The FALL of the WILD

Extinction, De-Extinction, and the Ethics of Conservation

BEN A. MINTEER

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For Madeline, and other wild things

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1

OUR VANISHING (AND REAPPEARING) WILDLIFE

BIRDS OF A FEATHER

Historical accounts tell us that the North American sky was once black with passenger pigeons. Given that at the time of European contact the bird numbered in the billions, this was probably only a slight exaggeration. Market hunters, however, would see to it that the sky was clear of pigeons by the second half of the nineteenth century.[1] The bird was last spotted in the wild around the time shovels first broke ground on the New York subway system. "Martha," the last surviving member of the species, drew her final breath in the Cincinnati Zoo on September 1, 1914 (figure 1.1).

Writers have long elegized this vanished bird. The conservationist-philosopher Aldo Leopold issued the most poignant tribute in his classic 1949 book *A Sand County Almanac*: "We grieve," he wrote, "because no living man will see again the onrushing phalanx of victorious birds, sweeping a path for spring across the March skies, chasing the defeated winter from all the woods and prairies of Wisconsin."[2]

The pigeon was a cheap and easily procured source of meat in the eighteenth and nineteenth centuries because of its

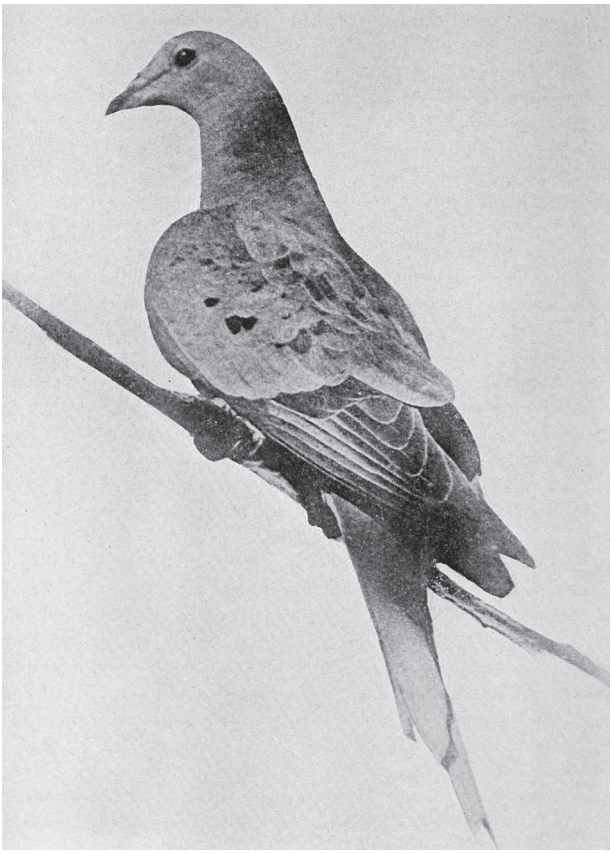

FIGURE 1.1 Martha, the last passenger pigeon.

Source: Public domain.

extraordinary abundance and an unfortunate tendency to travel in massive flocks. Its fate was sealed by the 1850s with the expansion of the railroad and telegraph, which fueled an insatiable commercial appetite and a profitable market for passenger pigeon by providing easy transport and rapid communication about the location of flocks.[3] There were precious few attempts

to save the species in that pre–Endangered Species Act era and none that made a difference.

Less than twenty years following Martha's quiet demise in Cincinnati, the sole surviving heath hen (a close relative of the greater prairie chicken) made its last appearance in southeastern Massachusetts. Nicknamed "Booming Ben" for the bird's distinctive vocalizations during its extravagant mating ritual, he was a relic of a population that was once common from New England to northern Virginia.[4] Like the passenger pigeon, the heath hen was a plentiful and convenient source of protein (a "poor man's turkey") in the eighteenth and early nineteenth centuries (figure 1.2). By the 1870s, however, the species had been hunted completely off the mainland. Only a few decades later, there were fewer than one hundred left, all of them hunkered down in a single flock on Martha's Vineyard—not a bad place to convalesce, unless you're part of a small, genetically isolated, and nonmigratory bird population.[5]

Unlike the passenger pigeon, the heath hen saw a few efforts to save it, including banning hunting and creating a sanctuary in the Vineyard in the early 1900s. But the die had been cast.[6] Like Martha before him, Booming Ben—and the heath hen along with him—vanished into the evolutionary ether, most likely sometime in the spring of 1932.[7]

Although the public was slow to rally to the conservation cause in the early twentieth century, not everyone greeted these losses with resignation. One of the strongest voices agitating for wildlife protection during these years was William Temple Hornaday, the rabble-rousing wildlife crusader and founding director of the Bronx Zoo. Hornaday challenged the complacency of an American public unwilling to acknowledge the destructive game it was playing with its wild animals.

FIGURE 1.2 The (still) extinct heath hen.

Source: Public domain.

His 1913 book, *Our Vanishing Wild Life*, was an early wildlife-protection jeremiad and a public plea to stop the "slaughter" of species by indiscriminate hunters and wildlife exploiters.[8] Published by the New York Zoological Society, it would prove influential in drawing public and professional attention to the growing challenge of protecting wildlife in the first half of the twentieth century. It had a profound impact on a generation of American conservationists, including Aldo Leopold, whose early interest in wildlife protection (what at the time would have been called "game" protection) was partly shaped by his encounter

with Hornaday's work.[9] In *Wild Life*, Hornaday tried to convey a sense of the size of the biological stakes when a species was pushed to the brink of extinction. "Let no one think for a moment," he warned, "that any vanishing species can at any time be brought back; for that would be a grave error. . . . The heath hen could not be brought back, neither could the passenger pigeon."[10]

What a difference a century makes. In his wildest dreams Hornaday could not have envisioned that someday scientists and their allies would seriously be contemplating bringing long-extinct species—including the passenger pigeon and the heath hen—back from the dead. Called "de-extinction," the proposal taps into a range of established and still emerging techniques in cloning and genetic engineering, including the ability to rapidly sequence ancient DNA from preserved tissues of extinct animals to allow scientists to create approximations of lost species by "editing" the genomes of closely related (living) species. So, for example, the genome of a contemporary band-tailed pigeon could be altered to resemble more closely that of a passenger pigeon, and a population of the new birds could theoretically be bred and released into the wild.[11]

Stewart Brand, the influential writer, entrepreneur, and technoenvironmentalist, is one of the driving forces behind the idea, which has grabbed considerable media attention in recent years. Brand's Long Now Foundation is currently supporting scientific efforts to re-create the passenger pigeon—and exploring possibilities for the heath hen—within its "Revive & Restore" project, which also has set its sights on a range of resurrection candidates, from the Tasmanian tiger (thlyacine) to the woolly mammoth.[12] And the list continues to grow.

MARTHA, HARRY, AND GEORGE

The passenger pigeon was on my mind several years ago when I participated in a public program at the American Museum of Natural History in New York City marking the centennial of Martha's death (2014 was a big year for the species, complete with a spate of books, exhibitions, and the release of a major documentary film).[13] The event, cosponsored by the Center for Humans and Nature (Chicago) and the Hastings Center (New York), was organized around the question, "How Far Should We Go to Bring Back Lost Species?"[14]

I was matched with Harry Greene, a distinguished evolutionary biologist at Cornell and one of the leading thinkers behind the "Pleistocene rewilding" idea, a proposal to establish populations of charismatic megafauna (e.g., Asian elephants, camels, cheetahs, etc.) in a system of new reserves in North America. The goal is to expand these species' ranges and restore ecological processes lost with the late Pleistocene extinctions of mammoths, American cheetahs, and other species that last roamed the continent more than 11,000 years ago.

Our pairing wasn't accidental. The program was designed to capture a range of thought about the acceptability of de-extinction, Pleistocene rewilding, and other "radical" proposals to conserve and recover species in the coming decades. Harry played the role of booster. I was cast as the skeptic. In truth, we probably agree about 90 percent of the time on conservation issues. De-extinction, however, is clearly part of the other 10 percent (though I should mention that I find Harry's views on the subject to be far more thoughtful and circumspect than the unabashed techno-optimism of Stewart Brand and company).

I'll have much more to say about de-extinction and many of these other topics in the following chapters. I only want to note

here that Harry asked a couple of questions at the end of his talk that, in many ways, serve as a point of departure for this book. The first was, "Are you satisfied with the course of contemporary conservation, [and] do you think that conventional measures are going to get it done?" The second drove the point home with an example from earlier in his talk: "If it really came down to it, would you really rather there were elephants nowhere on earth or somewhere on earth?"[15]

They're provocative questions, even if I don't fully buy the premise of the second, which seems to be partly a false choice. (For the record, I'd say we should exhaust all our options for conserving elephants in Africa and Asia before we consider more unorthodox and risky strategies, such as establishing elephant reserves in North America. Harry would no doubt respond by saying that by time we exhaust all of those conventional strategies, for example, improving monitoring and enforcement, expanding reserves in their indigenous range, and so on, it will be too late for the elephants.) There's certainly no mistaking the fact that the situation for African elephants in much of their native range is grim, primarily because of the scourge of the illegal ivory trade, a global black market that has proved extremely difficult to shutter (I'll pick up this thread again later in chapter 4, "Elephants Somewhere").

Harry's questions carried an additional weight that evening in New York given that not far outside the museum theater stood, mounted and in stony silence, "Lonesome George," the iconic Pinta Island tortoise (*Chelonoidis abingdonii*; figure 1.3). George, whose forlorn nickname took on added pathos because of his famous failure to breed, was on temporary display at the museum for a few months before being returned to his home in the Galapagos.[16] His line of giant tortoises has been almost wiped out by a combination of exploitation by eighteenth- and

FIGURE 1.3 Lonesome George in better days in the Galapagos.

Source: Wikimedia commons.

nineteenth-century whalers and competition from introduced "pests," especially those familiar island scourges, rats and goats.[17] The species was thought to be extinct until George was discovered in the early 1970s by a Hungarian scientist studying snails on Pinta Island.[18] When he passed away at the Charles Darwin Research Station on Santa Cruz Island in the Galapagos in 2012, Lonesome George was considered by scientists to be the last of his kind.

Yet there would be a dramatic turn of events in George's story, one that put an asterisk on all those epitaphic, "last of his species" headlines. Not long after the reptile's death in 2012, it was reported that more than a dozen giant tortoises plucked by biologists from a volcano on the island of Isabela, about forty miles away from Pinta, shared some genes with him, raising the possibility of selectively breeding something resembling a Pinta Island tortoise back into existence and perhaps one day even

restoring a George-like population of tortoises to the island.[19] It would be a form of "de-extinction" by "back breeding" extant animals to produce offspring with the genetic makeup and phenotype of Lonesome George, a less synthetic version of species revival than would be the case with the passenger pigeon or the heath hen (where no living specimen currently exists). Still, it would entail an intensive breeding, restoration, and conservation project requiring a high degree of manipulation and human intervention in wild-island ecosystems to pull off successfully.[20]

Maybe there'll be a happy conclusion to George's tale after all and even a prologue for a new Pinta Island tortoise 2.0 in the archipelago. If that's the case, the restored tortoise might serve as a powerful riposte to all those glum, dead-end accounts of species extinction: nature, it turns out, can be resilient as well as fragile, and it's full of surprises. With enough ingenuity, resources, and resolute commitment to the cause ("Are you satisfied with the course of contemporary conservation?"), we might someday help the Pinta Island tortoise find its way out of the evolutionary void.

MORAL STAKES

Extinction casts a shadow. The legacy of biotic loss in the moral imagination—the nagging reminders of the myopia, ignorance, antipathy, or avarice that led to the disappearance of species such as the passenger pigeon, the heath hen, the thylacine, and (maybe) the Pinta Island tortoise and the near extinction of species like the American bison and California condor—continues to provoke a range of responses among conservationists. For some, it prompts a profound sense of regret, which in its darkest moments can lead to a posture of hopeless resignation. For

others, this reminder of the biological stakes of our societal choices is simply evidence of the need for greater precaution not just in how we develop and consume on the planet but also in how we prioritize and conduct our conservation efforts. For still others it stokes a fiery rededication to the cause, a determination to combat the elegiac conservation narrative by doing whatever it takes to save species from extinction—including even trying to re-create fallen life forms—in an era of increased human influence.

That's certainly the message coming from Stewart Brand, who believes that our worries about extinction are often misplaced and keep us from tackling conservation problems with the full arsenal of tools and techniques available, the systematic use of which entails a far more manipulative and interventionist way of practicing species conservation.[21] Brand may be one of the more colorful and technophilic voices in conservation today, but the desire to toss out musty preservationist values and mythical ideals of an untouched (and untouchable) "pristine" wild is increasingly widespread in contemporary conservation science and thought.[22] These "ecopragmatists" argue that we need to embrace our human ambitions and abilities as we steer species, ecosystems, and even the planet toward a more sustainable and prosperous future.[23]

I've long counted myself a pragmatist on conservation and environmental matters, too—both in the philosophical sense of subscribing to that distinctively American tradition in philosophy (which flourished in its original form in the late nineteenth century and the first decades of the twentieth) and in the everyday sense of trying to focus on achieving workable outcomes rather than getting bogged down in matters of ideological purity.[24] But in recent years I'll confess that I've grown increasingly uncomfortable with many of the ideas being advanced under the name of "pragmatism" in environmental circles, ideas

that, at least to my eyes, bear scant resemblance to the tradition of Charles Sanders Peirce, William James, and, especially, John Dewey—the founding fathers of American pragmatism. Self-described ecopragmatists such as Brand and many of the thinkers associated with the Oakland-based Breakthrough Institute and similar organizations seem to believe their appeal to pragmatism provides justification and intellectual cover for the grand expansion of technological enterprise and the unleashing of human power in (and over) wild nature. And they often use this reading of pragmatism as a lever against what are described as "old-school" nature preservationists skeptical of technological solutions to moral and cultural problems and increasingly out of touch with the already patent reality of human influence on the landscape.[25]

What's missing in this environmental appropriation of pragmatism is a sense of contingency and restraint and the related notion that nature is the ultimate teacher of moral limits (through our experience of acting within it). These commitments, at least on my reading, are a vital part of the pragmatist tradition, a reminder of our own imperfections and limitations. Awareness of this fallibility, which for Dewey was reinforced by the recognition that, although humans are remarkable beings in many respects, we are not the center of the universe, should invite humility and respect for nature rather than an urge toward ecological mastery and control.[26] This more cautious and respectful reading of pragmatism, though, seems to have been abandoned by many of the new ecopragmatists in their eagerness to embrace an ethos far more Promethean than pragmatist in spirit. But more on all of that later.

