
Anderson, Bob, 107
Anderson River, 139–40
Anderson River Delta Bird Sanctuary, 249
Andrews, Thomas D., 57

animals: appointed place of, 1; dreams and, 57; will to survive by, 252–53, 255. *See also specific species*
Anna's hummingbirds, 13
antelope ground squirrel, 210
anti-syngenetic ice wedges, 25
antlers, 142
Antonosyan, Mariya, 26
ants, 110
Arctic Archipelago, 139
Arctic Bay, 5
Arctic char, 5, 118–19, 123, 124
Arctic cod, 117, 123–24
Arctic Continental system, 102
Arctic fox, 12, 40–41, 154
Arctic fritillaries butterfly, 109
Arctic grayling fish, 49
Arctic hare, 26, 40–41
Arctic Institute of North America, 202
Arctic National Wildlife Refuge (ANWR), 148, 149
Arctic Ocean: changes to, 116–17; climate change and, 122; ecosystem of, 122–23; fresh water into, 67; garbage in, 130; Great Salinity Anomaly and, 131; location of, 128; plumbing system of, 130–31; protection of, 128–29
Arctic poppies, 133
Arctic Sea, 206
Arctic three-toed woodpecker (black-backed woodpecker), 70
Arctic wolves, 28, 39
Arctic woolly bear moth *(G. groenlandica beringiana)*, 108, 111, 252
Aristotle, 86, 92
Armageddon Option, 197
Arnaz, Desi, 211
arthropods, 110
artificial intelligence (AI), 81
Ash Meadows, 210
Asian longhorned beetle, 112
asteroid theory, 9, 75
Atlantic flyway, 208–9
Atlantic Ocean, 67, 131, 132
Atlantic salmon, 119
Audubon, John James, 88
Audubon Canyon Ranch, 217–19, 220, 222, 231
Audubon Society, 230
Aulavik National Park, 4, 148, 237–38, *239*
Austerdalsbreen Glacier, 110
Australia, 73–74, 126, 217
avalanche, 21
avian flu, 76, 246
avocets, 220
awme borer moth, 105
Axel Heiberg Island, 189–90
Ayer Pond, 52
Azores High, 143
Aztlanolagu agilis, 3

Back River, 140
Bacon, Michelle, 187
Baffin Bay, 130
Baffin Island, 117–18, 125, 206
Baird's sandpipers, 252
bald eagle, 59
Baldwin, James Mark, 84
Baldwin Effect, 84
Ball, Lucille, 211
Ballast Brook, 152
Balton, David A., 130
banded gunnel, 124
Banff, Canada, 173, 177, 181, 183–84
Banff National Park, 183, 188, 194, 198, 201, 248
Banfield, Frank, 29
Bangor and Aroostock Railroad, 141
Bangor Daily Commercial (Maine) (newspaper), 198
Banks Island: animals on, 207, 237; Aulavik National Park in, 4, 59, 237; Ballast Brook in, 152; decline on, 207; description of, 207; muskoxen on, 11, 40, 167; photo of, *153*; rain-on-snow events and, 147
bank swallows, 98

Barents Sea, 119, 124
barred owls, 3, 247
barren-ground caribou, 138, 139
Barrio, Isabel C., 108
Barrios, Juan, 51
Bar-tailed Godwits, 217
Basinger, James, 189, 190
Basiuk, Holly, *19*
Bassich, Andy, 243
Basso, Keith, 57
Bathurst Island, 143–44, 148
Baxter State Park, 199
Bayne, Erin, 70
Beach Boys, 211, 214
beaked redfish, 124
bearded seals, 117, 162
Bear Rock, 56, 60
bears, 45, 243–44. *See also specific species*
Beaufort Gyre, 130–31, 207
Beaufort Sea, 28, 117, 124, 159
Beaver Creek, 52
Beaverhill Bird Observatory, 77–79, 83, 98–99, 100
Beaverhill Lake, 93, 95
beavers, 38, 70, 188, 253. *See also specific species*
bees, 13, 110
beetles, 16, 63, 70, 105, 110
Beets, Monica, 20–21
Beets, Tony, 20–21, 22
Bell, George Ford, 235
Bell, James Ford, 227
beluga seals, 117, 124
beluga whales, 117, 124–26, 150–51, 154, 155, 164
Benton, David, 129
Bergen, Brad, 232, 234
Beringia: avian speciation in, 85; biodiversity in, 6; conditions of, 22; diversity of, 170; ecosystem of, 36; extinctions in, 19; map of, *7*; naming of, 34; North American founder population in, 52; origin of, 6; species in, 107. *See also specific species*
Beringian Land Bridge, 9, 135
Beringian floater, 43
Beringian lion, 137
Beringian wolves, 6, 16
Beringia Winter Scene (illustration), *8*
Bering Land Bridge, 6, 13, 34–35, 120–21
Bering Sea, 14, 34, 106, 209
Bering Strait, 30, 35
Bering wolffish, 124
Bernard River, 237
Berryman Scott, William, 27–28
Biden administration, 221
bighorn sheep, 8, 70
Billings, Elkanah, 33
biodiversity, 6, 84, 113–14, 253
bird banding, 88–92
Bird-Borne Program, 97
birds: behaviors of, 150; castration of, 228; climate change and, 246; decline of, 226; disappearance of, 82; experimentation on, 95; Ice Age theories regarding, 82; migration of, 3, 4, 10, 77, 81–82, 84–85, 92, 208–9, 219–20, 227; monitoring of, 248, 249; overwintering by, 209; photo of, *233*; protection of, 91–92, 98; at Salton Sea, 83, 208–10, 211, 215–19, 221, 222; sanctuaries for, 235, 248; statistics regarding, 226. *See also specific species*
Birds Canada, 98
BirdVoxDetect, 81
bison: adaptation of, 67; Armageddon Option for, 197; in Beringia, 107; captive breeding program for, 194–95; changing landscape and, 75; decrease of, 8; discovery of, 17, 26, 36, 63; disease of, 196–97; at Elk Island National Park, 196; food of, 68, 206; hunting of, 55; migration of, 250; reintroduction of, 196, 197–98, 205; starvation of, 68–69. *See also specific species*
Bissonette, T. H., 96
Bitterroot Mountains, 184
bivalves, 117

black-backed woodpeckers (Arctic three-toed woodpecker), 70, 85
black bears, 38, 171, 220
black-billed magpies, 84, 85
black brant, 237
black-capped chickadees, 85
blackcap warblers, 86
Blackfeet Indian Reservation, 198
black-footed ferret, 6, 8, 191
Blackfoot tribe, 55
black guillemot, 249
Black Hills, 108, 172–73, 187
black-legged kittiwakes, 249
black rhino, 178
black spruce, 225
Black Summer, 73–74
black swan event, 167, 207
black witch moth, 105, 115
Blakiston, 103
blister ice, 25
Blitzkrieg, 20, 46, 53
blonde bears, 155–56
Blondin, George, 56, 57, 60
Blue Babe, 137
blueberry, 225
Bluefish Caves, 49, *50,* 51, 52, 170
Bluefish River, 49
blue-footed boobies, 209
Bluenose caribou, *137,* 248
Bluenose West caribou, 134, 141
blue whales, 126, 127
blue wildebeest, 138
Bob Marshall Wilderness, 184
Bodtker, Jackson, *19*
bogs, 110, 111
Bohemian waxwings, 85
Bolinas Lagoon, 218
Bombay Beach, 208, 212, 213–14, *215*
Bombay Beach Opera House, 213
Bonanza Creek, 21
Bond, Jeff, 18, *19*
"Bones of the Underground Game," 58
Boone and Crockett Club, 235
Boorstin, Daniel J., 48
boreal birds, 225
boreal chickadees, 84, 85
boreal forest, 71
boreal owls, 84, 85
boreal songbirds, 99
Bostock, Hugh, 35
Boston Globe (newspaper), 142
Boutin, Stan, 193, 201–3, 204, 205
Bouverie, David, 218-219
bovine brucellosis, 196
bowhead whale, 1, *2,* 118, 124, 125, 127, 154, 155, 164
Boyce, Mark, 173–74, 176, 177, 185, 187, 194
Bradley, Mark, 3, 201, 238
Branch, Trevor, 127
brants, 249, 252
Britain, 91
British Columbia, Canada: Indigenous people in, 58, 204; map of, *186*; warming waters of, 119; wetlands in, 209, 231; wildfire in, 101, 103–4; wolf reductions in, 204; Y2Y in, 182. *See also specific species*
British Museum, 44
brittle bush, 210
broad whitefish, 124
Brocchi, Giambattista, 189
Brock River, 133, *134,* 135
Brontotherids, 53, 189–90, 191
brown bears, 155–56
brown hyena, 178
brown lemming, 36
brown pelicans, 220
browsing, 206–7
bucardo, 191
buckwheat, 103
Buddhism, 175
buffalo, 178
Buffalo National Park, 196
Bureau of Biological Survey, 92
Burnside River, 140
burrowing owls, 97
butterflies: decline of, 106; evolutionary history of, 105; food for, 113; legends