In *The Fall of the Wild* I take stock of a set of practices, proposals, and ideas circulating in conservation today that generate

what I think of as "moral frictions," tensions that emerge between our competing desires to save threatened species at all costs and to respect the wildness of a world that can get crushed in our grip—or slip through our fingers.[27] The book develops from a consideration of traditional techniques and programs (specimen collection, zoos, and species reintroduction) to more radical strategies and interventionist projects currently dividing many conservationists and their allies: assisted colonization, de-extinction, and (briefly in the book's coda) geoengineering. There is a rough scalar logic to this discussion in that we move from the question of moral responsibility in collecting individual animal specimens in the field; to the ethics of conserving, observing (in zoos), and recovering species; to using emerging technologies to try to re-create species; finally to putting the entire planet under one big, engineering thumb.

The usual caveats and disclaimers, however, apply. By no means is this little book intended to be a comprehensive or even a representative survey of all the ideas and arguments throwing sparks in conservation these days (it would fail to do that at three times its length). Instead, the discussion that follows captures those questions and concerns that have drawn my attention and that have made me think hard, over a period of several years, about the values and direction of a more radical conservation effort. And as we'll see in the next chapter, that thinking has at times gotten me in hot water.

Also, although this book touches on a number of arguments and concepts endemic to the field of environmental philosophy, I've striven to treat this material, which can often be obtuse and esoteric to the uninitiated, lightly. What this means is that even though the focus here is generally on the ethical and philosophical dimensions of conservation, I've tried to present these ideas with a minimum of academic hairsplitting. My goal throughout

this book is to make this discussion accessible to readers with either a professional or a popular interest in conservation and, especially, in the particular run of topics covered here. I've therefore emphasized broad themes and big questions, staying as much as possible on the main path and out of the philosophical weeds (the lone exception, and it's only a partial one, is the discussion of Leopold's conservation philosophy in "Elephants Somewhere," where a little more parsing is required). Readers looking for a deeper dive in the philosophical, historical, or scientific issues raised here should consult the "Further Reading" section and the relevant chapter notes in the back of this volume. I hope this more user-friendly style also serves my original ambition of writing a compact book you can read in two sittings—well, maybe three if you include the notes.

Finally, I also hope you'll agree that, despite some sharp words in these pages for the tilt toward a more aggressively interventionist stance in certain conservation circles, this book is not a screed against manipulating nature nor a denunciation of our use of technology in wildlife and wildland conservation. In the next chapter, you'll see that I heartily endorse one kind of technological solution, "digital collecting," as an alternative to taking specimens from vulnerable animal populations in the field. I also continue to marvel at the groundbreaking designs for Denmark's Zootopia discussed in chapter 3, "The Call of the Quasi Wild," a thoroughly contrived and technologically mediated series of animal enclosures that an arch preservationist such as David Brower (not to mention John Muir) would have sneered at. And as I describe in chapter 4, "Elephants Somewhere," I remain open to a range of what most conservationists would consider to be highly interventionist efforts. That includes translocating species to places outside their indigenous range if doing so provides the only hope of saving a species from human-driven

threats—and provided we don't let these stopgap measures distract us from striking a more respectful and sustainable relationship to other species and to the land as a whole.

What I'm calling for in *The Fall of the Wild* is simply a little more restraint in our dealings with wild species in a time when that restraint seems to be slipping, a time that many are now calling the "human age," a.k.a. the "Anthropocene." That goes as well for our designs on wildlands and (as I write in the coda) also on the skies. Without such collective self-limitation, I fear we'll end up sliding deeper into a pathologically inverted relationship with technology so eloquently censured by Thoreau: we won't ride on the railroad; it'll ride on us.

So this book is about some of the places where I want to draw a bright line in the conservation sand. In that sense, it's an extended answer to Harry Greene's first question from that evening at the American Museum of Natural History. Although I may not be satisfied with conventional conservation practices in many cases, there are some thresholds in nature that I just don't think we should cross. Too many other values are at stake that I care about, as a preservationist-minded conservationist, yes, but also as an increasingly wary ecopragmatist. And I hope others will continue to care about these values and defend their place in a cautiously pragmatic and responsible conservation ethic, too.

2

A BIRD IN THE HAND

KILLING THE GREAT AUK

Like the extinction of the passenger pigeon, the disappearance of the great auk (*Pinguinus impennis*) looms large in the morality tales of conservationists. Looking like an unusually large-beaked penguin (figure 2.1), the ungainly, flightless seabird that once ranged on both sides of the North Atlantic was exploited by European explorers and fishermen for centuries, first for food and fuel and later for its feathers as a commercial market took hold (auk feathers found their way into mattresses and quilts). The feather trade ratcheted up the human pressure on the bird in the eighteenth century and, not surprisingly, its numbers swiftly plummeted. A massive breeding colony on Funk Island off the coast of Newfoundland, which held perhaps as many as one hundred thousand birds at its peak, was decimated in the eighteenth century. By 1800, the bird had by all accounts disappeared from the Western North Atlantic. On the European side, it was hanging on by the thinnest of biological threads.[1]

We know regrettably little about the great auk's life history and behavior—the species was lost before any trained naturalist

FIGURE 2.1 *The Great Auk*. Painting by John James Audubon.

Source: Public domain.

or scientist was able to observe it in the field.[2] Still, the evidence suggests that several things contributed to the great auk's fate beyond the gastronomic and commercial impulses of bird hunters and traders. A master swimmer, the bird was apparently slow and clumsy on land. Unable to breed on ice (like penguins) or retreat to the safety of cliffs like other birds of the north, it was especially vulnerable to hunters. The auk's need to cluster in large numbers made the pickings easy, at least if hunters could get to them. Although many auk colonies were located on remote and hard-to-access skerries, the large breeding colony on Funk Island was close to the end of a shipping route, a geographical coincidence that probably guaranteed its demise when commercial interest in the species took off in the eighteenth century.[3]

As great auks became scarcer in the late eighteenth and early nineteenth centuries, their value for collectors (both amateur and scientific, though the distinction then was not sharp) grew. As

one observer notes, a "collection frenzy" focused on the increasingly rare bird quickly emerged, with ornithologists and museum curators eager to acquire great auk skins and eggs.[4] The bird's breeding site—the great auk's final refuge—was located on the small island of Eldey, a bleak and uninviting rock jutting up out of the sea about ten miles off the tip of southwestern Iceland. It looks like a tombstone, which in a way, it is.

By the 1830s, Icelanders who took great auks from Eldey reported seeing fewer birds each time they visited the island. In June 1844, three fishermen (commissioned by a great auk dealer) killed what is the last confirmed breeding pair of the flightless birds. Although unverified reports of auk sightings would persist for a few years, including in Newfoundland, history has recorded the 1844 Eldey date as the moment the curtain dropped on the species.[5] The dead specimens were sold to a local chemist, who stuffed them and preserved them in spirits. Their internal organs currently reside at the Natural History Museum of Denmark.

Until recently, the location of the skins of the last breeding pair of great auks was not known. The veil of mystery surrounding their whereabouts, however, may finally be lifting, thanks to some cutting-edge scientific sleuthing. In 2017, researchers using advanced genetic analysis reported that they believed the internal organs of the last male great auk in Denmark match the skin currently held at the Royal Belgian Institute of Natural Sciences in Brussels. The skin of the female taken on that last collecting trip in 1844 is likely waiting in another museum collection, perhaps, the same research team suggests, in the Cincinnati Museum of Natural History and Science.[6] Time—and additional mitochondrial genome sequencing—may tell.

Did collectors drive the great auk to extinction? In a sense, yes, but saying so without qualification is misleading. Although the

historical record indicates that specimen collectors took the last two birds confirmed to be in existence, centuries of killing for food and fuel and a commercial market in great auk feathers clearly pushed the species to the wall long before their rarity attracted the eye of collectors and curators.

But collecting and hunting apparently weren't the only drivers of the bird's decline. Some scientists have argued that environmental factors, such as climactic oscillations before and during the period of intense human pressure on the bird, may have played a significant role in the auk's ultimate end. A hypothesized increase in sea ice around the Icelandic breeding grounds would have made great auk populations even more vulnerable to human predation.[7] Other natural events, including a volcanic eruption on Geirfuglasker (a small islet once near Reykjanes, Iceland) in 1830 that forced the remaining great auk population to beat a retreat to nearby Eldey, also made life difficult for the birds toward the end.[8]

Collectors, then, were neither solely nor primarily responsible for the extinction of the great auk—not by a long shot. But this only raises another question. If collectors shouldn't receive all or even most of the blame for the extinction of the great auk, don't they still bear a share of the responsibility for its disappearance? Clearly, they do. They were, after all, the ones to drive the final nail into the bird's coffin. Furthermore, we know that eighty stuffed specimens (give or take) ended up in museum collections, along with a nearly equal number of eggs.[9] The species was, it's true, on the evolutionary ropes by the time collectors swooped in. But if they hadn't, might the bird have survived?

Some auk experts don't think so. One of them is Errol Fuller, an authority on bird extinctions (and the great auk in particular). Fuller concludes that although scores of great auk specimens

ended up mounted in museums, the species had an unbreakable appointment with extinction, collectors or no:

> The truth is that the great auk was doomed to extinction long before any museum director became interested in it—and the reason for this was very simple. The bird was good to eat—and, during a particular season of the year, it was easy to catch. By the time collectors became seriously interested in it, the species' population was so small that it was not viable. Nothing could have saved it.[10]

Others, however, are not so sure that the bird was the "walking dead" by the time collectors picked up their clubs and specimen bags. The ornithologist and author Jeremy Gaskell puts it this way in his book *Who Killed the Great Auk?*:

> It is not least among the ironies shrouding the history of the Great Auk that those scientifically minded gentlemen who furnished the demand for "skins," which ensured that a brisk trade continued until the ultimate extinction of the species, are among those who must be counted the bird's greatest admirers. The Great Auk is far from being the only species to which collectors have delivered the final blow but there are very few creatures which have been extirpated solely as a result of collecting—an activity which is usually "the final straw" for one already threatened.[11]

Gaskell goes on to make the point that when the last two specimens were acquired by the Zoological Museum in Copenhagen in the 1840s, knowledge of the species' range and population size was at best imperfect. "No one had any idea," he writes, "of just how tenuous the bird's hold on existence had become."

This may provide a degree of exoneration for collectors—the familiar "ignorance excuse"—although anecdotal accounts from fishermen and collecting parties suggest that they knew the bird was becoming scarce (again, its growing rarity was one of the reasons they became interested in procuring specimens in the first place). But is it the case, as Fuller and others believe, that *nothing* (including the cessation of collection) could have saved the great auk from oblivion?

After all, at one point in the 1980s there were fewer than two dozen California condors left in existence, yet an aggressive and controversial breeding program was able to breathe new life into the species (I'll have more to say about this in the next chapter). Had a few dozen specimens of great auk held out long enough—say, until the early twentieth century—could they have been saved through similar heroic (albeit more nascent) conservation interventions? Maybe, maybe not.

Extinction parlor games aside, though, the auk story raises one final question. Knowing what we now know about the tightening of the biological noose around the great auk in the decades leading up to its extinction, do we really think those eighty birds (and the other specimens that never found their way into sanctioned museum collections) should have been taken?

THE "GOLD STANDARD"

There's an old Gary Larson *Far Side* cartoon that depicts two bespectacled and pith-helmeted lepidopterists in the field, brandishing their nets. One of them holds a large, charismatic-looking butterfly gingerly by the wing. "An excellent specimen," he declares to his compatriot, "the symbol of beauty, innocence, and fragile life." He then delivers the zinger: "Hand me the jar of ether."

The joke lands because of the apparent incongruity of the scene: an appreciation of natural beauty and frailty followed by the abrupt decision to kill the organism in the name of science. Yet specimen collection, as the cartoonist Larson clearly knows, is deeply ensconced in the traditions and methodologies of natural history and taxonomy.

The traditional method is indeed to collect a "voucher" specimen from the field—taking a bird, fish, frog, insect, plant, etc.—and carry it back to the lab to describe its taxonomic characteristics. Doing so permits the species to be identified and distinguished from animals and plants already known to science. Typically, the specimen is then deposited in a natural history collection, where it is pinned, pickled, and preserved for later scientific reference and study.

Collecting voucher specimens is a well-established practice for documenting a species' occurrence, especially when identification is difficult. In fact, voucher specimens are widely referred to as the "gold standard" in scientific description, inasmuch as they provide a verifiable, enduring (provided they're properly curated), and as complete a record of an animal as is possible. Although voucher specimens have been used for all manner of science, from natural history and evolutionary biology to the study of environmental change, the science of taxonomy in particular rests upon these resources and their preservation of the characteristics by which different species can be distinguished and identified.[12]

But what if it turns out that the new or rediscovered species exists only in a small and isolated population—that is, a population very vulnerable to human impact, including collecting? Even more likely, what if, as in the historical case of the great auk, we just don't *know* how many individuals of the species there are in the wild when a specimen is taken?

This scenario seems to describe the widely reported rediscovery, in 2015, of the Guadalcanal moustached kingfisher (*Actenoides excelsus*), a spectacularly plumed bird (figure 2.2) that hadn't been seen in decades and had never been photographed. The bird is only found in the thick, closed canopy forests of Guadalcanal in the Solomon Islands, a chain of islands lying southeast of Papua New Guinea. In September 2015, a group of researchers led by scientists from the American Museum of Natural History encountered this highly elusive "ghost" bird while performing a major biodiversity survey of the upland forests in Guadalcanal. After capturing and photographing the bird (a male), the lead scientist in the survey team euthanized the animal and brought it back to New York for cataloging and further study.[13]

Although the International Union for Conservation of Nature (or IUCN) currently lists the bird as "Endangered," the biologist who collected the bird wrote (in an op-ed in *Audubon*) that he believed it to be abundant on the island based on his interpretation of local tribal accounts of the kingfisher, bird calls heard and sightings reported by his research team, and a rough estimation of potential habitat area. Collecting a single specimen, he concluded, had no impact the bird's conservation status. Furthermore, he predicted that the procurement of a moustached kingfisher voucher specimen will yield great benefits to science and conservation efforts, now and in the future.[14]

The case reveals a conundrum at the heart of this scientific methodology regarding the description of new species or rediscovered species that may exist in small numbers and that are as a result highly vulnerable to human pressure—including scientific study. The population of the moustached kingfisher may indeed turn out to be large enough so that collecting one specimen (or several) doesn't make the species more vulnerable to extinction. But the point is that we can't know for sure, and so

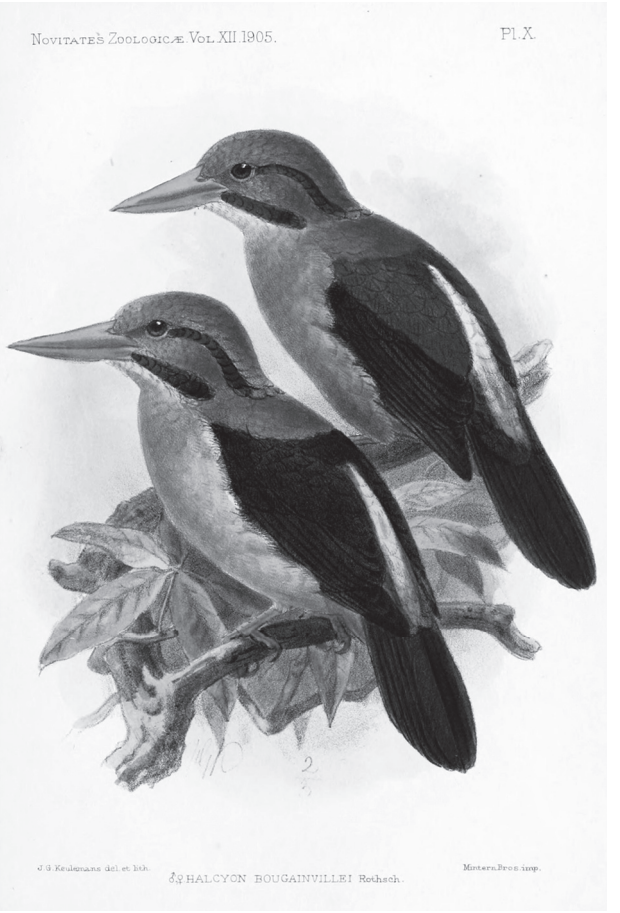

FIGURE 2.2 An illustration of the Bougainville moustached kingfisher (*Actenoides bougainvillea*), a closely related species to the newly documented Guadalcanal bird.

Source: J. G. Keulemans, *Novitates Zoologicae* (1905). Public domain.

collecting a specimen in these cases could unintentionally increase the extinction risk to the species. When the population is small and vulnerable enough, every individual matters.

The moustached kingfisher case, though, is not unique in raising the question of whether specimen collection within potentially vulnerable populations might be ecologically (and evolutionarily) risky. Field collection of individuals from small, isolated, and fragile populations vulnerable to extinction appears to have played a role—usually combining with other activities such as habitat loss or predation by invasive species—in a number of historical and contemporary cases of species decline and extinction.

Collection by professional and amateur scientists has been linked to the extinction of Mexico's socorro elf owl (*Micrathene whitneyi soccorroensis*), a small owl dwelling on an island south of Baja California. The animal was taken every time collectors visited the island and has not been seen since 1970.[15] Another species, the giant Cape Verde skink (*Macroscincus coctei*), a lizard endemic to this island archipelago off the northwestern coast of Africa, went extinct in the early twentieth century in part because of the selective collecting of adult specimens, which was likely driven by the demands of natural history museums.[16] More recently, the Ozark hellbender (*Cryptobranchus alleganiensis bishopi*), an endangered aquatic salamander found in southern Missouri and northern Arkansas, has experienced a documented decline since 1980 partly from the combination of illegal harvesting for the pet trade and legal scientific collection. As in many cases, there is a lack of baseline population data on the hellbender, so it's difficult to estimate the full impact of scientific collecting (and especially, illegal harvesting) on the species.[17]

Although species decline and extinction are the most problematic and ethically disconcerting outcomes that can be linked

to overzealous specimen collection (again, in tandem with other anthropogenic threats), the impacts of possible overcollection also raise questions about the consequences of excessive interference in animal communities on behavior and may portend a later rapid decline in population size. This scenario may describe the behavior of the orange-throated whiptail (*Aspidoscelis hyperythra* group), a lizard that occurs on several islands in the Gulf of California and most of the Baja California peninsular mainland. Researchers found that lizards located on the uninhabited islands displayed greater antipredator behavior (e.g., avoidance of humans) than those on the mainland, a phenomenon, they believe, that may be related to pressure from scientific collecting.[18] They conclude that the lizards' behavioral change may be an early signal of overcollection, one that might indicate that precautionary measures to avoid increased human disturbance should be considered.

As the case of the moustached kingfisher illustrates, the rediscovery of species presumed lost presents a particularly strong lure for specimen collectors. Newly discovered and rediscovered species are a bright spot in the murky gloom of the extinction crisis. Up to 18,000 species around the globe are discovered by scientists every year, a rough estimate and perhaps a generous one.[19] Still, it's true that scientists document thousands of new species annually—as well as many species thought to be extinct but recently rediscovered. It's a welcome reminder of the scrappy resilience of animal and plant life on Earth, even as tropical forests yield to oil palm plantations, the sea and land are stripped of profitable species, and the climate changes.

In 2012, for example, Australian researchers working in New Guinea collected dozens of small bats from a handful of known species. Among the specimens taken was a female bat that they could not identify in the field. It was deposited in the Papua New

Guinea National Museum and Art Gallery, where it sat (presumably very quietly) for a couple of years. Two years later, an Australian museum researcher requested the specimen and was able to determine that it was, in fact, a New Guinea big-eared bat, a species last observed in the late nineteenth century and long presumed lost.[20] Despite its happy return from the (apparent) dead, scientists once again have no idea how many individuals of the species currently exist in the wild.

The story is similar across a wide assortment of taxa. "Lazarus species" that have reappeared after being presumed extinct include amphibians like Costa Rica's angel robber frog (*Craugastor angelicus*), which hadn't been encountered since 1994. A likely victim of a lethal fungal pathogen that has decimated amphibians in Central America and worldwide, the frog was listed as "Possibly Extinct" by the IUCN. In 2016, however, a researcher came across one during a routine field survey in Monteverde. Despite the absence of an estimate of the frog's current population size (presumably quite small, given its decades-long invisibility to field scientists), the specimen was collected (legally) and deposited in the taxonomic reference collection of the Costa Rican Amphibian Research Center.[21] The desire to collect voucher specimens to verify the reappearance of species presumed extinct thus often seems to be heightened by the recognition of the organism's rarity—a compulsion to acquire elusive specimens that has long gripped both amateur and scientific collectors.[22]

KICKING THE HORNET'S NEST

Should scientists have taken specimens in these cases—that is, when there is significant uncertainty about the population size

of the organism in question yet good reason to believe that it may be very small and vulnerable to collecting? Should they have taken this risk?

I don't believe they should have. In a paper published in *Science* in 2014, my coauthors and I argued that methodological traditions in field biology and taxonomy encouraging the collection of voucher specimens to confirm a species' existence can magnify and combine with other forms of extinction risk for small populations of rare and vulnerable species.[23]

Although specimen-collection norms are deeply ingrained in many scientific communities, there are now alternative methods of documentation, including high-resolution photography (even with a smartphone), audio recording (if the organism has a call), and noninvasive DNA sampling (for instance, via skin swabbing). The voucher specimen should, we argued in *Science*, no longer be viewed as the gold standard in species description, especially given the power and availability of these alternative technologies and means of description. When used together, we suggested that these techniques can provide a very effective (and importantly, a *nonlethal*) method for identifying new or rediscovered species. We suggested that "collect first and collect always" should no longer be the default norm in species description, especially in risky collecting contexts (i.e., in the case of small, rare, and vulnerable populations or when there is considerable uncertainty about population size but reason to suspect it is small).

Our paper drew a quick and forceful rebuke from the scientific collecting community. More than 120 academic and museum scientists (including E. O. Wilson, often referred to as the "father of biodiversity") on six continents apparently took great offense at our proposal, as evidenced by the strongly worded letter they sent to *Science* not long after our paper appeared. The authors of

the letter doubled down on the necessity of the voucher specimen in taxonomic description and biological science and vigorously defended natural history museums from what they took to be an antiscientific assault on their value.[24] Writing that we had overstated the risk collection has and continues to pose to species conservation, they also characterized our paper as suggesting (incorrectly) that collecting was a significant driver of species extinction. The controversy quickly spilled out of the pages of *Science* and was picked up by the national media, including National Public Radio, which ran a feature on the collecting debate on their *Morning Edition* program.[25]

But—and this should have been clear from a careful reading of our original paper—the focus of our concern was the particularly risky case of collecting specimens from *vulnerable* populations (especially when we don't have a reliable estimate of their size). In other words, and despite what our critics suggested, we weren't advocating the banning of responsible specimen collection. To do so would have been seriously hypocritical—two of my coauthors (the biologists James P. Collins and Robert Puschendorf) have and continue to collect research specimens. And as we wrote in our response to the critics in *Science*, nowhere in our original article did we claim that scientific collection was a leading driver of extinction.[26] Habitat loss and fragmentation, commercial exploitation, the spread of invasive species, toxins, infectious diseases, and climate change remain the primary threats to biodiversity around the globe. As we just saw, specimen collectors may have taken the last great auks, but the species was in serious decline after centuries of human overexploitation for food, fuel, and feathers.

Still, the point remains that without a reliable estimate of population size, collecting individuals from a small, isolated population can pose an extinction risk. And if collecting a specimen

increases extinction risk, then it is a threat to biodiversity and should be avoided. In our reply to our critics in *Science* we tried to underscore that it is important to highlight this risk and to find ways to mitigate this particular threat (e.g., by using alternative methods to identify new and rediscovered species that don't require taking specimens from the field). We also made it clear that we hold no animus toward natural history museums. Quite the contrary; we admire them greatly and appreciate the good work they do for science and education—and, of course, for conservation. The use of ancient DNA from museum specimens to fill in the evolutionary gaps of our understanding of species and the value of existing museum specimens to conservation and to science generally (including prospective uses we don't yet anticipate) are widely recognized and justly celebrated.[27] Genetic material extracted from museum specimens has proved important, for example, in understanding the origins and spread of wildlife diseases, such as the devastating chytrid fungus, which has carved a vicious swath through amphibian populations around the world.[28] And as we've seen, it can also help us solve "mysteries of natural history" like the whereabouts of the last great auk specimens. But that doesn't mean we should refrain from discussing and assessing practices that may put unintended pressure on already vulnerable populations in the wild.

Our critics also argued that scientific collectors today are always responsible and follow strict regulations and ethical guidelines (where these exist) for collecting from vulnerable populations that render concerns about irresponsible collecting unwarranted. Yet as the cases just mentioned suggest, specimen collection may be sanctioned yet still be inadvisable based on our ignorance of population demography in particular situations or because we have reason to assume that the organism is very rare (a precautionary response in the case of species rediscovered long

after they've been presumed extinct in the wild). Furthermore, although I'd like to think that ethical research conduct is ubiquitous in modern scientific practice, adherence to strict ethical codes and research protocols by researchers is neither universal nor unfaltering. Personal accounts from field biologists (including one of the coauthors of my *Science* paper) suggest that violations of collecting ethics and regulations are not confined to those benighted collectors that plucked the last great auks from Eldey; such violations have and continue to take place. A culture of responsible scientific practice, including practices relating to specimen collection, is not created simply by publishing regulatory guidelines and ethical prescriptions in professional codes of ethics.

Perhaps the most troubling line of thinking in the various rebuttals to our collecting paper, however, concerned the presumed absolution of collectors in cases where the species in question was the most vulnerable. Some scientists seem to subscribe to the notion that if the population size of a particular species is already so low that scientific collecting poses an extinction risk, then it is already an ecological goner. Collecting in such cases is therefore largely guilt-free from a conservation perspective. This is the "walking dead" argument.[29] Following this logic, however, it would seem that any very small, fragmented, and at-risk population in the wild would be eligible for collecting.

Needless to say, this "collection or bust" philosophy evokes troubling scenarios. What if, for example, the great auk somehow managed to pull off one of the most stunning ecological reappearing acts of all time, reemerging on some far-flung skerry in the North Atlantic? Would these same scientists urge the bird's collection?

If this seems a little too uncharitable a thought experiment, consider that some researchers writing in the wake of our

collecting debate suggested that in those cases where we know for certain that a species is declining or when we're sure that the habitat of a threatened species will be demolished, there is an even *greater* need for collecting. It would in fact be "folly," one group of Australian museum scientists argued, to *under*collect, given the possible prohibitive costs of returning to the field to procure specimens. Since in these cases there may be no specimens left of this species to take in the future, they argue, we need to collect while the collecting is good.[30]

As an environmental ethicist and conservationist, I find this argument bizarre and, frankly, a little disturbing. The primary interest seems to be procuring specimens at almost any cost, including under the most ecologically catastrophic of circumstances.[31] Even if the evidence indicates a species is hurtling toward extinction, a raft of examples, from the California condor and Arabian oryx to the Devil's Hole pupfish, reminds us that with ample resources, political will, and more than a little luck, a species can be brought back from the brink, even when population numbers slip below what is taken to be a viable size. And even when this is not possible, should responsible and experienced scientists really be so cavalier about giving a species the final push off the biotic cliff?

In any case, our paper obviously touched a nerve in the collecting community. No doubt some of the irritation can be chalked up to a sense of embattlement among a community that already is hemmed in to a degree by a cordon of institutional red tape, including permitting requirements and animal-care committees that scrutinize research activities involving vertebrates. The scientific collector today operates in a far more regulated research environment than the one enjoyed by earlier generations of specimen seekers. But the general defensiveness surrounding the call to take a more careful and cautious view of collecting

and the strong pushback from taxonomists and museum scientists are far from new.