regarding, 105; migration of, 105–6; protection of, 114; replacement and, 13; significance of, 105; statistics regarding, 106; wildfires and, 112; wind and, 102–3. *See also specific species*
Butterfly Glacier, 254
bycatch, 128
Bylot Island, *251*

caballine horse *(Equus scotti)*, 27
Cactus Hill, 52
caddisflies, 110
Cade, Tom, 244, 245, 250
Cadzow, Dan, 43
Cahuilla Lake, 210
Calico Bluff, 243
California, 68, 119, 172, 221. *See also specific locations;* specific species
California brown pelicans, 209
California Conservation Genomics Project, 114
California Desert Protection Act, 216
California dogface butterfly, 105
California juniper, 210
Call of the Wild (Service), 244
camels, 38–39, 53, 63, 65, 107, 205
Cameron Falls, 102
Canada: agreement with, 129; Arctic Ocean and, 128; conservation land in, 230, 231; conservation treaty with, 91–92; Indigenous people of, 42; International Geophysical Year and, 28; map of, *186*; police of, 185; Post stamp of, 97; weather stations in, 146; wildfires in, 74. *See also specific locations; specific species*
Canada geese, 70, 188
Canada jay, 70
Canada's Three Oceans (C3O), 122
Canadian Arctic Archipelago, 251
Canadian Armed Forces, 190–91
Canadian Association of Zoologists, 29
Canadian Centre for Architecture, 214
Canadian Coast Guard, 122
Canadian Conservation Institute, 190
Canadian Defense Research Board, 28
Canadian Museum of Nature, 37, 49
Canadian Parks and Wilderness Society, 197, 202
Canadian Rockies, 71
Canadian swallowtails, 114–15
Canadian Wildlife Service, 28, 77–78, 166, 197, 248
canals, 211
Cannings, Syd, 108
Cape Bounty Arctic Watershed Observatory, 147
capelin, 124
Capromeryx, 3
captive breeding program, 194
carbon dioxide, 8, 160
caribou: adaptation of, 10, 135, 138, 147, 151; aerial survey of, 200; antlers of, 142; in Banff National Park, 248; in Beringia, 6; changing landscape and, 75; conservation of, 202–3; culling and, 247; decline of, 140–41, 142–43, 144, 145, 146, 149–50, 200–201, 204; discovery of, 17, 36, 49, 134–35, 137; at Eagle, Alaska, 243–44; evolution of, 134–35; food of, 71, 136; in Greenland, 40; hunting of, 54–55, 141–42; increase of, 138; in Jasper National Park, 248; maternal penning of, 203–4; memory and, 151; migration of, 135, 138–39, 140, 146, 206; peatland habitat and, 204–5; perseverance of, 8; photo of, *135*, *137*; polar bears and, 160; as prey, 200; protection of, 134, 142–43, 148, 247–48; radiocarbon dating of, 49, 51; rain-on-snow events and, 147; at Ramparts River, 225; recovery of, 204, 205; re-introduction of, 198–200; rhythm of weather and climate and, 143; thriving of, 141; tracking of, 42, 43, 81, 97; at Tuktut Nogait, 135, 136–37; value of, 148; Western Arctic herd of, 140–41; wolves and, 200, 201–2. *See also specific species*

Carlsberg Foundation, 89
Carmack, Eddy, 122, 131
carnivores, 175, 184. *See also specific species*
Carson, Rachel, 244
Cascades, 183
Cassatt-Johnstone, Molly, 170
catclaw, 210
caterpillars, 108
cave hyenas, 107
cave ice, 25
ceanothus, 68
Cedar Fire (California), 73
cedar waxwings, 84, 85
cedar wood wasp, 112
Central Europe, mammoth hunting in, 54
Central flyway, 208–9
Cetacean Research Centre, 126
Chacón-Duque, J. Camilo, 26
chamise, 68
chaos, 14
chaparral ecosystem, 68
char, 117, 118–19
charcoal, 68
Charlevoix, Pierre Francois Xavier de, 57
Charley River, 243
Charlie, Alfred, 45
Charlie, Johnny, 42–43, 56, 60
cheetah, 6, 178
Chemehuevi tribe, 210
Chetkiewicz, Cheryl, 168, 169–70, 173, 184, 185
Chicken, Alaska, 240
Chilkoot Trail, 21
China, 20, 129
chinook salmon, 128, 132
chipping sparrow, 70
Christianity, geological science and, 62
Chrysler, 228
chryxus Arctic butterfly, 106, 109–10
Chukchi Sea, 28, 34, 119, 123, 209
Chukotka, Russia, 6, 106
chum salmon, 118, *120,* 121, 123
Church, George, 206
Churchill, Manitoba, 158
Church of England, 32
Cinq-Mars, Jacques, 48–49, *50,* 52
citizen science, 250
Clarke, John, 168, 169–70
Clarke, William Eagle, 88
climate change: adaption to, 67; controlling, 13; de-extinction and, 193; early publications of, 158; ecosystems and, 122; effects of, 130; elements of, 8–9; evolution and, 14, 107; extinction and, 247; images of, 159; impacts of, 246; ocean circulation and, 130; plants and, 113; restlessness and, 3; severity index of, 251. *See also specific locations; specific species*
cloning, 190–91, 193, 205
clover, 114
Clovis people/Clovidians, 45–46, 48, 52, 53, 54, 55, 60, 68
coastal marshes, 209
Coast Mountains, 102
Cobb, Ty, 91
Coburg Island National Bird Sanctuary, 116
Coca Cola, 159
coexistence, with wildlife, 188
Cohen, Bradley S., 226
Collip, J. B., 95
Colorado Delta, 221
Colorado River, 210–11, 212, 216, 219
Colossal Laboratories and Biosciences, 191–92
Columbian mammoths, 46, 63, 155
Columbia Plateau, 102
Columbia wetlands, 209
Colville River, 245
Commission of Conservation, 196
common eiders, 249
common yellowthroat, 70
Compendium Physicae (Morton), 87
conditions, nature of, 87
condors, 63, 174
Confederacy of Mainland Mi'kmaq, 231
conifers, 71
Conly, Clifford, 218

Connecticut, 5, 172
conservation: data for, 98; process of, 161; relocation and, 113; Three C's of, 175; treaty for, 91–92, 129; types of, 249–50. *See also specific organizations; specific species*
consistency, importance of, 219
Cook Inlet, 125–26
cooling, as extinction theory, 20
Coope, Russell, 107
Cooper's Ferry, 52
Cooper's hawks, 85
Cope, Edward, 21–22
copepods, 117
Coppermine River, 140
Corbett, Ned, 93
Cordilleran ice sheet, 33
cores of wilderness, 175
cormorants, 211, 213, 226, 247
Cornell Lab of Ornithology, 81
Cornwall, Jim, 196
Coronation Gulf, 124
corridors of wilderness, 175, 176
cougars: adaptation of, 10; American cheetahs as compared to, 171; avian flu and, 76; bounty for, 172; dangers of, 172, 173–74, 187; decline of, 174; description of, 170; disappearance of, 69–70; discovery of, 63, 168–69, 170; ecological role of, 187; escape of, 169–70; evolution of, 171; expansion of, 185, 187; history of, 170; hunting by, 77, 78; isolation of, 177; locations for, 172–73, 219; migration of, 4–5, 13, 176, 184, 185, 187–88; photo of, *169*; prey of, 70, 188; resurgence of, 253; tracks of, 168; wildfires and, 72, 73
Court, Gordon, 109
coyotes, 14, 63, 67, 70, 75, 180, 210
Craighead, Frank, 244
Craighead, John, 244
Craighead, Lance, 177
cranes, 86
creosote bush, 210
Crespi, Juan, 71
crested caracara, 3–4
Cretaceous dinosaur bones, 35
Cretaceous period, 9
Crockford, Susan, 161
crocodilians, 189
Cronmiller, Derek, 18, *19*
Crosby, Bing, 229, 235
crows, 95, 96
Crowsnest Pass, 168, 185
Cruikshank, Julie, 57
cryoprotective dehydration, 108
Crystal Serenity (cruise ship), 117
Cumberland Sound, 125
curious half-moon hairstreak butterfly, 102–4, 105, 107, 108, 112
cyanobacteria, 71
cyclone, 116
Cypress Grove Preserve, 217–18
Cypress Hills, 108, 185
cypress-tupelo trees, 75