Writing in *Science* a century ago, the great University at California–Berkeley zoologist and museum director Joseph Grinnell (figure 2.3) lamented the decline of what he called the "shotgun method" of collecting field specimens, a growing trend among researchers that he worried would undercut the scientific foundations of ornithology and replace the venerable standard of the "skin record" with the inaccurate observations of the "opera glass" naturalist.[32]

At the same time, Grinnell was a fervent conservationist and a great champion of wilderness and wildlife protection. His views toward specimen collection, though, suggest that he didn't grasp the problem of risky or irresponsible collecting, at least not fully. In his 1915 *Science* essay, Grinnell did importantly acknowledge that there should be restrictions imposed on the taking of individuals from "rare or disappearing species like the ivory-billed woodpecker or the Carolina parakeet," but he also believed that the scientific collector, "because of his appreciation of the facts upon which the principles of conservation are based, is more likely to abstain from killing the wholly protected species."[33]

A FLY IN THE OINTMENT

Grinnell's forceful plea to "conserve the collector," however, didn't anticipate the surge in the trend of species rediscovery and the strong desire to authenticate and procure the reemergent organisms by scientific collectors. (He believed, in fact, that "comparatively few" people would have the requisite training and the naturalist's "bent" to collect.)[34] But Grinnell also couldn't have predicted the many technological and methodological

FIGURE 2.3 Joseph Grinnell in 1930. "Accuracy in identification of species and especially subspecies rests for final appeal upon the actual capture and comparison of specimens."

Source: The Museum of Vertebrate Zoology, University of California, Berkeley; used by permission.

innovations over the past century that have fundamentally changed the game when it comes to recording and verifying species in the field (from easily available high-resolution photography to molecular techniques). Collecting specimens may be important for many purposes, but it is no longer required to

describe a species—or to document its rediscovery. We've come a long way from opera glasses.

And this holds for even some of the smallest of specimens. After our *Science* paper was published, an article referencing our argument appeared in the taxonomic journal *ZooKeys* describing a new and rare species of bee fly in South Africa (*Marleyimyia xylocopae*).[35] The species was identified and described relying solely on photographic documentation. Even though the authors argued that specimen collection is still for them the preferred method of species identification and description, they also concluded that "it is indeed no longer required."[36]

Not surprisingly, the paper stirred up its own share of controversy in the taxonomic community, with rebuttals from other scientists (one letter alone had nearly five hundred signatures) defending, once again, the necessity of voucher specimens for scientific description while criticizing the value and completeness of even the best digital photography.[37] The authors of the original paper, for their part, defended the use of photography in situations such as theirs, where the individual flies escaped before they could be collected and preserved.

The debate quickly got into the weeds of taxonomic rules and practices regarding proper species description, species naming, the implications of normalizing "digital collecting" as a valid taxonomic practice, and so on.[38] But it's encouraging evidence that the winds of change may be blowing in certain pockets of scientific collecting, albeit fitfully.

In the years since our paper originally appeared, other scientists have cautioned against collecting vouchers from newly discovered or rediscovered species, at least until we know that the populations and species are viable and can be collected without negative demographic consequences and increasing the risk of extinction.[39] For example, researchers conducting field surveys

in Panama to learn whether critically endangered harlequin frogs still persist after the spread of the lethal chytrid fungus endorsed our suggestion to use photographic methods to confirm species reappearance rather than the collection of whole specimens.[40] And in their recent study of endemic bird and mammal specimens collected historically from Madagascar, an international team of scientists called for the greater use of nonlethal alternatives to document biodiversity and for increased data sharing and more extensive digitization of museum collections, which would reduce the need for the collection of new specimens.[41]

Analogous calls to take a precautionary approach to field research in light of potential ecological impacts are also a sign that a growing number of researchers are recognizing the need to (at times) constrain the march of biological science when it threatens to run afoul of conservation ethics. A case in point is a recent paper published in *Science* titled "Do Not Publish," in which David Lindenmeyer (a notable Australian conservation scientist) and his coauthor Benjamin Scheele raised worries about the increased accessibility of location data for species of conservation concern: digital and open-access publishing platforms can make it easier for individuals (including illegal collectors and poachers) to find and take rare organisms from the wild.[42] As with our collecting argument, which called for balancing taxonomic and species-identification demands with an ethic of species protection, the authors argued that we must weigh the value of location information for science with the commitment to reducing human impacts and extinction risks. It's another example of scientists urging increased care and caution in the conduct of biological field research that has the potential to affect—directly or indirectly—the viability of sensitive populations and species.

The discussion of collecting risk and responsible scientific practice regarding research on (and sharing information about) rare and vulnerable species can be seen as part of a larger conversation about what my Arizona State University colleague Jim Collins and I have called "ecological ethics." The collection of voucher specimens joins a host of research practices, from the use of specimen marking and monitoring techniques (which may have both population-level as well as individual-level impacts) to manipulative research in sensitive ecosystems. But the discussion of ecological ethics also applies to those wildlife- and biodiversity-management practices that require careful deliberation over the harms, benefits, and responsibilities of conservation managers, from the control of invasive species and the treatment of wildlife disease to the conservation of wildlife populations across the full spectrum of in situ (wild) and ex situ (zoos and aquariums) environments.[43]

The idea of ecological ethics is modeled in part on the field of biomedical ethics, which has done a much better job than traditional environmental ethics in engaging real-world ethical challenges and speaking to the concerns of biomedical researchers and clinicians. The goal of ecological ethics as Jim and I see it is to develop a more practical and useful ethical "toolkit" for ecological researchers, field biologists, and wildlife and biodiversity managers, one that drags the concepts and principles of environmental ethics down from the philosopher's mountaintop and throws them into the messy world of environmental research and management. In the process, the abstract expressions of environmental ethics are reshaped to meet practical scientific challenges, such as specimen collection from new and rediscovered populations, that raise critical questions about researchers' obligations to wild species and ecosystems, their responsibilities

to expanding the frontiers of science, and how we might weigh the tradeoffs between them.

Collecting vouchers from new or rediscovered species will no doubt remain an ethically contentious issue in field biology and taxonomy for some time to come. But the adoption of conservation-minded alternatives to specimen collection will hopefully also continue to be explored and assessed across taxa and across research communities.

In the end, though, two things are clear. No scientist or conservationist today (including me) would deny the importance and value of describing a new species or confirming the return of one thought lost to extinction. But it's also inarguable that scientists share a powerful ethical responsibility to minimize the adverse ecological impacts of their work, however vital that work is thought to be for advancing basic or applied science.[44] That holds true even for (and maybe *especially* for) research to authenticate a species' existence—or to verify its welcome return from the dead.

3

THE CALL OF THE QUASI WILD

WHY THE BUFFALO STILL ROAM

Possibly no species embodies our conflicting impulses to destroy and protect nature as fully as the American bison (*Bison bison*, a.k.a. the buffalo). Like the passenger pigeon and the great auk, the bison was intensively exploited (hunted) by humans. It was also pummeled by an additional fusillade of natural and human-driven stressors, from the spread of disease and fire to changes in climate and competition with domestic livestock.[1] In the latter third of the nineteenth century, commercial demand for bison leather nearly did the species in, a market impact magnified (as with the case of the passenger pigeon) by the completion of the transcontinental railroad.[2] Once ranging across a large swath of North America and numbering in the tens of millions, by the turn of the twentieth century the hulking animal known as the "Thunder of the Plains" was reduced in the wild to a pair of small remnant populations in Canada and in and around Yellowstone National Park (figure 3.1).[3]

It's by now a familiar story: a species pushed to the brink by a potent mixture of human voracity, technological ingenuity, and imprudence. Yet unlike the great auk and the passenger pigeon,

FIGURE 3.1 A mound of bison skulls waiting to be ground for fertilizer in the 1870s.

Source: Public domain.

the bison drew the attention of several naturalists and early wildlife conservationists. The most consequential among them was the hard-charging wildlife advocate William T. Hornaday (whom we met briefly in the early pages of this book). In 1889, Hornaday published his landmark study, *The Extermination of the American Bison*, which today is considered to be one of the founding texts of the American wildlife conservation movement.[4]

In this work, which examined the natural history and decline of the species, Hornaday made the case for the bison's protection as a national imperative. And he described a perverse dynamic at play as the animal became increasingly scarce on the

range. "The nearer the species approaches to complete extermination," Hornaday wrote, "the more eagerly are the wretched fugitives pursued to the death whenever found." The fading of the bison begat in his view a kind of frontier narcissism as hunters jockeyed for "the honor (?) of killing the last buffalo."[5]

There was a fair amount of cognitive and moral dissonance at play in Hornaday's invective against bison hunters, however. The author could also count himself among those "eager pursuers" of the last of the species, even if it was a pursuit cloaked in the garb of science and the public interest rather than crass commerce. A taxidermist by trade, Hornaday was dispatched in the mid-1880s by the secretary of the Smithsonian to collect dozens of complete bison specimens, as well as skins, skeletons, and skulls, for the US National Museum. Hornaday lamented that the museum had only a paltry collection of old bison specimens in poor condition, an "alarming state of affairs" that needed to be corrected.[6] Although he confessed to feeling guilty about killing bison for the museum, Hornaday believed that the species' fate was likely sealed and that the proper, professionally rendered display of the animal at the Smithsonian—and at other US museums lacking bison exhibits—was a scientific and public service that offset his own role in the killing (an argument that, as we saw in the previous chapter, remains compelling to collectors even today).[7]

Yet Hornaday also appears to have undergone something of a moral conversion during his bison expeditions, one that the historian Mark Barrow describes as a transformation from acquisitive museum collector to staunch wildlife preservationist committed to saving the species from vanishing once and for all from the landscape.[8] Soon after he took the reins of the New York Zoological Park (a.k.a. Bronx Zoo) in 1899, Hornaday would preside over a historic bison breeding and reintroduction

FIGURE 3.2 William T. Hornaday (left) observing bison at the Bronx Zoo being prepared for delivery to the Wichita Forest and Game Preserve, Oklahoma, in 1907.

Source: © Wildlife Conservation Society. Reproduced by permission of the WCS Archives.

program widely credited with helping to save the species from extinction in the early twentieth century—a program that enjoyed the support of other well-heeled and powerful East Coast conservationists (figure 3.2). Chief among them was President Teddy Roosevelt, who would also recalibrate his view toward the bison, ultimately leading him to support the protection of an animal he famously hunted, albeit with declining zeal, throughout the 1880s.[9]

Even as other species around it slipped away, the bison was saved from oblivion for several reasons, not least the animal's responsiveness to breeding in captivity and the existence of privately held bison herds, which became de facto "assurance

populations" as the animal declined in the wild.[10] But the bison's subversion of the exploitation-decline-extinction narrative in the early twentieth century was likely also a function of an aesthetic quality lacking in other contemporaneously disappearing species like the passenger pigeon. Unlike the pigeon, the bison stoked the fires of the imagination, evoking to many the history and image of a raw and untamed land, a rapidly vanishing American frontier. [11] For Hornaday, Roosevelt, George Bird Grinnell, and other elite wildlife conservationists of the time, it was thus a symbol—and a species—well worth preserving, even at considerable cost and effort.

The recovery of the bison is one of the great success stories in American conservation history. For a century, its grand visage has adorned the seal of the US Department of the Interior, the agency that administers the National Park System and many of the wildest places on the American landscape. Viewed by many as an icon of "hope and resilience," in 2016 the bison was designated the "national mammal" of the United States by President Barack Obama, joining the bald eagle in the bestiary of American national identity.

The rescue of this icon of the wild also remains one of the crowning conservation achievements of American zoos. Yet even though the Bronx Zoo's role in the breeding and reintroduction of the bison has secured its place in American conservation history, it's fair to say that zoos have always had a vexed relationship with what's taken to be the "genuine" wild.[12]

US zoos have asserted their scientific and wildlife protection bona fides since their emergence (in their modern, professional form) in the latter part of the nineteenth century. But zoological parks have also had to balance their conservation and wildlife protection goals with a more dominant and more visible entertainment mission. It's a challenge that can reinforce the

criticism (fair or not) that zoos are contrived and unnatural places, artificially arranged collections of exotic animals displayed for human amusement and little else.

Still, a growing number of voices today (from zoo designers and architects to biologists and conservation psychologists) are challenging the assumption that the designed-within-an-inch-of-its-life zoo landscape—and the animals displayed within it—can only ever be shadows of "real" nature, a counterfeit wild. In the process, they're stirring up some big ideas about what zoos are and what we want them to be—and shining a light on some of the assumptions crouching behind our ideals of wilderness as the human footprint sinks deeper into the landscape.

These attempts to blur the boundary between the zoo and the wild, however, are working against the grain of some powerful traditions in nature preservation, traditions that have rendered the biological and philosophical margin separating wild conditions from the zoo a brightly lit cordon, a distinction and distance many conservationists and wilderness enthusiasts have long believed are vital to maintain. I think there's no better historical example of this deep-seated rift than the story of the Yosemite zoo.

THE YOSEMITE *ZOO*?

John Muir probably would have been shocked at the sight of it: a caged collection of mountain lions, deer, and bears on public display in the heart of his beloved Yosemite National Park. Yet had the iconic naturalist and wilderness advocate lived only a few years more (he died in 1914), he would surely have encountered Yosemite's unlikely—and today mostly forgotten—zoo.