Daily Telegraph (newspaper), 160
Dakelh (Carrier) people, 58
Danyliuk, Janet, 234
dark-eyed juncos, 95
Darwin, Charles, 29, 87
date palm trees, 211, 212
David, Père, 20
Davis, Loren, 52
Dawson, George Mercer, 30–34, *31,* 34
Dawson, John William, 31–32
Dawson, Mary, 38, 54
The Day After Tomorrow (film), 132
daylight, 94, 96
DDT, 244–45, 250
Dease River, 33
deaths head hawkmoth, 105
deep time, 25
deer, 63, 65, 70, 77, 142, 188, 203, 210. *See also specific species*
deerlets, 38
de-extinction, 192, 206
Delawski, Travis, 17–18

Delta Waterfowl, 227–28, 229, 235
Dene K'eh Kusan, 231
Dene National Assembly, 56
Dene peoples, 54–55
Denmark, 128, 129, 163
Denton, William, 61, 62, 64, 76
Derocher, Andrew, 156, 157, 158–59, 161, 162, 163, 166
DeSantis, Larisa, 65
Desert Land Act, 220
desert sheep, 210
Devon Island, 53–54
DiCaprio, Leonardo, 203
Dickinson, Emily, 208
Dickson, Robert, 131
Dillehay, Tom, 51, 52
Dillon, Frank, *120*
dinosaurs, publicity of, 24. *See also specific species*
dire wolves: adaptation of, 67; cloning of, 191, 193; description of, 65–66; disease and, 76; extinction of, 64, 171, 191; hunting by, 63; illustration of, *192*; prey of, 65; reintroduction of, 193; skeleton of, *66*; starvation of, 68–69
Dirty Thirties, 227, 232
diseases, 20, 76
Disko Bay, 127
dispersal, defined, 2–3
DNA, 23–24, 26, 190–91, 192
Dolly (cloned sheep), 191
Dolly Varden, 119, 123
domestic swine, 76
double-breasted cormorants, 226
Douglas, David, 71–72
Douglas, Marianne, 252
Doutt, Richard, 218
Douverie, David, 218–19
Doyle, Arthur Conan, 15
Dragon's mouth orchid *(Arethusa bulbosa)*, 225
dreams, 56–57
drought, 72, 99, 234
drunken forests, 225
Dryas octopetala, 67
ducks, 70, 211, 220, 225, 226, 227, 228–29. *See also specific species*
Ducks Unlimited, 99, 228–29, 230–31, 232, 233–35, 236, 250
DuckTales (television show), 230
Duke, Damon James, 213
Duke of Burgundy butterfly, 105
dunlin, 217
Dunmall, Karen, 123
Dunn, Regan, 64, 68, 69
dust control, 222
Dyck, Markus, 160

Eagle, Alaska, 128, 240–44, 254
eagles, 59, 139
eared grebes, 209, 211, 213
Eberle, Jaelyn, 53
École Centrale de Nantes, 81
Ecological Dynamics in a Novel Biosphere (ECONOVO), 53
ecological resilience, theory of, 122–23
ecologists, characteristics of, 157–58
ecosystems: climate determination of, 207; maintaining, 206–7; properties of, 122; resilience of, 122–23. *See also specific locations*
Edmunds, Jan, 200
Ekoomiak, Normee, 56
Elbroch, Mark, 188
elegant terns, 4
elephant, 178
Elias, Scott, 106–7, 111
elk: decrease of, 8; in extinction zone, 26; food of, 206; as prey, 70, 77, 78, 179, 180, 188; reintroduction of, 194
Elkford, British Columbia, 182
Elk Island National Park, 77, 78, 196, 197
Ellef Ringnes Island, 251, 252
Ellesmere Island, 38, *40*
Elmendorf Air Force Base, 242
emerald ash borer, 112
Endangered Species Program, 242
England, John, 152, *153*

environmental changes, as extinction theory, 20
epigenetic ice wedges, 25
Equinox Magazine, 158, 178–79
Erlich, Paul, 175
Erysipelothrix rhusiopathiae, 76
Ethyl (bear), 12, 184
Eurasian badgers, 38
Eurasian blackcaps, 139
Europe, 20, 32. *See also specific locations*
European cherry fruit fly, 112
European corn borer, 112
European earwig, 112
European fire ant, 112
European Union, agreement with, 129
Evans, David, 24
Eversmann's butterfly, 109
evolution, 14, 30
evolutionary biologists, 27
experiential learning, 11
extinction: causes of, 9, 19, 64; climate change and, 247; discoveries regarding, 26; from disease, 76; evolution and, 14; from flooding, 74–75; hunting and, 46, 54–55, 235, 247; from landscape changes, 64; learning about, 15; mass, 9, 13, 111, 171, 253; questions regarding, 9–10; replacement and, 12–13; sixth, 253; from starvation, 69; statistics regarding, 53, 253; theories regarding, 20, 53; from wildfires, 74; zone, 26

Fairbanks, Alaska, 98
Fairholme Range, 183
Falconer, Hugh, 223
Far East, woolly rhinoceros in, 54
Fart Creek, 245
fasting, 157
Fay, Charles E., 30
fecal biomarkers, 48
Federated Indians of Graton Rancheria, 219
Feinstein, Diane, 216
fens, 110, 111
feral horses, 254
Ferguson, Steve, 1, 125, 127
Field, Poole, 58
Fields, W. C., 116
Finley, Michael, 180
Finnamore, Bert, 110
fin whale, 124
fire science, 71
fireweed, 114
Firth River, 148, 149
Fisheries and Oceans Canada, 1, 130
fishing, 119–20, 128, 129, 216. *See also specific species*
Fishing Branch (Ni'iinlii Njik) River, 42, 45
Flannigan, Mike, 158
flight species, 127–28
flooding, 9, 20, 74–75, 210–11
Florian, Chris, 240, 242, 244, 245, 248
Florida panther, 175
food chain, 10, 13, 54, 126
food web, 117
Ford, Henry, 91
Fording Coal, 182
Foreman, David, 175, 194
Forest Alliance of British Columbia, 182
Fort Egbert, 241
Fort Good Hope, 223, 231
Fort McMurray wildfire, 101
Fort Selkirk, 134
Fort Yukon, 43
Fossil Lake, 9, 63
fossils, 21–22, 62. *See also specific locations; specific species*
Foxe Basin, 125, 127, 157
foxes, 70, 180
Frances River, 33
Fraser, Danielle, 36–37, 54
Fraser River, 132
Freeman, Morgan, 230
freeze avoidance, 108
freeze tolerance, 108
Freija fritillary butterfly, 106
Frey, Albert, 212, 214
frigatebirds, 209

Froese, Duane, 16, 17, 19–23, 25–26, 36–37, 60, 137, 231, 254
Frost, Frances, 173
Frost, Laura, 174
Fuller, Bill, 97
Furze, Mark, 153
Fyfe, Richard, 244

Galapagos finch, 8
Galperin, Paul, 233–34
Game of Thrones (books and television show), 65
Gansbaai, South Africa, 126
garbage, 130
garden warblers, 86
Garroway, Colin, 2
Gaston, Tony, 248
geese, 89–90, 211. *See also specific species*
Geist, Otto, 45
Geist, Valerius, 235
gene flow, 14
genetic diversity, 14
Genetics (journal), 84
geographical isolation, 84
Geological Magazine (newspaper), 32
Geological Survey of Canada, 33, 252
George River, 142
George VI (King), 91
George W. Bush administration, 164
ghost ranges, 26
Giant Bear story, 56–57
giant beavers, 36, 55, 56, 226
giant black witch moth, 5, 105, 109
giant short-faced bears, 6, 8, 10, 22, 43, 54, 162, 163, 170
giant sloths, 63
Gilbert, Marisa, 54
Gill, Jacquelyn, 193
Gilmore, Charles W., 17, 45
Glacial Lake McConnell, 223
Glacial Lake Peace, 223
Glacial Period, 2, 39
Glacier Bay, Alaska, 121
Glacier National Park, 101, 181, 184
glaciers: alpine, 243; ecosystems left from, 106, 121, 254; mice, 225; receding of, 9, 74, 84, 106, 110, 121; transportation by, 62. *See also specific locations*
Glasier, James, 102, 104
glaucous-winged gulls, 249
Global Warming Policy Foundation, 161
goats, 205
gold, discovery of, 21
gold-bearing gravels, 33
Goldblum, Jeff, 192–93
golden eagles, 97, 180
golden rod, 103
Gold Rush (television show), 21, 22
Goodall, Jane, 199
Gormezano, Linda, 160
government, wilderness protection and, 218, 250
Graham, Max, 196
gray plover, 81
Grayson, Donald, 55
gray whale, 5
gray wolves, 65–66, 171, 191, 193
grazing, 206–7
Great Bear Lake, 56, 122
Great Bear River, 56
Great Black Swamp, 227
Great Britain, 67
Great Depression, 214
Great Dismal Swamp, 75
great horned owls, 83, 85
Great Ice Age, 61
Great Northern Paper Company, 199
Great Plains, 55, 172. *See also specific locations*
great red paintbrush, 114
Great Salinity Anomaly, 131
Great Salt Lake, 222
Great Slave Lake, 70, 140
great white sharks, 126
greenhouse gas emissions, 13
Greenland, 40–41, 73, 116, 131, 156, 167
Greenland Ice Cap, 12
Greenlandic halibut, 124

Greenlandic sharks, 124
Greenland Institute of Natural Resources, 119
Greenpeace, 117, 232
Grey's Anatomy (television show), 185
Griffin, Martin, 218, 231
Grinnell, Joseph, 210, 220
Grise Fiord, 116
Grizzled skipper butterfly, 225
grizzly bear/polar bear hybrid, 109
grizzly bears: adaptation of, 162; attack of, 181; behaviors of, 162; in Beringia, 6; culling of, 247; decline of, 174; discovery of, 45; fears regarding, 58; fire and, 71; hunting by, 43, 162; hunting of, 235, 246; hybrid of, 5, 246; isolation of, 177; locations for, 219, 220; migration of, 13, 154, 176; photo of, *163*; polar bears and, 162; at Ramparts River, 225; recovery of, 171–72; resurgence of, 253; salmon and, 139; tracking of, 97; tracks of, 154; at Tuktut Nogait, 135; in the wild, 181; Yellowstone to Yukon (Y2Y) project and, 184
ground ice, 17, 25
ground squirrel, 36, 107
grouse, 70, 199
growing seasons, 71
Guitarrero Cave (Peru), 52
Gulf of Boothia, 246
Gulf of California, 4, 210
Gulf of Mexico, 223
gulls, 211
Gunn, Anne, 141, 143, 150, 151
Guthrie, Dale, 139, 206
Gwich'in, 42, 43–44, 148
gyrfalcons, 92, 237

hairstreak butterfly, 255
Hak, Andrew, 232, 233, 234
Halffman, Carrin, 121
half-moon hairstreak butterfly, 102–4, 105, 107, 108, 112
Hancock, Major, 61
Hansen, James, 158
Harari, Yuval Noah, 247
hares, 70
Harington, Richard: background of, 27–28; Beth Shapiro and, 192; cougars and, 170; description by, 40, 41; discoveries of, 36, 37, 38, 152; expedition of, 35–36, 39, 59; land bridge theory and, 34; muskox and, 28; at National Museum of Canada, 35; photo of, *37*, *40*; polar bears and, 29; on radiocarbon dating, 49, 51
Harington's horse, 27
Harington's Loc. 11A, 43
Harper, Joel, 145
Harris, Larry, 175–76
Harvey, Jeffrey A., 161
Hauer, Grant, 203
Haughton Crater, 53–54
Hays, Harvey, 216
heat stress, 128
Hebblewhite, Mark, 185, 201
Heilprin, Angelo, 30, 34
Helgoland, England, 89
Hell Gate, 248
helmeted muskox, 36
Henry IV (King), 88
herb shrub tundra, 75
hermit thrush, 8, 71
Hershey, Pennsylvania, 83
Heuer, Karsten, 178–79, *180,* 180–82
Hickey, Joe, 244
Higdon, Jeff, 1, 125, 127
High Arctic, wildlife in, 189–90. *See also specific locations; specific species*
High Seas treaty, 129
Hills, Len, 152
A History of Land Mammals in the Western Hemisphere (Scott), 27
HMS Beagle, 87
hoary fringe, 225
Hochbaum, Hans Albert, 228
Hoffecker, John, 52
Holling, Buzz, 122, 253

Holroyd, Geoff, 6, 77, 78–79, 80–81, 83, 98, 99, 100
homelessness, 214
Homestead Act, 185, 220
hooded seals, 155
Hooker, John Dalton, 29
hoot owl, 3
Hoover, Herbert, 91
Hopkins, David, 30, 34–35
Hornaday, William T., 194
Hornaday River, 133–34, 135, 139–40
horned larks, 237
horses: adaptation of, 67, 254–55; in Beringia, 6, 16, 107; discovery of, 16, 22–24, 26, 36, 63; DNA of, 23; evolutionary origin of, 24; extinction of, 138; in extinction zone, 26; feral, 254; food of, 64; hunting of, 38; migration of, 254–55; reintroduction of, 205; will to survive by, 252–53. *See also specific species*
Horton River, 133–34, 139–40
House Stark, 65
Hudson Bay, 33, 109. *See also specific species*
Hudson Bay Company, 43
Hudson River Valley, 74
Hudson Strait, 124
Hughes, Owen, 35
Hultén, Elsie, 34
Hultén, Eric, 30, 34
humanity: dominion of, 76; early behaviors of, 45–46; food chain and, 54
hummingbirds, 92
humpback whale, 124
Hungary, 89
Hunter, William, 16
hunting: bans on, 142–43; changes to, 14; Ducks Unlimited and, 235; extinction and, 46, 53, 54–55, 235, 247; justification for, 246, 247; killing contests and, 235; strategies of, 54. *See also specific locations; specific species*
Huxley, Thomas, 32, 33
hybridization, 51, 109, 154–55, 246
Hydro Quebec, 97
Hymenoptera, 110

Ice Age, 15, 29, 66. *See also specific locations; specific species*
ice algae, 117
icebergs, shifting of, 39, 116–17
Iceland, 67, 124, 129
Icelandic Low, 143
ice wedge, 25
Idaho, 3, 248
inbreeding, 103, 175
Indiana Dunes National Park, 203
Indigenous peoples: bison killing and, 195, 197; bounty of, 172; in caribou recovery, 204; fire lighting by, 71–72; historical wisdom of, 57; hunting by, 54–55; mass extinction and, 13; migration of, 57; oral history of, 57. *See also specific peoples*
insects: adaptations of, 112, 115; biodiversity and, 113–14; climate change and, 107; decline of, 106; extinction rate of, 106; humans and, 111; in the Ice Age, 106; migration of, 105–8, 111–12; resiliency of, 112; statistics regarding, 104–5; tracking of, 11; turnover of, 106; wildfires and, 112; will to survive by, 255
interbreeding, 66, 154
International Geophysical Year, 28
Inuit peoples: butterflies and, 105; Canadian Arctic Archipelago and, 251–52; char and, 5; conservation and, *251*; hunting by, 1, 54–55, 116, 126; national parks and, 148; objections of, 117; photo of, *2*; tourism and, 117; at Tuktut Nogait, 136; weather study with, 146
Inuvialuit Game Council, 231
Inuvialuit Land Claim Agreement, 148
Inuvialuit peoples, 134, 137
Inuvialuit Settlement Region, 231
Iowa, 228
Irving, William, 48–49
island biogeography, 174
Isla Rasa, 4

Israel, 5
Isthmus of Panama, 6
ivallda Arctic *(Oeneis chryxus ivallda)* butterfly, 111, 253, 255
ivory gull, *251*
Ivvavik National Park, 148

Jackson, Ian, 28
Jacob's ladder, 133
James Bay, 97, 156, 166
Japan, 82, 129
Jasper National Park, 3, 183, 200–201, 248
Jasper Park Lodge golf course, 183
Jefferson's ground sloth, 36
Jenner, Edward, 87, 94
Jensen, Johannes V., 88
Jesuits, 172
Jette, Julius, 58
Joe, Merv, 148, *150*
Joe Creek, 148–49, *150*
Joly, Kyle, 138, 141, 147
Jones, Charles Jesse (Buffalo), 194–95
Joshua National Park, 226
Joshua trees, 210
June bugs, 110
juniper forests, 68
Jurassic Park (film), 14, 191–93
Jurassic period, 9

K'ahsho Got'ine Guardians, 231
Kaktovik, Alaska, 123
Kalmykian cows, 205
Kamchatka, 34
Kane Basin, 161
Kaska Dene people, 231
Katcheetohuskw, 58
Kay, Joe (Joe Kyikavichik), 59
Kazakhstan, 81–82
Kebreab, Ermias, 160
Kelly, Brendan, 154–55
Kempthorne, Dirk, 164
Kendall, Kris, 194
Kendall Island Bird Sanctuary, 249
Kendeigh, S. C., 96
Kennedy, John F., 218
Kennicott, Robert, 1
Kent Island (California), 218
KGF Guardians, 231
Khaleesi (cloned wolf), 191
killer whales: climate change and, 159; deaths of, 127; diversity of, 126; in food chain, 126; food of, 154; hunting by, 1, *2*, 126–27, 159; migration of, 2–3, 5, 13, 122, 124, 125–26, 154, 206, 250–51; research regarding, 126
Kines, Klare, 118
king salmon, 250
Kipling, Rudyard, 61
Kitikmeot region, 224
Klondike, theory regarding, 33
Klondike gold fields, 9, 60, 170, 254
Kluane Lake, 202
Kluane National Park, 4
Knaggs, Michelle, 70
Knapp, Joseph Palmer, 227, 228, 235
Knopff, Kyle, 70, 187–88
Koch, Frederick, 95
kokanee salmon, 132
Kola Peninsula, 119
Kolbert, Elizabeth, 253
Kootenai National Forest, 184
Korean Peninsula, 82
Koyukon people, 58
Kringayark, Laurent, 126
Kuptana, Roger, 118, 154
Kuskokwim Delta, 15
Kutag, Julia, 44