By all accounts a misfire in the park's (and the National Park Service's) history of wildlife management, the Yosemite Valley

zoo is nevertheless a fascinating episode in the evolution of one of the nation's iconic wilderness parks. The "menagerie," as the park naturalist Ansel Hall called it in his 1920 guide to Yosemite, was about a third of a mile from the center of Yosemite village, part of a cluster of structures that included the park schoolhouse, barns, and various utility buildings.[13] It opened in 1918 following the donation of several orphaned mountain lion cubs to the park by Jay C. Bruce, a lion hunter for the state of California.[14]

The motivation behind putting a zoo in Yosemite seems to have been to ensure that tourists would have a chance to see some of the park's most popular wildlife during a visit.[15] The commitment to the display of native animals was fairly relaxed, however. Although the naturalist Hall described it as containing "several wild animals captured in the region," not all the animals in the Yosemite zoo were, in fact, plucked from native populations. Two of the zoo's mountain lions were actually Rocky Mountain varieties taken from Yellowstone National Park, making them "exotic" to the northern California landscape.[16]

The Yosemite Valley zoo never amounted to anything more than a small, opportunistic, ad hoc animal collection. Still, it was apparently enough to draw the ire of one of the nation's most renowned biologists (whom we heard from in the previous chapter): Joseph Grinnell, director of the Museum of Vertebrate Zoology at the University of California–Berkeley. Grinnell, like Muir before him, was a staunch supporter of the national parks (and of nearby Yosemite in particular). More significant, he was a pivotal figure in early efforts to put wildlife protection in the parks on solid scientific footing during the formative decades of the National Park Service.[17]

"I recommend the elimination of the 'zoo,'" Grinnell wrote in an open letter to the park superintendent after a Yosemite

Valley visit in 1927, a missive he summarized and published in the *Journal of Mammalogy* the following year.[18] The park resources currently employed in supporting the menagerie would be much better spent, Grinnell thought, on the Yosemite Museum, which he suggested was a far more suitable vehicle for educating park visitors on the diversity and natural history of the area's wildlife. Although Grinnell rather reluctantly admitted that zoos were appropriate institutions "in a crowded city, for benefit of people who cannot reach the open spaces," he emphasized that a national park should be a completely different kind of place: an area maintained as far as possible as a natural landscape.

Grinnell's vision of park management at times bordered on the Edenic, however, elevating an aesthetic and historical ideal of wild country while simultaneously discounting the record of human influence on the landscape, especially the activities of Native Americans. A dozen years earlier, Grinnell (with his Berkeley colleague Tracy Storer) wrote in *Science* that the national parks, as those lands "kept fairly immune from human influence," offered the rare opportunity for visitors to experience nature as it was before "the advent of the white man."[19] Grinnell's celebration of the untrammeled character of the great parks of the American West was, of course, not an unusual sentiment during the early years of the National Park Service; indeed, as an aesthetic expectation and environmental ethic for US park and wilderness management it would persist throughout most of the twentieth century.[20]

For Grinnell and similarly minded wildlife biologists it thus seemed an obvious question: Why have a zoo in a magnificent place like Yosemite, when it already served as a "zoological park in the widest and best sense"?[21] An "artificial" zoo just didn't belong in a national park, especially a flagship wildlife and

wilderness park like Yosemite. Despite their shared interest in attracting and satisfying a curious public, biologists and park administrators clearly saw the park and the zoo as fundamentally different entities, reflecting disparate aesthetic and ecological values and priorities. Transplanting a zoo into a place like Yosemite (or Yellowstone, which in 1925 opened its own menagerie of bison, bears, coyotes—and a badger)[22] must therefore result in the institutional equivalent of tissue rejection. The message was clear. In the midst of a truly spectacular wild landscape, a zoo could only be a pitiable spectacle.

BETWEEN THE WILD AND WALLED

Grinnell's lobbying worked: Yosemite's zoo was shuttered in 1933. But the dissatisfaction with the perceived inauthenticity and artificiality of the zoo, especially compared with what was deemed truly wild nature, would prove a difficult narrative for zoos to shake over much of the twentieth century. Zoos played into this critique for the next several decades, what the zoo leader and friendly critic David Hancocks calls the "Disinfectant Era." The focus was not on making zoo exhibits more natural or wild so much as it was on providing efficient and sterile enclosures that could be easily cleaned—a "bathroom" aesthetic heavy on plate glass, white tile, and steel doors.[23]

It often amounted to a bleak landscape, one that in the 1970s found the distinguished art critic and novelist John Berger lamenting that, as an institution, "the zoo cannot but disappoint."[24] As with the case of the Yosemite zoo, the manifest artificiality of the zoo was the primary culprit. But Berger went further. He argued that the zoological artifice led to a deeper and more profound ethos of "separation": species were segregated

from one another (and from their natural habitats), and animals were cordoned off from people by layers of glass, concrete, and steel. It all reinforced an ethic and a visual culture, he wrote, that promoted the greater marginalizing of animals in modern society.

Berger's tough assessment of the utilitarian trappings and aesthetic banality of zoos was not an unusual one during the 1970s and 1980s. It likely would have drawn the assent of many environmental advocates, including David Brower, the legendary environmentalist (the writer John McPhee called him the "archdruid"), dogged wilderness advocate, and former executive director of the Sierra Club. Brower's own antipathy toward zoos stemmed from an especially devout wilderness ethic, which was on full display in the late 1980s when a controversy erupted over the recovery of the California condor.

The species was down to a population of fewer than two dozen individuals by the early 1980s. Scientists weren't entirely sure what was driving the bird's decline, although the erosion of their marine food supply, hunting, and poisoning were considered the likely culprits.[25] Later research would reveal that lead poisoning from hunters' spent ammunition (consumed by the birds in shot carcasses) was a major factor in the bird's mortality.[26]

Brower, who founded the environmental organization Friends of the Earth after leaving the Sierra Club in the late 1960s, was a fierce opponent of the proposed recovery plan for the condor, which involved capturing the remaining wild birds, breeding them in captivity (at the San Diego Zoo and Los Angeles Zoo), and returning them to their natural habitat with tags and transmitters to allow researchers to study their behavior and mortality employing radio telemetry. Brower and his Friends of the Earth allies felt that captive breeding in zoos was so

aesthetically and morally unacceptable that a "death with dignity" for the species was, in their eyes, preferable.[27] A symbol of pure, free, and untrammeled nature, the condor in Brower's view simply didn't belong in an artificial "prison" like a zoo. Once the bird's tight link with the wilderness habitat that supported it was severed, its value for Brower seemed to drain away. As the environmental historian Peter Alagona notes, for Brower the value of the condor as a species depended almost entirely on the preservation of the wilderness it inhabited and symbolized.[28]

Yet had Brower's argument, which was motivated by a nonnegotiable anti-interventionist wilderness ideology, carried the day, the species would almost surely have been lost. Declared extinct in the wild in 1987, today hundreds of condors soar through the skies in sites across California, Utah, Arizona, and Mexico (figure 3.3). The bird's recovery is far from complete, but it exists (albeit banded and surveilled) thanks to the intervention of zoos and the efforts of scientists and conservationists to give the species a fighting chance at survival.[29] Its recovery is a shining example of the steady intensification of zoo-based conservation efforts in the last third of the twentieth century, a trend that has deepened and expanded in recent years as more zoos embrace their role as full-fledged "conservation centers."[30]

Nevertheless, zoos continue to be singled out by many critics (especially animal advocates, but also conservationists) as anathema to those "true" wilderness values that drive wildlife protection and appreciation.[31] But it's important to point out that the standards and environmental aesthetics of professional zoos have evolved dramatically since the early bars-and-cage years, especially in the decades since critics like Berger and Brower voiced their disdain. In particular, the development of what came to be known as "immersive" animal exhibits and the growth of a more

FIGURE 3.3 A California condor at Pinnacles National Park, California.

Source: Pixabay.

ecological philosophy in zoo landscape architecture, which many observers link to the redesign of the Woodland Park Zoo in Seattle beginning in the late 1970s, have done much to reduce the zoo's patent artificiality (figure 3.4).[32]

Today many zoological parks contain large barrier-free and naturalistic enclosures (including mixed-species exhibits) that

FIGURE 3.4 A gray wolf at the Woodland Park Zoo.

Source: Wikimedia commons; photo by Joe Mabel.

offer not only more biotic diversity and space—and less separation—but more opportunities for animals to engage in a fuller suite of natural and social behaviors, a widely acknowledged (though not unambiguous) component of zoo animal welfare.[33] The Arizona-Sonora Desert Museum in Tucson is one of the more distinctive institutions employing this approach, a "regional biopark" with naturalistic grottoes that often seem to well up out of and melt into the Arizona high desert.[34]

Saying all this doesn't mean that zoos are equally innovative and professional when it comes to exhibit naturalism, animal care, and conservation—or that the divisive ethical issues surrounding the keeping of zoo animals such as elephants have been settled once and for all. The smoldering ethical debate over zoos and their perceived callousness toward animals in their care was

reignited in 2014 by the case of Marius the giraffe in the Copenhagen Zoo.[35] A young and healthy giraffe considered a "surplus animal" by zoo managers, Marius was shot and his body dissected and fed to the zoo's lions and polar bears. The Copenhagen Zoo officials emphasized that the decision was made primarily on the grounds of science, space, and efficiency; Marius's genes were already well represented in the zoo system, and so he had little, if any, remaining conservation value.

Whatever one thinks about the Copenhagen case—and, for the record, the Association of Zoos and Aquariums (or AZA; the accrediting body for US zoos) distanced itself from it—modern zoos have to make a complex set of decisions about animal population management, including planning for surplus animals. AZA-accredited zoos in the United States generally avoid euthanasia, instead using contraception and other nonlethal forms of population management. Nevertheless, animal rights organizations such as the People for the Ethical Treatment of Animals (PETA) frequently criticize even accredited zoos for their population-management policies, which can involve moving surplus animals outside of the AZA system into less stringently managed institutions lacking a professional ethic of care.[36]

Regardless, in general terms it would be difficult to deny that as an institution the professional, accredited zoo has changed in significant and in some cases revolutionary ways with respect to exhibit naturalism and animal care. Yet these reforms clearly haven't been enough to mollify many zoo critics.

Writing a few years ago in *Outside* ("The Case for Closing Zoos"), the journalist Tim Zimmermann posed the question, "Are there any good arguments for keeping animals in artificial enclosures that, at best, are only a fraction of the size of their natural habitats?"[37] He ended up concluding that there weren't any, dismissing the educational and conservation claims of public

zoos and arguing that the move to large animal sanctuaries and reserves (with limited public access) was the only morally defensible future of the zoological facility.

The journalist and self-described "zoo lover" Benjamin Wallace-Wells similarly argued (in a high-profile *New York* article) that the mainstream zoo is playing a game with naturalism and the wild that it simply cannot not win. Its residents, moreover, were aware of the score. "It is hard to avoid the conclusion," Wallace-Wells wrote, "that in some way the animals understand that the world around them is an artificial one . . . the central illusion of the zoo is no longer holding. The animals know."[38]

A RADICAL REBOOT

Into this longstanding debate over zoos, artificiality, and naturalism (which goes back at least to Grinnell's screeds against the Yosemite Valley zoo in the 1920s) steps "Zootopia," a three-hundred-acre expansion of Denmark's Givskud Zoo proposed by the iconoclastic architect Bjarke Ingels and his firm, BIG.[39] A creative mash-up of immersive zoo and safari park, Zootopia has been promoted as a radical rethinking of the tired zoo concept: a nearly wall-less and cage-free zoo landscape in which the animals roam relatively freely in multispecies habitats. Ingels's innovative plan has even been described as proposing a dramatic reversal of "captor and captive."[40] The first phase of the new park is planned to open in 2019.

Zootopia's design philosophy is clearly driven by the goal of minimizing and in some cases completely concealing the human presence. Visitors to the new zoo, for example, will be sequestered in hidden viewing galleries and transported through the air in mirrored pods (figure 3.5). Elsewhere they'll use bicycles

FIGURE 3.5 Zootopia's airborne pod transportation system.

Source: Bjarke Ingels Group, used by permission.

and boats to get up close and personal with the zoo's elephants and zebras (figure 3.6), which will be separated from zoogoers by an ingenious array of natural and mostly undetectable barriers (strategic placement of log piles, water, bamboo stalks, etc.). The largest and most discernible human artifice in the park will be the dramatic bowl-shaped "arrival crater," a resplendent entry pavilion that serves as a gateway to the zoo's different "continents" (Africa, Asia, the Americas) and a symbolic entry point into the "wild" environs awaiting visitors beyond the threshold.

Perhaps not surprisingly, commentary on Ingels's plan has tended to evoke film analogies, including the false-reality conceit of *The Truman Show*, rendered here as a simulated wilderness that "fools" the animals into thinking they're on the savanna or in the North American woods rather than in a three-hundred-acre zoological park in Denmark.[41] And although the Zootopia design was unveiled well before 2015's summer blockbuster *Jurassic World*, its mirrored transport pods bear more than a passing resemblance to the gyrospheres the film's characters employ

FIGURE 3.6 Ground transportation in Zootopia.

Source: Bjarke Ingels Group, used by permission.

(with less than happy results) to move through the resurrected dinosaur exhibits.

These cinematic qualities, furthermore, are not all accidental. Ingels has admitted that the park's grand arrival crater (figure 3.7)—the liminal structure partitioning "civilization" and the zoo's "wilderness" habitats—was partly inspired by the jungle gate protecting (spoiler alert: not very well) the villagers from the rampaging wild beast in the 1933 classic *King Kong*.[42] It's an amusing and perhaps also disconcerting confession for a zoo design that has already raised some concerns about visitor safety.[43] But it's clearly all part of the desire to create a zoo that—sensu Berger—will do anything but disappoint.

WILDNESS IN THE HUMAN AGE

Although Zootopia has received mostly positive (at times even fawning) press coverage, not everyone is sold on Ingels's

FIGURE 3.7 A visualization of Zootopia's "arrival crater."

Source: Bjarke Ingels Group, used by permission.

reimagining of the modern zoological park. In "The Dark Side of Zootopia," Charles Siebert, writing in the *New York Times Magazine*, describes it as instead auguring a rather bleak outlook for wildlife and wilderness in the twenty-first century. "Ultimately," Siebert writes, "Zootopia is not a reinvention of the zoo as much as a prefigurement of its inhabitants' only possible future . . . a wilderness with us lurking at its very heart." The new zoo project at Givskud, he concludes, is the manifestation of a wider and more depressing trend: the eclipse of the wild in the human age. Zootopia, in fact, "could well be one of the singular achievements of the [A]nthropocene, a time when human representations of the wild threaten to become the wild's reality."[44]

I share Siebert's worry about the environmental ethos courted by the conceit that we are living in the Anthropocene, the "age of humans," an idea some believe compels us to loosen our moral and political commitments to traditional nature protection

(I'll have more to say more about this in the coda to this book).[45] But the notion that wilderness *should* exist apart from human culture and experience—and that Zootopia somehow violates the integrity of this relationship by offering an illicitly anthropocentric and contrived vision of "wild" nature—is also problematic.