Labrador, 142, 146, 206
Labrador tea, 225
La Brea Tar Pits (Rancho La Brea), 9, 61, 62, 63, 64, *65*, 67, 170
Lafrenière, Melissa, 147
Laidre, Kristin, 167
Lake Agassiz, 75
Lake Edmonton, 78
Lake Elsinore, 67
Lake Erie, 83

Lake Hazen, 28
Lake Iroquois, 74–75
lake trout, 122, 123, 135
Lamb, Clayton, 176, 204
Lancaster Sound, 124, 130, 166
lances, 46
land bridge: first crossing of, 45–46; insect migration and, 106–7; theory of, 29–30, 34, 35. *See also* Beringian Land Bridge; Bering Land Bridge
Landry, Michelle, 20
Lapland long spurs, 39, 237
large-horned bison, 36
Lasius ants, 108
Last Ice Area, 167
Latino population, 213
Laurentide icefield, 33
Laurentide Ice Sheet, 43
Laurentide Ice Shield, 75
Lawrence, D. H., 81
Leadership Counsel for Justice and Accountability, 221–22
least flycatcher, 6
least sandpipers, 39
Lefort, Kyle, 125
Le Guin, Ursula K., 237
Lemming, Ingeborg, 89
lemmings, 238
lens ice, 25
leopard, 178
Leopold, Aldo, 157–58, 227–28
Lewis, Jerry, 214
Lewkowicz, Antoni, 25, 207
Liard River, 33, 224, 231
Libby, Orin, 88
lichen, 71, 134, 148, 204, 225, 237
Life Below Zero (television show), 243
lighthouses, 91
lightning, 68, 72, 73, 101, 242, 254
Liidlii Kue First Nation, 231
limestone, 243
Lincoln, Frederick C., 91–92, 228
Lindsey, Emily, 64, 67, 68, 69, 193
Linklater, Charles, 45
lion, 178
Little Fish River, *120*
Little John Site, 52
lizards, 210
Locke, Harvey, 176–77
Loera, Mariela, 221–22
loggerhead shrikes, 84, 85
London, England, 89
London Times (newspaper), 32
long-eared owl, 78, 79
Long Island, 83, 92
Long Point Bird Observatory, 79
long rough dab, 124
Loo, Tina, 90
Lord, Peter, 35–36, 45, 49, 59
Los Angeles, California, 14, 212, 220–21
Lotka, Alfred, 174
Louis St. Laurent (icebreaker ship), 122
luna moth, 111
lupines, 103
Lynch, Thomas K., 51–52

MacDonald, Zac, 102, 103, 104, 111, 114, 253
MacEachern, Alan, 195–96
Mackenzie Game Sanctuary, 197
Mackenzie River, 43, 56, 118, 122, 223, 224, 231, 254
MacPhee, Ross, 26
Maddren, A. G., 44–45
Madikwe Game Reserve, 178
Madison, Wisconsin, 88
Maine, 141–42, 198–99
Maligne Valley, 200–201
mallard duck, 89, 226, 227
Mallory, Mark, 248, 249
mammoths: adaptation of, 10; arguments regarding, 32–33; in Beringia, 6, 107; changing landscape and, 75; characteristics of, 54; death causes of, 55; de-extinction of, 205–6; discovery of, 16, 17–18, 33–34, 36, 44, 45, 55, 59; ecosystem decline of, 206; for food, 46; food of, 68, 206; ghost herds of, 16–17; hunting of, 20, 54, 55; illustration of, *47*;

legends regarding, 58–59; migration of, 46; in oral history, 55; Pribilof Islands and, 33–34; starvation of, 68–69
Mammoth Site, 63
Manhattan, 74
Manhattan Declaration, 160
Manifest Destiny, 172
Manis Mastodon, 52
Manitoba, 75, 226
Mann, Paul, 206
manzanita, 68
Marias Pass, 184
Marin County, California, 218, 219, 220, 231
marmots, 70
Marra, Peter, 82
Mars, 9
Marsh, Othniel, 22
MARSH program, 230
marten, 70
Martin, Paul, 46, 53
Martinique, 30
Marx Brothers, 214
Massachusetts, 172
mastodons, 10, 16, 36, 51, 55, 75
maternal penning, 203–4
Matinez, Lisa, 67
Max Planck Institute of Geoanthropology, 26
McArthur, Robert, 174
McCaughan, Brian, 17–18
McClure Strait, 152
McCollough, Mark, 199
McCovey, Barry, Jr., 132
McDonald, Robert, 43–44, *44*
McGill University, 28, 31–32, 33, 34
M'Clintock channel, 161
McMaster Ancient DNA Centre, 60
McPhee, John, 24, 25, 241
meadow blazing star, 112–13
Meltzer, David, 48, 51–52
Melville Island, 147
memory-related genes, 138–39, 150–51
meningitis, 21
Mercer, George, 200
Merriam, John C., 62–63, 66
Metasequoia tree, 190
Mexican wolves, 210
Michigan, 188
microplastics, 130
micro-technologies, 217
Middle Springs, 183
migration: adaptation and, 87; alteration of, 3; changes to, 6; climate change and, 246; complexities of, 92; connection of, 86; daylight and, 94, 96; discoveries regarding, 87–88; experiential learning and, 11; genetically triggered, 138–39; habits of, 86; humans following, 13; Ice Age effects on, 84–85; ice-free corridors for, 16; of insects, 105–8, 111–12; on land bridge, 35; monitoring, 88; mysteries of, 92; myths regarding, 86; parasites and, 6; pathogens and, 6; patterns of, 92; preparation for, 85–86; refining of, 11; religious beliefs and, 86; restlessness and, 3; routes for, 88, 176; sex organs and, 87, 94–95; statistics regarding, 81; *synurbic,* 14; theories regarding, 86–87; tracking studies of, 5–6, 11; tracking tools for, 81, 88, 97; triggers for, 94; understanding, 10, 77; wildfires and, 11; *Zugunruhe* and, 3, 4. *See also specific species*
Migration of North American Birds, The (Lincoln), 92
Migratory Birds Convention Act, 250
Migratory Bird Treaty Act, 91–92
Milford, Connecticut, 187
Miller, Frank, 141, 143–45, 146
Milne, Brian, 140
Min (bird), 81–82
Miner, Jack, 89–91, 96, 195, 227
mining, 14
Minister of Environment, 202
Minnesota, 228, 230
missionaries, 43–44
Mississippi flyway, 208–9
Missouri River, 223
mites, 16

Mojave Desert, 208
Mojave tribe, 210
mollusks, 117
molting, 80–81
monarch butterfly, 105, 111, 113, 139, 209
Montana, 5, 98, 103–4, 228
Monteath, Alistair, 106
Monte Verde, 9, 51
Moon, 9
Moore, Jonathan, 121
moose: changing landscape and, 75; culling and, 247; discovery of, 26, 43; at Eagle, Alaska, 243–44; in extinction zone, 26; food of, 206; hunting of, 142; as prey, 70, 77, 188; at Ramparts River, 225; reduction of, 204; reintroduction of, 205; stories regarding, 57; in the wild, 181
More Game Birds in America Inc., 227
morel mushrooms, 112
Morlan, Richard, 48–49
Mortensen, Hans Christian Cornelius, 88
Morton, Charles, 86–87
mosses, 225, 252
Mossop, David, 245
moths, 13, 105–6
Motus Wildlife Tracking System (MOTUS), 98
mountain aven plant, 67
mountain bluebirds, 5–6, 70
mountain caribou, 135, 198–99, 202
mountain goats, 70
mountain lions, 20, 69
Mounties (Northwest Mounted Police), 185
Mount Whitney, 111, 253, 255
Mt. Pinatubo, 167
muck, 22
Muir, John, 30
mullet, 211
Murchie, Tyler J., 60
Murphy, Scott, 101
mushrooms, 112, 134
muskoxen: adaptation of, 10, 135; at Axel Heiberg, 189; on Banks Island, 207; in Beringia, 6, 107; captive breeding program for, 195; deaths of, 144; discovery of, 44; disease and, 76; at Ellef Ringnes Island, 252; extinction of, 28; locations of, 11; migration of, 5, 40; parasites and, 167; photo of, *12*; as prey, 237; rain-on-snow events and, 147; reintroduction of, 194, 205, 206; tracking of, 11; at Tuktut Nogait, 135
muskrats, 36, 43, 75
Muskwa-Kechika Management plan, 183
Muskwa-Kechika region, 176–80
Myar, Ernst, 84–85
myrmecophily, 108

Nabokov, Vladimir, 101
Nagano, Debbie, 18
Nahanni River, 58, 224
Nakoda people, 185
nanotag transmitters, 98, 99
narwhals, 117, 118, 124, 125, 126, 154, 155, 164
Naskapi people, 58
National Audubon Society, 91, 217, 218
National Conservancy, 198
National Geographic (magazine), 117, 138, 160, 244
National Museum of Canada (Canadian Museum of Nature), 29, 35
National Oceanic and Atmospheric Administration (NOAA), 141
National Park Service, 114
natural selection, 87
natural systems, traditional view of, 122
nature, unpredictability of, 174–75, 253
Nature Conservancy of Canada, 183
Naujaat, 126
Neale, Graham, 176
Neanderthals, 51
needle ice, 25
Neufeld, Leila, 201
Neufeld, Tim, 78
New Brunswick, Canada, 198–99
New England, 82
Newfoundland, 82, 142, 143, 199
New Mexico, 46, 52

New River, 222
New York, 89
New York City, 92
New York Explorers Club, 45
New York Times (newspaper), 45, 51, 52, 92–93, 96, 160, 172, 191, 213–14
New York University, 81
New Zealand, 217
Nez Perce Indians, 58
Nielsen, Scott, 71, 112–13
Nirjutiqarvik National Wildlife Area, 249
nocturnal flight calls, 88
Nome, Alaska, 34–35
North American Agreement in Environmental Cooperation, 177
North American founder population, 52
North American wolf, 66
North Atlantic oscillation, 143
North Dakota, 226, 228, 230
North-East Atlantic Fisheries Commission, 128
northern elephant seals, 76
northern fulmars, 249
northern goshawks, 84, 85
northern leopard frog, 194
Northern Lights, 56–57
northern marble butterfly, 109
northern mockingbird, 78
northern saw-whet owls, 79, *80,* 84
northern shrikes, 84, 85
North Shore Beach, Bombay Beach, *215*
North Slope, 15
Northwest Mounted Police (Mounties), 185
Northwest Passage, 5, 116–17, 130, 241
Northwest Territories, *186,* 223–24. *See also specific locations; specific species*
Norton Sound, 243
Norway, 12, 67, 128, 129
Norwegian Bay, 156
Noss, Reed, 175–76, 177, 178, 182–83, 194, 248
Nowlan, Danny, 245
Nugent, Ted, 235
Nukon, John, 45
nunataks, 108
Nun cho ga (mammoth), 18, *19*
Nunivak Island, 194

oak forests, 68
oceans, 129, 130. *See also specific locations*
Oceans North, 125
Oceans North Canada, 231
Oden (icebreaker ship), 130
Ogilvie Mountains, 121
oil sands and energy industry, 203, 252
oil spill, 218
Okanagan Lake, 132
Old Crow Basin, 43, 121
Old Crow Flats, 42–43
Old Crow gold field, 9
Old Crow region, 35–36, 42, 49, 59, 121
Old Crow River, 43, 44–45
Old Crow village, 43–44
Oliver, Frank, 196
olive-sided flycatcher, 70
Olson, Wes, 197
Oñate, Don Juan de, 210
One Million Years B.C. (film), 51
Ontario. *See specific locations; specific species*
orange-crowned warbler, 70
orcas. *See* killer whales
Orcutt, W. W., 62–63
Oregon, 3, 126, 172
organism, nature of, 87
Ornithoptera, 114
Orr, Jack, 125, 126
Osborn, Henry Fairfield, 27
Osgood, Cornelius, 56–57
Ottawa Citizen (newspaper), 142
otters, 139, 220
Outdoor Life (magazine), 230
overharvesting, 128, 141–42
overhunting, 20
overwintering, 13, 209, 249
Owens Lake, 6, 220–21, 222
owls, 81. *See also specific types*
oxide minerals, 254

Pablo, Michel, 195
Pacific flyway, 208–9, 211, 217
Pacific loons, 225, 237
Pacific Ocean, 43
Pacific salmon, 5, 43, 118–22, 132, 253
Pacific sand lance, 124
Pacific sockeye salmon, 132
packrat middens, 210
painted lady butterfly, 105, 209
Paisley Caves (Oregon), 52
Paiute tribe, 71–72
Paleoindians, 121
Palm Springs, California, 212
Panama, 130
Papilionidae, 114
Paquet, Paul, 176, 177
Paradise Hill, 21, 22
parasites, 6, 20, 167
parasitic jaegers, 249
Parks Canada, 101, 102, 103–4, 197, 201, 204
pathogens, 6
Peace-Athabasca, 43
Pearman, Myrna, 5–6
Peary, Robert, 30
Peary caribou, 28, 139, 144, 148, 189, 237, 252
peatlands, 9, 110, 135, 204–5, 225
Peel River, 43
pelicans, 63, 211, 213, 215–16, 220
Pelly River, 33
Pennsylvania, 172
peregrine falcon: at Aulavik National Park, 4, 237, 238; banding of, 88; breeding of, 245; DDT and, 244–45; decline of, 244, 245–46; description of, 108–9; discovery of, 244; at Eagle, Alaska, 244; hunting by, 81; migration of, 138, 250; Migratory Birds Convention Act and, 250; monitoring of, 238, 240; recovery of, 220; speed of, 250; tracking of, 97; on Yukon River, 245–46
permafrost, 9, 25, 147, 207, 254
Persius Duskwing butterfly, 225
pesticides, 244
Peter Lougheed Provincial Park, 176
Peterson, David A., 74
Petty, Alek, 132
phalaropes, 220
phenotypic plasticity, 84
Phoebus parnassian butterfly, 109
Phoenix, Arizona, 212
photobiology, 96
phytoplankton, 117
pigeons, 88
pikas, 36, 108
pile worms, 213
pilot whale, 124
pine trees, 70, 71, 75
pink-edged sulphur butterfly, 106
pink salmon, 119
pintails, 209
Pitman, Kara, 121
Pitman, Robert, 127
plants: biodiversity and, 113–14; insect migration and, 106–7; land bridge theory and, 34; observations of, 34. *See also specific plants*
Pleistocene, 9, 171
Pleistocene epoch, 2
Pleistocene Overkill Model, 20, 46, 53
Pleistocene Park (Siberia), 205–6
Pluie (wolf), 176
Poe, Edgar Allen, 81
Poinar, Hendrik, 26
Point Pelee, 83, 227
Point Reyes Bird Observatory (Point Blue Conservation Science), 217, 219
Point Reyes National Seashore, 218
Poland, 55, 129
polar bears: adaptation of, 160, 162, 163, 167; ancestor of, 155–56; in the Arctic Ocean, 117; avian flu and, 76; behaviors of, 156–57; climate change and, 159–60; conservation and, 161, 250; decline of, 158; den of, 153–54; diseases of, 20; evolution of, 155–56, 163; fasting by, 157; as food, 154; food of, 117, 156, 160, 162, 164; fossil record of, 162; grizzly bears and, 162; hunting by, 162, 163; hybrid of,

5, 109, 246, 253; jail for, 158; migration of, 12, 40–41, 156, 157, 246; overreach and, 159; photo of, *163, 165*; pollutants in, 164; protection for, 159–61, 164, 166–67; publications regarding, 160–61; range of, 156; research of, 158–59; scientist position for, 28–29; as specialist, 163; tracking of, 98
Polar Bears International, 161
Polar Bear Specialist Group, 160
Polixenes Arctic butterfly, 109
pollock, 128, 129
pollutants, 164
Pomo Indians, 219
Pongracz, Jodie, 246
Popko, Richard, *251*
porcupine, 70
Porcupine caribou, 149–50
Porcupine Caribou Management Agreement, 148
Porcupine Caribou Management Board (PCMB), 148
Porcupine (Ch'oodèenji) River, 35–36, 42, 43, 59, 119, 121
potentilla, 103, 133
potholes, 226, 230, 231–32, 234, 236
Potter, Ben A., 46
Potts disease, 30–31
poultry, 76
prairie marsh, *233*
prairie potholes, 230, 236
prairie sage *(Artemisia frigida),* 107
Pratt, Helen, 218
Prebushewsky, Willie, 234, 236
predator/prey interactions, 174–76. *See also specific species*
predator swamping, 139
prescribed burns, 219
Pribilof Islands, 33–34
Prince Leopold Island Migratory Bird Sanctuary (Akpaqarvik Migratory Bird Sanctuary), 78, 249
proboscideans, 55
pro-hunting movement, 229–30
pronghorn antelope, 171
Proshutinsky, Andrey, 131
Przewalski's horse, 24
Pseudolarix tree, 190
psithurism, 78
ptarmigan, 240
Pucuncho Basin (Peru), 9
Puijila darwini, 38
Pukaskwa park, 248
Punic Wars, 88
pupfish, 210
Puzzle Creek Drainage, 184
Pyrenean ibex, 191
pyrocumulonimbus (PyroCbs), 73
pyrodiversity, 70
pyrophyilic insects, 112