Although Siebert acknowledges that the wild is increasingly subject to the forces of human alteration and control, he nevertheless still seems to be in the grip of a classical ideal of the wilderness, a version of that older, dualistic image of nature and culture that droves of archaeologists, environmental historians, paleobotanists, ethnohistorians, and others have increasingly called into question by documenting the deeper narrative of human modification of the wilder corners of the earth.[46] John Muir's and Joseph Grinnell's wild Yosemite, for instance, reflects the historical activities of California's Native Americans, who through their "harvesting, tilling, sowing, pruning, and burning" shaped, at least to some degree, the modern landscape of the Sierra Nevada.[47] But we don't need to go digging into pre-Columbian soil to find evidence of this influence.

In the case of the national parks, we're talking about sites that since the early decades of the twentieth century have been subjected to extensive scenic and recreational development, "natural areas" that have nevertheless been shaped by generations of landscape architects, planners, and engineers seeking to encourage mass tourism and accommodate growing visitor access by building road systems, bridges, trails, campsites, lodges, and park villages.[48] The management of park wildlife, too, took many years to conform to the naturalistic and ecological principles pushed by Grinnell and other scientists during the early years of the National Park Service.[49] For most of the twentieth century, in fact, the Park Service groped for a coherent philosophy to

guide its wildlife policy as it confronted a host of controversial and challenging issues, from decisions about culling wildlife herds and introducing nonnative species to the suitability of "unnatural" zoolike animal entertainments such as roadside feeding of bears and the popular "bear shows" at park garbage dumps in Yosemite and Yellowstone.[50]

The point is that the "real" wilderness values that are supposed to represent such a stark contrast to Zootopia's simulation of the wild are not nearly as ecologically pure or as historically tidy as we might think. And this isn't just an American story. Consider the case of the Arabian oryx (*Oryx leucoryx*), which I mentioned in passing in the previous chapter. A desert antelope that was nearly extinct by the early 1970s (primarily from hunting), the species was recovered through captive breeding efforts and reintroduced to the "wild" at several sites in the Middle East beginning in the early 1980s. Although the animals reintroduced to Saudi Arabia probably come the closest to the ideal of living in the wild without significant human support, oryx populations in both Oman and Abu Dhabi are managed more intensively, including the use of enclosures and, in the latter case, the supply of water, food, and shade.[51] As the biologist Mark Stanley Price (who literally wrote the book on the species) notes, such conservation-dependent conditions force us to ask some difficult questions about what exactly it means to return an animal to "the wild" if it remains dependent on continuing human intervention and care.[52]

Our understanding and image of the wild, in other words, is at least in part a mythic one. As some astute observers of these discussions have pointed out, there are even fences in South Africa's Kruger National Park, barriers that artificially hem in the elephants, lions, and rhinos—and hem out the humans—at one of the most iconic wildlife reserves in the world.[53]

But this line of argument can at times be pushed too far. The science journalist Emma Marris has suggested, for instance, that the wilderness can really only ever be "half wild" given the narrative of human influence, management, and ecological change.[54] In making so much of the "altered" and anthropogenic character of what we consider wild, however, there's been an unfortunate tendency to overcorrect, to swing the rhetorical pendulum too far in the other direction. Railing against the wilderness orthodoxy of American environmentalism, some scientists have even argued that since nothing is truly or fully wild anymore (if indeed it ever was), we should back away from "the wilderness" as a core concept in conservation and environmental thought and focus more seriously on meeting human needs, wants, and interests.[55]

Accepting a more nuanced cultural and technological narrative about the wilderness, though, doesn't require rejecting the idea that a meaningful sense of the wild is available to us, even in this age of accelerating human influence and control. The prominent environmental historian and conservationist Curt Meine, for example, defends what he calls the "relative wild," or "the degrees of wildness and human influence in any place, and the ever-changing nature of the relationship between them over time."[56]

A parallel redefinition of the wild has been proposed by Harry Greene (whom we met in the introduction). Greene's approach to the concept is more biological. We should define wilderness and the wild, he argues, less on philosophical and aesthetic grounds and more on the basis of the presence of integral ecological and evolutionary processes. A wild system on this view is simply one in which the full suite of processes, that is, predation, competition, selection, nutrient cycling, and so on, are intact—with organisms in place that enable them.[57]

Importantly for our discussion here, Meine's and Greene's understandings of the wild avoid shaky idealist notions premised on a vision of a totally unpeopled, unmanaged, and unmanipulated nature. The human presence, at least in principle, is not barred from the wild when the latter is viewed as a matter of degree rather than as an absolute—and as a set of specific ecological-evolutionary conditions rather than as a context-free ideological commitment.

What all this means is that, even though I think we can agree that a remote and roadless stretch of Amazon rainforest or of Yosemite backcountry are both wilder than the enclosures of Zootopia ever will be or can be, Zootopia may prove to be much wilder—and wilder in an important sense—than the average zoo, even if its wildness is necessarily qualified and relative rather than pure and absolute.[58] And depending on the public desire for and acceptance of such spaces, there may be opportunities to experiment with a greater degree of wildness in Ingels's vision as the Zootopia project plays out in the years to come.

Furthermore, just as Zootopia is not the inevitable future of the wild, it also isn't the future of the zoo. Or, at least, it likely isn't the future of most zoos. Like the national parks, which vary from small urban landscapes to millions of acres of (relatively) untrammeled wilderness, zoos come in all shapes and sizes and will doubtless continue to do so, with an increasingly diverse range of institutional profiles and identities. The recent uptick in talking about the future of "the zoo" as if it were a singular, monolithic entity therefore seems to me somewhat misplaced.[59] A more likely path, I'd predict, is a kind of divergent evolution, with some zoos morphing slowly into more serious conservation organizations and others continuing to hew to the familiar recreation and entertainment path, amending at the margins rather than overhauling the core of their traditional missions.

Zootopia suggests yet another direction. Its calling card won't be conservation or recreation in the traditional sense but rather will be providing amped-up visitor excitement tied to an enhanced aesthetic of naturalism, a high-profile experiment with the experiential possibilities of augmented wildness in a zoological park. It's clear from some of Ingels's own commentary on the project that he sees it at least in part as an effort to hold the interest of an increasingly fickle and attention-scattered public that, thanks to the ubiquity of live webcams of wild animals, TV channels such as Animal Planet and National Geographic, and a steady stream of breathtaking IMAX nature documentaries, has access to a seemingly bottomless digital well of virtual, high-definition "encounters" with wildlife. Ingels has been quite frank about his goal of embracing and upgrading the entertainment function of the zoo, stating that he wants Zootopia to provide an alternative to the typical "premeditated, prepackaged" zoo experience.[60]

This heightened sense of immersion and excitement could also be marshaled for greater ends than entertainment. Back in the late 1980s, the environmental philosopher Bryan Norton suggested that personal experiences with wild species can have "transformative value," that is, the potential to trigger critical reflection and evaluation of our consumer preferences, eventually putting them in line with a more ecological worldview and ethic supporting the goals of biodiversity conservation.[61] Recent work in the field of conservation psychology, which studies our perceptions, attitudes, and behavior toward species and the natural world, has provided some indirect empirical support for Norton's idea by demonstrating the impact of encounters with zoo animals on visitors' attitudes of care and concern for them—and their desire to engage in pro-conservation behaviors outside of the zoo setting.[62]

Admittedly, Norton's notion of transformative value raises more than a few questions, especially when applied to zoos (his original argument was focused on experiences in natural areas and with wildlife rather than with zoos and captive animals). These include the possibility of negative transformations (zoos can bore visitors, turn people off, or even provoke fear)[63] and the worry that the creation of a closer emotional connection to individual zoo animals may promote attitudes that can make it difficult to manage populations and species for more ecological goals (and lead to tensions around decisions like culling, as with the case of Marius the giraffe).[64] Still, it suggests the potential of the zoo experience to inspire a conservation ethic useful in the wider effort to curb species extinction and perhaps points to the value of hyperimmersive zoo designs, such as Zootopia, in catalyzing a greater interest in and connection to wildlife.

So, there are glimmers of a more progressive environmental philosophy in Ingels's Zootopia vision, ideas that suggest a desire to move beyond the entertainment agenda as well as the more traditional framings of the human-wild relationship. "It's almost a question of trying to find ways of actually creating successful cohabitation between humans and different species of animals," he told an interviewer for National Public Radio.[65] Still, as an exercise in cohabitation, Zootopia can at times seem largely one-sided: it purports to offer a journey into the wild, but it's a journey with the human presence mostly submerged, in some cases quite literally. The older romantic view of the wilderness, that is, seems alive and well in many parts of Ingels's design, a philosophy reinforced by putting us so ingeniously, but also so invisibly, into the animals' world.

Yet some of BIG's zoo projects outside of the Zootopia plan at Givskud promise something different. The design for the

FIGURE 3.8 The panda house design for the Copenhagen Zoo. "To design a home for someone is like capturing their essence, their character and personality in built form" (Bjarke Ingels).

Source: Bjarke Ingels Group, used by permission.

Panda House at the Copenhagen Zoo (figure 3.8), which broke ground in the fall of 2017, is a case in point. According to BIG, the exhibit's goal is to make us feel like we're visitors in the pandas' home, an end realized by designing the curvy enclosure so that the separation between human and animal is less geometrical and stark and more of a seamless, undulating integration.[66] The exhibit is also configured to contain "his" and "hers" spaces for the zoo's panda pair, a nod, the architects point out, to the animal's solitary nature. Presented as a highly naturalistic enclosure design that will enhance opportunities for mating in captivity, the panda house is also touted as serving the broader conservation aims for the species.[67] It's an arranged marriage of innovative, attention-grabbing design, naturalism, and conservation values that could push creative zoo exhibitcraft into the next generation, perhaps even restoring a sense of aesthetic and naturalistic integrity to the familiar notion of zoo as spectacle.

The Zootopia plan and much of the discussion it has generated remind us that zoos today are caught on the horns of a dilemma regarding their relationship with the wilderness. On one side, they continue to be criticized for being too artificial and too contrived, an indictment not all that different from the one Joseph Grinnell leveled at the Yosemite Valley zoo back in the 1920s. Yet when zoos actually try to become more parklike and "wild," they're often pilloried for falling well short of the mark and for trying to simulate something—wilderness—that some believe simply can't be replicated. Furthermore, if zoos do become appreciably wilder in their animal management practices, they'll likely run up against the aesthetic and ethical predispositions of a public conditioned to expect a peaceable kingdom rather than a collection of animals behaving naturally, as their wilder counterparts do.[68]

Ultimately, I think how we view Zootopia and other efforts to push the limits of wildness and naturalism in zoological parks depends not only on how we see the prospect of constructing an authentic version of the wild in meticulously designed and managed landscapes but on how optimistic we are about our ability to maintain respect for what's taken to be the "real" wilderness on a human-dominated planet. From one vantage point, Ingels's project is simply another effort to conceal the inherent unnaturalness of the zoo with the latest architectural wizardry, a vision that only lowers our expectations for the wild. Yet from another angle it's an innovative and exhilarating attempt to inspire different ways of seeing and valuing wildlife and wild places in the twenty-first century.

In the end, radically immersive zoo projects like Zootopia embody a difficult and probably inescapable moral friction, one that exists even if we accept a more pragmatic and nuanced view of the wild in the Anthropocene. It's the recognition that our

attempts to get closer to other species often only end up reminding us of our distance and our difference. And it's a tension reinforced by the acknowledgment that we're both coinhabitants with other animals and (increasingly) creators of their worlds, including those beyond the zoo walls. To paraphrase Dr. Seuss, we all run the zoo.

4

ELEPHANTS SOMEWHERE

ON THE MOVE IN MALAWI

The first two decades of the twenty-first century have not been kind to African elephants (figure 4.1). A sharp uptick in poaching (fueled by the illegal ivory trade) starting around 2006 marked the beginning of a precipitous decline in the numbers of one of Africa's most iconic animals, totaling nearly a 30 percent loss in elephant numbers from 2007 to 2014.[1] That continental assessment, however, masks even more dismal regional trends. In central Africa, the numbers are more devastating. A recent study conducted at Minkébé National Park in Gabon, a protected area created primarily because of its high concentration of forest elephants (smaller and darker in color than their kin on the savanna), estimated a calamitous 78 to 81 percent decline in the park's elephant population from 2004 to 2014, a figure that amounts to a loss of more than 25,000 animals in this one park alone.[2]

Recently, there have been some encouraging signs that the ivory market may be cooling off as China (the leading consumer of elephant ivory) works to close its domestic ivory market following an economic downturn and thanks to growing

FIGURE 4.1 African elephant.

Source: Pixabay.

international conservation advocacy.[3] But the elephant is by no means out of the woods. Poaching for ivory will likely continue to thin elephant populations for some time to come. So too will a set of more diffuse challenges, including accelerating habitat loss, increased droughts (augmented by climate change), and human competition for scarce resources—competition that often produces significant social and economic consequences.[4]

These difficult circumstances, and the conclusion that the elephant's prospects are tenuous absent intensive human interventions, are leading conservationists to take sweeping measures to improve the animal's lot. One of the most dramatic of these efforts began in Malawi in 2016 and involved the relocation—or, more technically, translocation—of more than five hundred elephants from the country's Liwonde National Park and Majete Wildlife Reserve. The elephant populations at both parks were

actually growing, but the animals were coming into conflict with human communities adjacent to the parks. Their movement thus provided an opportunity to shore up elephant populations elsewhere and to reduce local human-wildlife tensions.[5] The animals were darted from a helicopter, lifted by crane into crates, and loaded onto trucks for their 185-mile journey to their new digs at Nkhotakota Wildlife Reserve, a protected area that African Parks, a nonprofit conservation organization managing the translocation, took over in 2015. Nkhotakota, which saw its elephant population decimated by poachers before the arrival of African Parks, is now viewed as a secure "hub" for elephant conservation and tourism—and as a potential reservoir for reinforcing elephant populations in other parts of the continent where poaching has cut a large swath through the species.[6]

The Malawi translocation is notable for the scale of its ambition; it's difficult to capture and relocate one elephant safely, let alone more than five hundred. Yet as the early-twentieth-century reintroduction of the American bison (described in the previous chapter) reminds us, we've been moving species around the landscape for conservation purposes for some time, either to reinforce existing populations, as in the Malawi case, or to reintroduce species to their indigenous range after extirpation (e.g., the bison, Arabian oryx, California condor, gray wolf, and a host of other species). Such "conservation translocations" are increasingly common across animal taxa. Hundreds and perhaps even thousands of terrestrial, freshwater, and marine animal and plant conservation translocations have been performed over the last several decades, with the goal of reinforcing or reintroducing species to enhance their viability in the wild.[7]

Moving species to reinforce extant populations or to reestablish them after (usually human-driven) eradication is normally not very controversial among conservationists. But as

translocations have expanded in number and scope over the years, and as the motivations for the movement of species have stretched to include responding to emerging conservation threats like climate change, the human movement of species has started to generate some concern—and even sharp disagreement among many conservationists and ecologists. That's especially true in the case of the more radical proposals to translocate species to ecosystems outside—in some cases, *well* outside—their indigenous range, either to enhance their chances for survival or to restore ecological and evolutionary processes in the recipient ecosystem. Or, in some proposals, to do both.