Qaanaaq, 117
Qanatsiaq, Solomon, 125
Queen Elizabeth Islands, 144
Quest for Fire (film), 51

raccoon, 75
radar technology, 97
radiocarbon dating, 36, 49, 51, 170
radio tagging, 217
Ragged Range, 254
rain, 143–44, 145
rain-on-snow events, 10, 143–44, 145–48
rake marks, 127
Rampart House, 43
Ramparts, 223, 224
Ramparts River, 223, 224–25
Rampart Wetlands, 231
raptors, 3–4, 82, 135, 220, 238, 244, 246
ravens, 70, 188, 225, 249
red fox, 75, 154
red knots, 39
red squirrels, 70, 202
redstarts, 86
red wolves, 75, 171
Redvers, Grant, 116
regeneration, 253
reindeer, 205

Reist, Jim, 118
relict ice, 25
relocation, 113
Remus (cloned wolf), 191
Repulse Bay, 127
restlessness, 3
rewilding, 194
Reynolds fire, 101
rhino *(Epiaceratherium itjilik),* 54
rhythm of weather and climate, 143
Riddle of Migration, The (Rowan), 96
Ridington, Robin, 57
right whales, 155
ringed seals, 117, 124, 162, 163
river otters, 75, 220
robber flies, 16, 108
robins, 70, 86
rock ptarmigan, 238
Rockwell, Robert, 160
Rocky Mountains, 3, 102, 172–73, 176–80
Romulus (cloned wolf), 191
rooks, 88
Roosevelt, Teddy, 195
Rossby waves, 3
Rossitten, East Prussia, 89
Ross's geese, 209
rough-legged hawks, 4, 237
Roundtable on Central Arctic Ocean Fisheries Issues, 129
Routti, Heli, 164
Rowan, William, 93–97, 99, 228
Royal Canadian Mounted Police, 196
Royal Ontario Museum, 24
Royal School of Mines, 32
ruby-crowned kinglet, 70
Ruby Range (Yukon), 108
ruby-throated hummingbird, 114
ruffed grouse, 70–71
rufous hummingbird, 11, 114, 251, 254
Runcie, Robert, 42
Russell, Dale, 152
Russell, Don, 141, 150, 151
Russia, 128, 129, 166
Rybczynski, Natalia, 36–37, 38, 53
saber-toothed cats: adaptation of, 67; discovery of, 16, 61, 63, 64–65; disease and, 76; extinction of, 171; illustration of, *65*; prey of, 65; starvation of, 68–69
sage weevil *(Connatichela artemisiae),* 107
Sahtu Dene people, 231
Sahtu people, 225–26
Saiga antelope, 6, 138, 171
Sakiasie Qaunaq, 118
saline lakes, 208–9
salmon: climate change and, 121; decline of, 128; discovery of, 121; fishing for, 118; on the fringe, 123; harvesting of, 42; heat stress and, 128; migration of, 13, 118, 119, 122, 123, 206; overview of, 119–23; predator swamping and, 139; as prey, 243; resilience of, 120–21; spawning of, 243; wolf domestication and, 46. *See also specific species*
salmon shark, 124
Salton Basin, 211
Salton Sea, 6, 83, 208–10, 211–13, 215–19, 221, 222
Salton Sea Management program, 222
Salton Sea National Wildlife Refuge, 215
Salton Sink, 211
salvia, 113–14
sandhill cranes, 133, 209, 238
San Diego, California, 212
sandpipers, 220
San Francisco Bay, 218
Sangoya, Jacob, *251*
Sans Sault Rapids, 223
Santa Lucía, 155
Santa Monica mountains, 72
Santa Rosa Island, 68
Sapiens (Harari), 247
Sargent's muskox, 36
Saskatchewan, 75, *186,* 226, 232. *See also specific locations; specific species*
satellite tracking systems, 98, 217
Satudene (Sahtu Dene), 56
Saulteau First Nations, 204–5
"Save the Sea" strategy, 216

Sawchuk, Wayne, 176, 182
saw-whet owls, 11, 78–81, 82–84, 85, 98, 99, 100, 246
saxifrage, 133, 135, 144, 252
scaups, 225
Schindler, Daniel, 121
Schmidt, Chris, 5, 105, 106, 108, 110, 115
Schneider, Richard, 203
Science (journal), 35, 244
science of surprise, 122
scientific breakthroughs, 48
scimitar cat, 6, 8, 64, 69, 138
scoters, 225
Scott, William Earl Dodge, 87–88
screech owls, 83
scrub oak, 68
sculpins, 123
seabirds, 124
sea-eagle, 82
sea ice: drifting of, 156; ecosystems from, 3, 4; formation of, 124, 127, 130; microplastics in, 130; migration on, 144, 154; receding of, 8, 40, 116, 118, 125, *165,* 206, 207; shipping season and, 81; snow and, 147. *See also specific locations; specific species*
sea lions, 154–55
seals, 116, 154–55, 156, 252
Sea of Cortez (Mexico), 4
sedges, 134, 252
Selkirk caribou, 201, 204, 248
Serrano tribe, 210
Serrouya, Rob, 204
Service, Robert, 244
Seton, Ernest Thompson, 195
settlement, effects of, 247
Seventymile River, 243
sex organs, migration and, 87, 94–95
SF Gate (newspaper), 213–14
Shaffer, Brad, 72
shale, 243
Shapiro, Beth, 170, 191–92
sheep, 205
shellfish, 219
Shepard, Jim, 230
shorebirds, 211, 217, 220, 237. *See also specific species*
short-eared owls, 83, 99, 238
short-faced bears, 6, 8, 10, 16, 22, 43, 54, 55, 107, 162, 163, 170, 191
Shugar, Dan, 18, *19*
Siberia, 32, 34, 61, 81–82, 205–6
Sierra Club, 230
Silins, Uldis, 102
silvery lupine, 102
Simpson, George Gaylord, 84
Sinatra, Frank, 211, 214
singing, by whales, 127–28
single needle pinyon pine, 210
Sjare, Becky, 150–51
Skyline Trail, 181
Slave River, 118
sled dogs, 116
sloth, 38
Smilodon, 64, *65*
Smith, Cyndi, 238, *239*
Smith, Frank, 241
Smith, John Pye, 62
Smith, Kirby, 200
Smith, Tom, 150
Smithsonian Institution, 35
Smol, John, 134, 252
Snake River (Yukon), 109
snakes, 72
snow. *See* rain-on-snow events
snow buntings, 249, 252
snow geese, 160, 226, 227, 237
Snow Goose Festival, 99
snowy egret, 78
snowy owls, 4, 83, 84, 85, 92, 237, 238
sockeye salmon, 118, 132
soft-shelled turtles, 189
Sommer, Ralf J., 84
songbirds, 11, 150
sonic booms, 242
Sonoran Desert, 208
Soulé, Michael, 174–75, 176, 177, 194, 247, 248

South Africa, 126
South America, 20
South Carolina, 75
South Castle region (Alberta), 181
South Dakota, 226, 228
southern mountain caribou, 6, 198–99
South Korea, 129
sparrows, 95
spears, 54
Species at Risk act, 202
Speir, Francis, Jr., 27
spiders, 110
spotted knapweed, 102
spotted owls, 247
spruce trees, 70, 71, 75, 153, *153*
Squirrel Camp, 202
starlings, 88
starvation, 69
Staten Island, 74
steelhead trout, 132
Stefansson, Vilhjalmur, 251–52
Stegner, Wallace, 234
St. Elias ice fields, 187
St. Elias Mountains, 202
Steller's sea-eagle, 82, 226
Stenhouse, Gordon, 157
stenonoid, 22
steppe bison: adaptation of, 135; in Beringia, 6; discovery of, 16, 137; extinction of, 138, 254; food of, 64; land bridge and, 6; migration of, 206; perseverance of, 8; will to survive by, 252–53
steppe eagles, 81
steppe tundra, 107
Stikine River, 33
stilt-legged horse, 38
Stirling, Ian, 158–59, 166
St. Lawrence tiger moth, 110
stone tools, 49, 51
Storer, John, 53
storm petrels, 209
Strathcona Fiord, 38
Strong, Wilson Duncan, 58
Sturm, Ken, 215
sulphur butterfly, 105, 109
sun, in the Arctic, 24
sundew, 225
sunlight, variations of, 8
Sun Magazine, 247
Sutherland, William J., 253
Swainson's thrush, 71
Swales, Bradshaw, 83
swallows, 86, 87
swallowtail butterfly, 109, 114–15, 254
Swamp Acts, 227
swamp sparrow, 71
Sweden, 163
swifts, 87
swift-winged goshawks, 92
Syilx Nation, 132
symbiotic relationships, 108
Syme, Ian, 173
syngenetic ice wedges, 25

Taggart River, 39
Tagliarinis arctica, 190
Tallmon, David, 155
tapir, 65
Tate, Doug, 109
Taverner, Percy, 83, 91
Taylor, Mitch, 160
Taylor Highway, 240
temperature changes: animal perceptions of, 86; effects of, 8–9, 13; migration and, 3, 94; ocean, 123; statistics regarding, 13, 38, 124. *See also* climate change; *specific species*
Tener, John, 28, 39, *40,* 145
Teratorn, 82, 210, 226
terns, 92, 211
Tessaro, Stacy, 197
testes gonads, 94–95
Texas, 5, 82, 174
theory of ecological resilience, 122–23
thick-billed murres, 248–49
Thienemann, Johannes, 89
Thompkins, Douglas, 175
Thompson, David, 58
Thomsen River, 237

Three C's of conservation (Cores, Corridors, and Carnivores), 175
three-toed woodpeckers, 85, 92
thrips, 16
Thunderbird Place, 225–26
tiger moth, 105, 109, 110
tilapia, 211
Tolkien, J. R. R., 42
Tomales Bay (California), 209, 218
Tom Tom, Emma, 20, 27
Tonquin Valley, 201
Torngat Mountains, 146
Toronto Island, 83
Tory, Henry Marshall, 93
Totterdell, John A., 126
Trans-Canada Highway, 183–84
Transpolar Drift, 130
Treadstone Gold mining company, 17–18
tree pollen, 68
T-rex, 9
Triassic period, 9
Trollope, Anthony, 152
TRUE (magazine), 96
Trump administration, 129, 166, 218
trumpeter swan, 250
Ts'udé Nilįné Tuyeta, 231, 236
Tucson, Arizona, 212
Tuktut Nogait National Park, 133–34, 135–37, 141, 148, 248
Tulita village, 56
tundra, 36, 40, 107
tundra bunnies *(Hypolagus)*, 38
Turtle Mountains, 108
Ts'udé Nilįné Tuyeta Protected Area, 231
two-barred flasher butterfly, 105
type C avian botulism, 216
typhoid, 21
Tyrell, James W., 133

umber moth, 111
Ungava Peninsula, 105
United States, 32, 128, 129. *See also specific locations*
University of Maine, 199
University of Saskatchewan, 233
University of Wisconsin, 244
Upward Sun River, 9, 52, 121
US Biological Survey, 92
US Fish and Wildlife Service (USFWS), 92, 114, 164, 204, 221
US Geological Survey, 33, 166

Valdez, Alaska, 241
Vancouver, 98
very high frequency (VHF) technology, 97
Victoria Island, 11
"The Viking Baptism," 21
Villaseñor, Amaris, 214
Virbia moth, 105
Virginia, 75
vitrification, 108
Vitus, 30
vivianite, 137
Vogt, William, 228
Volterra, Vito, 174
Vuntut Gwitchin community, 42, 49

Wallace Bay, 231
walrus, 117, 154–55
Wappo Indians, 219
Warnock, Nils, 216–20, 221, 222
Warnock, Sarah, 217
Washington, 3, 248
Washington, DC, 89
wasps, 110
waterfowl: changing landscape and, 75; drought and, 234; prevalence of, 13, 226, 234–35; statistics of, 82; success of, 227. *See also specific species*
Waterton Lakes National Park, 101–2, 183, 253, 255
Waterton National Park, 177
Waterton Park Front Project, 183
Watson Lake, 182
Way, A. G., 207
Way, Robert, 146
Wayne, John, 229, 235
weather, patterns of, 143

Weaver, John, 177, 178
Weegman, Mitch, 233
Weeks-McLean Act, 91
weevils, 16
Welch, Raquel, 51
Wessman, Chris "Ssippi," 213
West Bluenose caribou, *137*
Westdal, Kristin, 125
Western camels, 107
western columbine, 114
western sandpipers, 217
western wood pee-wee, 70
West Moberly Nations, 204
The West Wing (television show), 185
wetlands, 111, 221, 227, 231. *See also specific locations*
whales, 150. *See also specific species*
whiskey trading, 185
whistling swans, 92
white cedar swamps, 75
white-crowned sparrow, 71
white-faced ibis, 78, 99
Whitehorse, 187, 241
Whiteley, Andrew, 155
white rhino, 178
Whitestone River, 59, 60
white-tailed deer, 75, 154
white-throated sparrow, 71
Whittington, Jesse, 201
whooping cranes, 96–97, 174, 250
Widney, Joseph Pomeroy, 211
Widney Sea, 211
wild bergamot, 114
wild dog, 178
Wilder Institute, 114
wilderness, as cultured/cultivated, 246
wildfires: butterflies and, 112; in Canada, 101–2; ecosystems and, 70; evidence of, 68–69; as extinction theory, 20; human triggering of, 14; illustration of, *69*; increase of, 14–15; insects and, 112; overview of, 71–74; understanding, 11
Wildlands Project, 175, 176
wildlife bank, 203
wildlife corridors, closing of, 174
Wildlife Society, 174
Willerslev, Eske, 26
Williams, Andy, 4
willow, 108
willow ptarmigan, 238
willows, 252
Wilson, E. O., 174
wind, butterflies and, 102–3
Winker, Kevin, 85
winter moth *(Operophtera brunata)*, 111
Witschi, Emil, 96
Wolfson, Albert, 95-96
wolves: attack of, 179; on Banks Island, 237; caribou and, 200, 201–2; changing landscape and, 75; culling of, 247; discovery of, 17, 63; domestication of, 46; at Eagle, Alaska, 243–44; increase of, 138; isolation of, 177; migration of, 250; as predators, 179, 180, 237; as prey, 70; reduction of, 204; reintroduction of, 174; reproduction of, 203; sterilization of, 204; at Tuktut Nogait, 135. *See also specific species*
Wood, Charles, 72
wood bison, 206, 244, 254
Wood Buffalo National Park, 53, 174, 196, 250
woodland caribou, 75, 135, 202
Woods, John, 83
woolly bear moth *(G. groenlandica beringiana)*, 108, 111
woolly lousewort, 252
woolly mammoths: discoveries of, 26, 137, 152; evolution of, 155; extinction of, 138; food of, 64; land bridge and, 6; landscape changes and, 75; migration of, 10–11; perseverance of, 8; radiocarbon dating of, 36; will to survive by, 252–53
woolly rhinoceros, 6, 26, 54, 107
Woolsey Fire (California), 72
World Wildlife Fund, 116, 159, 197
Wrangel Island, 246
Wrangell Island, 187

Yacht Club, 214, *215*
Yamal Peninsula (Siberia), 147
Yamoria, 56
yellow-billed magpies, 84–85
yellowjacket wasps, 5
yellowlegs, 220
Yellowstone National Park, 172, 173, 174, 179–80, 183, 194
Yellowstone to Yukon (Y2Y), 177–80, 181–82, 183–85, 186, 249
Young, Neil, 203
Younger Dryas, 67, 207
Yukon, 16, 17–18, 24, 33, 98. *See also specific locations; specific species*
Yukon Beringia Interpretive Centre, 247
Yukon camel, 6
Yukon-Charley Rivers Preserve, 240
Yukon-Kuskokwim Delta (Alaksa), 73
Yukon River, 33, 119, 121, 128, 139–40, 241, 243, 245–46, 254
Yukon wild ass, 36
Yuma clapper rail, 209

Zazula, Grant: on American cheetahs *(Miracinonyx trumani)*, 171; on biodiversity, 6; caribou and, 137; cougars and, 170; discoveries of, 16, 17–18, 19, 20, 21, 22, 24, 25–26; on extinction, 14; hunting tools and, 247; influences to, 36–37; at Klondike gold fields, 254; photo of, *25*; sage weevil and, 107
Zimov, Sergey, 205–6, 207
zooplankton, 117, 130
Zugunruhe, 3, 4, 86