Elephants are illustrative of the range of attitudes toward conservation translocations driven by different motives and proposed across diverse ecological contexts. In the Malawi project, there appears to have been wide support among wildlife scientists and conservationists for the elephant translocation. Despite the intensive and interventionist nature of the effort, the animals were kept within their native range and were relocated following established scientific protocols, with the conservation of the elephant population driving the overall process.[8] Other proposed elephant translocations, however, especially those entailing movement of the animals to locations outside their indigenous range—and for ecological reasons beyond saving the species from extinction—are far more controversial.

A case in point is the intriguing and widely debated idea, which I mentioned briefly in the first chapter, called "Pleistocene rewilding," that is, the proposal to establish populations of elephants and other large, Old World herbivores and predators (from camels to lions) from captive stock in North America and from managed populations elsewhere (e.g., some of the thousands of domesticated elephants in Asia) in a future reserve network in North America. It's a conservation vision motivated

primarily by the goal of restoring, via the introduction of proxy species functioning as "environmental engineers," key evolutionary and ecological processes lost with the late Pleistocene extinctions that began around 13,000 years ago. But it's also driven, its architects write, by the need to increase the geographic range of threatened megafauna via an intercontinental network of wildland reserves.[9]

This type of bold translocation proposal, which is often referred to as "ecological replacement" to distinguish it from other forms of translocation of species outside their indigenous range, has been influential in Europe and a number of other places.[10] It has also proved polarizing.[11] In a controversial commentary published in the journal *Nature*, for example, the biologist David Bowman floated the idea of translocating elephants to Australia to help control gamba grass, an invasive, fire-prone species too big for kangaroos to regulate but perfect for elephants, who, Bowman argued, could effectively "replace" the ecological control function of Australia's long-extinct giant marsupials.[12]

Conservation translocation efforts and proposals therefore come in a variety of shapes and sizes, from the movement of populations short distances within their native habitat to improve their conservation odds, to the more controversial movement of populations outside their indigenous range for these same ends, to the large-scale movement of populations with the primary goal of enhancing ecological and evolutionary processes in the new environment (while at the same time expanding the range of species threatened in their home territories).[13] As we'll see, the worries raised about those translocations that depart most dramatically from older conservation norms and traditions stressing the cardinal value of indigenous habitat remain compelling for many conservationists.[14] But so too does the conviction that we may have to consider such radical conservation measures if

we're serious about giving some of the planet's most imperiled species a shot at survival in the face of accelerating ecological decline and loss.

The tension between these competing impulses when assessing environmental responsibility in a time of rapid and likely unprecedented pressure on global biodiversity is palpable. On the one hand, and as the more ambitious conservation interventions demonstrate, there's a strong desire to "do whatever it takes" to recover and protect vulnerable species from any further losses (recall the biologist and proponent of Pleistocene rewilding Harry Greene's question from the opening chapter: "Would you rather have elephants somewhere or elephants nowhere?"). On the other hand, there's the worry that we should avoid taking risky and, some would say, reckless actions that may make things worse, including undermining other important environmental values (e.g., the relative wildness and autonomy of natural systems and communities) as we consider bolder efforts to save species from plunging into the void.

MOVE IT OR LOSE IT?

As the plight of the African elephant demonstrates, reports documenting the state of the planet's animal biodiversity are mostly a gloomy read. A 2014 analysis performed by *Nature* found that, globally, 41 percent of all amphibians and 26 percent of mammal species are thought currently to face extinction, with considerably higher percentages at risk in the future if present threats, from climate change and habitat loss to species exploitation, continue unabated.[15] The Audubon Society, in its widely covered *Birds and Climate Report*, projects that climate change will cause 314 of the 588 North American bird species studied to

lose more than half their current climatic range by 2080, with extinction looming for those species unable to adapt to smaller or new spaces.[16] Some ecologists have also suggested that we may be on the verge of a major extinction event in the planet's ocean species, underscoring the global scope of the crisis.[17] Regardless, the trends add up to a global extinction rate that is probably one thousand times higher than the background (or "natural") rate of extinction.[18]

These and dozens of similar assessments have led many scientists and writers to proclaim that we are witnessing a sixth mass-extinction episode on the planet, a period of destruction rivaling the disappearance of the dinosaurs.[19] But it isn't only accelerating extinction trends that are troubling. The wider pattern of animal declines at the population level is also cause for concern, prompting some biologists to refer to the current situation also as a mass "defaunation."[20] Again, the numbers are unsettling. The 2016 Living Planet Index (a collaboration between the World Wildlife Fund and the London Zoological Society) estimated that globally, on average, vertebrate species populations declined by 58 percent between 1970 and 2012.[21]

Habitat loss remains the leading driver of biodiversity decline and extinction, joined by human overexploitation, pollution, and other activities.[22] In addition, global climate change has emerged as a significant threat to species survival, with a growing number of studies suggesting that its role in biodiversity decline and extinction is only expected to increase in the coming decades (figure 4.2).[23] It's also a complex kind of threat. Global climate change, for example, can combine with and magnify other threats to biodiversity, including land-use change and the spread of invasive species and emerging infectious diseases.[24]

The interaction of rapid climate change and habitat fragmentation has been of particular concern to conservationists,

FIGURE 4.2 Atlantic puffin. Ranging from Iceland to Norway in the North Atlantic, the bird is highly vulnerable to warming waters and shifts in prey abundance caused by climate change.

Source: Pixabay.

especially in scenarios in which plant or animal populations vulnerable to climate shifts cannot adapt fast enough to a changing environment or can't disperse naturally to more suitable habitat because of human barriers (e.g., subdivisions, office parks, and highways). Unable to move to higher (or wetter, or cooler) ground on their own, the conservation of these plants and animals poses a challenge for conservationists accustomed to responding to more direct and proximate threats (e.g., pavers, poachers, and pollutants) by keeping human activities at bay, that is, setting up protected areas to save habitat, enforcing strict no-take policies, and the like.

A recent study published in *Science* underscored the global impacts of altered animal movement patterns, especially in areas

where the human presence is significant. Researchers determined that terrestrial mammal movement, or "vagility," in these areas was "on average one-half to one-third the extent of their movements in areas with a low human footprint."[25] This trend has significant implications not only for the health and survival of animal populations over time but also for the persistence of ecological processes that depend on animal movement, from predator-prey interactions and nutrient cycling to disease transmission.

These and related scenarios have forced some biodiversity scientists and advocates to explore a range of anticipatory, bold interventions into ecological systems *before* wildlife populations thought to be at risk from global climate change interacting with landscape fragmentation and other stressors start to spiral into the extinction vortex. One of the more controversial interventionist strategies is a particular type of conservation translocation, "assisted colonization" (also referred to as "managed relocation" or, less commonly nowadays, "assisted migration"). Assisted colonization (AC) is the movement of animal (or plant) populations threatened by current or future climate change—and/or other threats that make survival in their native habitat unlikely—to locations outside their indigenous or historical range.[26] The technique has already been performed for a number of animals and plants that are relatively easy to move, including trees, butterflies, frogs, and turtles.[27] Supporters of AC argue that this intensive mode of conservation intervention will be increasingly necessary to address a heightened extinction threat under conditions of rapid environmental change.[28] In other words, "move it or lose it."[29]

Not surprisingly, AC has divided members of the conservation community, at times quite sharply. The main objection is its potential to disrupt populations and disturb the ecological

integrity of the "receiving" systems, that is, the new habitats for the translocated populations. It's a critique amplified by our inability to predict exactly how a relocated species will act when transplanted into a new ecosystem outside its native range, especially whether it will become invasive and create a new set of ecological problems to be mitigated.[30]

There are other worries. These include animal welfare concerns in cases where further stress is placed on animals during movement and AC's potential to increase the risk of disease transmission when the targeted species is introduced into new communities. Some critics have also predicted that AC will likely fail to save relocated species given the spotty success record of past translocations and the fact that relocated populations may be especially vulnerable to additional threats in their new habitat, especially if the introduced population size is, as expected, small.[31] Move it, they suggest, and we *will* lose it.

For their part, cautious supporters of considering AC as a conservation strategy (and I count myself among them) have countered that many of these risks are not deal breakers, because they're ultimately manageable. We can learn how to conduct successful AC translocations via careful experimentation and adaptive conservation management—and develop the analytical techniques and protocols to help shore up the evaluation of appropriate translocation candidates (and recipient ecosystems).[32] In this vein, the International Union for Conservation of Nature (IUCN), the global scientific and policy authority for most matters related to species conservation, has promulgated a set of guidelines for AC and other conservation translocations, stressing the importance of a careful and orderly planning process, including risk analysis and post-translocation monitoring.[33] Yet, even if ecological risks cannot always be minimized, supporters of AC argue, our moral obligation to save species from

evolving anthropogenic threats like climate change requires that we at least consider novel conservation strategies such as AC despite the fact that implementing the practice may be difficult, costly, and plagued by unpredictability and the potential for unwanted ecological consequences.

But there's another sticking point. AC clearly upends longstanding conservation norms surrounding human intervention in and manipulation of ecological systems, particularly moral aversion to intensive human meddling and control of nature. As we've seen in the preceding chapters, however, conservation scientists and wildlife managers have long engaged in practices that could be characterized as "interventionist," such as captive breeding and wildlife reintroduction. Even those areas administered under the stringent preservationist directives of the 1964 Wilderness Act, for example, are at times managed in a more active manner, including prescribed burning, species reintroductions (e.g., wolves), the stocking of nonnative fish, pesticide spraying, the use of helicopters, and other activities that depart from a pure "hands-off" philosophy.[34] Nevertheless, for many critics, the degree of intervention suggested by assisted colonization falls well outside the lines of acceptable conservation practice.

The critical arguments against AC are important because they remind us that considerations of place, evolutionary history, ecological integrity, and other traditional values in biodiversity conservation are not to be cavalierly brushed aside when making decisions about the movement of species for conservation purposes. These considerations may not always have "trumping power" in conservation decision making, especially as managers cope with the novel conditions presented by rapid environmental change and the attendant accelerating extinction risk, but they shouldn't be taken lightly in deliberations over the merits

of assisted colonization, especially given the high stakes involved (ecological disruption, extinction).

But in my mind a bigger worry hangs over discussions about the risks and rewards of AC and related proposals that open the door to increased human manipulation and control of species and ecosystems. It's the objection that, although well intended, such efforts do not in the end address the deeper moral problem: the need to restrain ourselves on the landscape and, especially, to rein in our ecologically destructive activities. By putting us in a more commanding position in the natural world—which at the extreme end of the continuum promotes us to the role of "planetary manager"—strategies such as AC can appear to elide this deeper moral challenge of environmental forbearance and possibly even exacerbate an already dysfunctional human-nature relationship. The concept of "moral hazard," a term of art in the insurance industry describing how attempts to insulate ourselves from bad consequences (e.g., by buying insurance) may perversely end up incentivizing rather than discouraging reckless behavior (e.g., the tendency for people to drive more carelessly in cars equipped with more safety features), is apt here.[35] If we conclude that aggressive conservation interventions like moving species preemptively to novel environments will take care of the problem of species endangerment from climate change, then we may not feel as compelled to mitigate emissions and alter our energy choices, consumer habits, and lifestyles. It's a worry I'll return to at several points in the rest of this book.

The controversy over assisted colonization therefore presents a moral conundrum for conservationists: to save species from emerging anthropogenic threats, we may have to consider actions that entail more rather than less control of the natural environment. But in doing so, we run the risk of increasing other ecological vulnerabilities as a byproduct of the more aggressive

conservation interventions and of undermining other important environmental values, such as maintaining a meaningful sense of the wild while we shuffle species around the landscape. It isn't clear how to weigh these concerns—or how to navigate the apparently warring responsibilities of biodiversity conservation in an age of deepening human intervention.

WHAT WOULD LEOPOLD DO?

I've been in favor of considering assisted colonization as a conservation strategy for some time, mostly because I see it as of a piece with our long-running efforts to conserve species and keep extinction at bay using the time-tested tools (such as translocation) we have at our disposal. When the debate over AC began about a decade ago, I participated in an interdisciplinary, National Science Foundation–funded working group composed of a diverse team of biologists, economists, legal theorists, and policy makers tasked with exploring the practice, including its potential benefits and costs as a conservation strategy. When I joined the group, I was the only ethicist in the bunch; by the end it had grown into an august assembly of over thirty scholars and conservation practitioners, including a trio of philosophers versed in environmental ethics, conservation, ecology, and the philosophy of science.[36] Even though the group encompassed a wide array of views surrounding the appropriateness of AC (we used the alternative and slightly less-loaded term "managed relocation" in our conversations), in the end we were able to produce an integrated assessment of the risks and rewards of the practice as we saw them, encouraging best practices and more explicit guidelines and policy for decision making and implementation of AC strategies.

But what struck me in our discussions, and even more so in the back-and-forth over AC and other intensive forms of conservation translocation in the literature, was the lack of an appeal to history, that is, an anchoring in the traditions and values that have long shaped conservation philosophy and practice. The perception that climate change presents us with a "new normal" in conservation seems to encourage an ahistorical posture among many conservationists and environmental writers.[37]

Yet even if the ecological context surrounding emerging proposals like AC may have its novel elements (the recognition of anthropogenic climate change as a potential driver of extinction being the most notable), the question of the nature and scope of our responsibilities to save species, protect ecosystems, and temper our own actions is, of course, far from new.[38] So why wouldn't we look to the work of the greatest conservationist the nation has (so far) produced to help guide us through this thicket? What, we might ask, would Aldo Leopold do?

Aldo Leopold (1887–1948; figure 4.3) remains the most important figure in the history of American conservation. A Midwesterner who spent the early part of his professional career in the national forests of the American Southwest, Leopold was one of the nation's first scientifically trained foresters and an important figure in the early decades of applied ecology. He was also a deep and versatile thinker and an enormously gifted writer. Leopold's posthumously published collection of nature essays and ruminations, *A Sand County Almanac*, is one of the most influential and revered entries in the modern environmental canon ("one of the prophetic books, the utterance of an American Isaiah," according to the renowned author and conservationist Wallace Stegner).[39] As a result, Leopold would end up influencing the development of several areas of conservation thought and practice during his lifetime and in the decades following his

FIGURE 4.3 Aldo Leopold at "the shack" in Sauk County, Wisconsin, a converted chicken coop that became the site of his own land-restoration experiments.

Source: Courtesy of the Aldo Leopold Foundation, www.aldoleopold.org.

death, including wildlife and range management, conservation biology, and restoration ecology.[40] An amateur or "practical" philosopher, his thinking also inspired the growth of academic environmental ethics beginning in the early 1970s.[41]

Still, "What would Leopold do?" seems an ill-advised question in the context of debates over assisted colonization and other "radical" conservation proposals. For one thing, it's being asked seventy years after Leopold's death and in a time characterized by a different set of conservation challenges than those he grappled with in the first half of the twentieth century, which were mostly local and regional conservation and resource-management

concerns rather than the global ecological and demographic issues we face today. Not only that, but Leopold's widely admired "land ethic" appears poorly suited to a landscape transforming under the forces of global environmental change, a condition, many believe, in which historical baselines and older notions of wilderness, "ecological integrity," and other more preservationist-leaning ideals seem to be losing much of their scientific and managerial relevance.[42] The oft-cited "summary moral maxim" of the land ethic, "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise," certainly can reinforce this reading.[43]

It's increasingly clear, however, that we need a conservation philosophy today able to anchor a more experimental and activist approach to environmental management, one in which the goal is not to halt ecological change or preserve some predisturbance ideal of ecological integrity but rather to determine and guide rates of acceptable change in rapidly transforming socioecological systems.[44] So the preservationist Leopold might, then, seem a poor choice to guide us in the current age of "intervention ecology," "novel ecosystems" (that bear scant relationship to historical conditions), and so forth.[45]

Yet I think a wider analysis of Leopold's writing reveals a more nuanced picture of his conservation thinking than the simple, one-note preservationist reading suggests, especially regarding his views concerning conservation actions deemed necessary to save or recover species from human impacts. The land ethic is rightly elevated in discussions of Leopold's conservation thought, but when placed within the broader context of his writing (in *A Sand County Almanac* and elsewhere), we can see that it's part of a wider vision of environmental management that doesn't preclude significant conservation interventions

in plant and wildlife populations and in ecological systems (provided, that is, that certain ecological and ethical standards are met).

Leopold actually held a fairly pragmatic view of nature preservation, one that allowed for significant environmental manipulation and experimentation—including even preemptive actions—to restore depleted species and save species vulnerable to extinction. But as we'll see, his pragmatism and his support for such activities and interventions were tempered with a heavy dose of humility and restraint, laced with caveats and qualifications that I think make his prescriptions especially useful—and prescient—for current debates over assisted colonization and, for that matter, other radical interventions in wildlife populations and on the land. He was in this, as in most other conservation-related matters, ahead of his time.

Valuing Species, One by One

One of the first objections to claiming that Leopold would have cautiously supported AC hinges on its clear single-species emphasis. It's true that Leopold was a well-known (perhaps the *most* well-known) ecological holist; that is, he was ultimately concerned with the health and integrity of the biotic community over more individualistic (e.g., single-species) goals. But it's also clear that Leopold's moral, aesthetic, and scientific regard for the worth of individual wild species, including predators, was quite powerful and that it endured even as his thought and writing took on a pronounced ecological character in the 1930s and 1940s.

"It hardly seems necessary to say," Leopold wrote in 1920, "that the wiping out of a species is wanton barbarism, especially

species of high value, from both the sporting and esthetic points of view."[46] In one of his more lyrical essays in *A Sand County Almanac*, Leopold laments the aforementioned loss of the passenger pigeon, one of the iconic extinction events in American conservation history: "We have erected a monument to commemorate the funeral of a species. It symbolizes our sorrow. . . . There will always be pigeons in books and in museums, but these are effigies and images, dead to all hardships and to all delights."[47] Elsewhere in *Sand County* he writes about the shooting of one of the last grizzly bears in Arizona on Escudilla Mountain during his early forestry career on the Apache National Forest. "The government trapper who took the grizzly knew he had made Escudilla safe for cows," Leopold wrote. But "he did not know he had toppled the spire off an edifice a-building since the morning stars sang together. . . . Escudilla still hangs on the horizon, but when you see it you no longer think of bear. It's only a mountain now."[48]

What's interesting in these snippets is that they show how Leopold, despite his well-known emphasis on the larger ecological picture, never lost sight of the unique value of individual species, particularly those, such as the passenger pigeon, the wolf, and the grizzly, that had been victims of human avarice, shortsightedness, or fear. Top predators like the grizzly and the wolf (see his moving and influential essay "Thinking Like a Mountain" in *Sand County*) take on great aesthetic and moral significance in Leopold's conservation philosophy, so much so that without its bear, Escudilla can "only" be a mountain.

Leopold's regard for individual species and their conservation was not walled off from his broader ecological vision: just as the grizzly lent a special dimension to the high country of eastern Arizona, so too did the ecosystem reciprocate (after a fashion), conferring de facto value on its constituent elements. As he remarked in his 1938 essay "Conservation," if the ecological

system considered as a whole is good, "then every part is good, whether we understand it or not. If the biota, in the course of aeons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts?" This led Leopold to make one of his more famous observations about the imperative of species conservation, an early statement of the presumptive value of single species within a principle of biotic insurance: "To keep every cog and wheel is the first precaution of intelligent tinkering."[49] Each species had a known or potential contributory value for the healthy functioning of the whole, especially given the limits of our ecological understanding.

Leopold, then, didn't downplay the value of and efforts to care for single species within his conservation outlook; rather, a complex mix of aesthetic, moral, and ecological values motivated his commitment to species protection. Leopold's rightly celebrated ecological holism was differentiated; a full appreciation of biotic components *and* wider ecological wholes and processes defined his ethical system, each informing the other.

Among other things, this conclusion has implications for how Leopold's work might contribute to current debates over assisted colonization, which often seem to pit single species–centered considerations (typically in the "pro-AC" camp) against the more holistic concerns about ecological integrity (a marker of the "anti-AC" position). His integration of these perspectives was not without its tensions, but it's a reminder that we're dealing with two sides of a single philosophical coin when it comes to biodiversity conservation in the modern era.

Trying, Tinkering

Several additional features of Leopold's conservation ethos are useful in navigating the current debates over AC and species

FIGURE 4.4 "The ordinary citizen today assumes that science knows what makes the community clock tick; the scientist is equally sure that he does not. He knows that the biotic mechanism is so complex that its workings may never be understood" (Aldo Leopold).

Source: Courtesy of the Aldo Leopold Foundation, www.aldoleopold.org.

protection under rapid environmental change more generally. One is his explicit support for experimental and manipulative approaches to environmental management, including for conservation purposes (figure 4.4). Not surprisingly, these themes are quite strong in his earlier writings on wildlife (game) management, a more utilitarian context that found Leopold striking a managerial tone.

In his 1930 piece "The American Game Policy in a Nutshell," which was a summary of the national policy and report he was then overseeing, Leopold observed that conservationists always seem to have ideas about which course of action is the most

desirable and lamented the fact that they often conflict. It was a recipe for a stalemate, Leopold believed: "We are in danger of pounding the table about them, instead of going out on the land and giving them a trial." He urged a more experimental approach: "[We should] quit arguing over abstract ideas, and instead go out and try them."[50] It's a pragmatic suggestion that Leopold would describe in much more detail in his seminal 1933 textbook *Game Management*. For example, in discussing the restoration of bird populations Leopold commends the "judicious use of those tools employed in gardening or landscaping or farming" to build environments able to attract desired species. It was, as he wrote, simply a process of "deliberately and intelligently reversing the processes which are destroying bird environments."[51]

Leopold would push this line of thinking even further. That same year, in his landmark essay "The Conservation Ethic," he explicitly linked this experimental and manipulative approach to wildlife management to the challenge presented by species extinction. In doing so, he unmistakably promoted a hands-on approach to ecological recovery and conservation:

> Why do species become extinct? Because they first become rare. Why do they become rare? Because of the shrinkage in the particular environments in which their particular adaptations enable them to inhabit. Can such shrinkage be controlled? Yes, once the specifications are known. How known? Through ecological research. How controlled? By *modifying the environment* with those same tools and skills already used in agriculture and forestry.[52]

In step with Leopold's endorsement of a robustly experimental approach to wildlife conservation (including interventions that entailed a significant degree of habitat modification and

manipulation) was his support for more preemptive forms of conservation practice. In fact, he regularly expressed frustration at the generally reactive and elegiac mode of conservation, as in the essay "Post-War Prospects," which Leopold penned in 1944. "One defect in conservation," he noted, "is that it is so far an ex post facto effort. When we have nearly finished disrupting a fauna and flora, we develop a nostalgic regret about it, and a wish to save the remnants." Instead, Leopold, wondered, "Why not do the regretting and saving in advance?"[53] Again, his was a vision of anticipatory conservation well ahead of its time.

Presumed Innocent?

Leopold's conservation philosophy was progressive in a number of other ways, too, including its attitude toward nonnative species. As we've seen, one of the main objections to proposals such as AC is that it will amount to nothing more than "planned invasions." That is, many critics describe AC as a recipe for ecological disaster given the translocated species' potential to disrupt native species and habitats when released into new environments. The invasion biologist Dan Simberloff has been one of the strongest critics of AC in scientific circles, calling it (in a widely cited paper coauthored with Anthony Ricciardi) "ecological roulette."[54] Simberloff has elsewhere suggested that even Leopold began to hold an increasingly negative view toward nonnative species over the years, an attitude that rested on the great conservationist's aesthetic and ecological aversion toward exotics as well as his steadfast commitment to the goals of ecological integrity and the protection of native flora and fauna.[55]

Simberloff is generally correct in noting Leopold's concern about the conservation implications of the spread of invasive

species (or "pests," as he often called them)—as well as Leopold's prizing of both nativeness and a particular notion of ecological integrity (including in "The Land Ethic"). But I think he also overstates his case, on two counts. For one thing, while Leopold may have had a generally negative view of nonnatives in conservation contexts, he wasn't nearly as ideological about this as Simberloff suggests. Indeed, Leopold seems to have subscribed to a consequentialist view toward nonnative plants and animals, focusing on what these species actually *do* in the environment rather than starting from a snap judgment about their intrinsic destructiveness. "No species is inherently a pest, and any species may become one," he remarked in his 1943 essay "What Is a Weed?"[56] Although it's true that Leopold embraced a rosier view of exotic species in his earlier writing on game management in the 1930s than he did in his later years, he was far from an absolutist about the necessity of maintaining conditions of strict nativeness in conservation.

We can see this more nuanced view of nonnative species and ecological integrity emerge in Leopold's mature thinking about ecological restoration. In 1934, Leopold was appointed research director of the University of Wisconsin's new arboretum (at the time he was also serving at the university as professor of game management). His original plan for the arboretum was for it to serve as a research site for university students, but it was also envisioned as a restoration effort, emphasizing the region's native plant and animal species.[57] Yet, as Bill Jordan and George Lubick note in their insightful study of the history of the science and practice of ecological restoration in America, Leopold would soon temper his restoration goals as he realized that the re-creation of strict historical assemblages and communities was not always possible.[58] This found Leopold slowly warming to the view that, at least in some cases, novel

associations of plants and animals that could be maintained effectively within a mixed environmental and human matrix formed a realistic and valid conservation target.

The ultimate ecological objective for Leopold, in other words, was not a rigid, all-or-nothing recreation of past ecosystems and species compositions but rather the maintenance of what he called "land health," defined as the persistence of the self-renewing capacities of the ecosystem. As Leopold put it in his 1944 essay "Conservation: In Whole or in Part?": "Conservation is a state of health in the land. . . . It is a state of vigorous self-renewal. . . . Such collective functioning of interdependent parts for the maintenance of the whole is characteristic of an organism. In this sense land is an organism, and conservation deals with its *functional integrity*, or health."[59] So, despite Simberloff's assertion that Leopold's fidelity to "integrity" (especially in an aesthetic sense) was so powerful that it "could no more be maintained by adding a nonnative species than could the integrity of the Mona Lisa be maintained by adding a moustache or a necklace, even a pretty necklace,"[60] Leopold in fact held a more plastic and pragmatic understanding of ecological integrity. It was *functional* integrity, not historical integrity, that Leopold was after, and although his working hypothesis was that native species were crucial to maintaining land health, he was no purist on the issue.

If, for example, nonnative species introduced for conservation purposes (i.e., to reduce the threat of extinction) could be accommodated by ecological systems such that they didn't reduce the diversity and fertility of the system—the "yardsticks" for land health Leopold advanced in his important essay "Biotic Land Use," written in the early 1940s—then their presence wasn't inherently objectionable. It's a view, I believe, that tracks nicely with some of the current revisionist thinking about exotic

species in ecology and biodiversity science, where the emphasis on a species' origin (i.e., whether it was introduced by humans) is less important than whether an introduced species is producing benefits or harm to valued elements of biodiversity, ecological services, and other natural and human goods.[61] Interestingly, it also anticipates the more relativistic and process-oriented views of wilderness mentioned briefly in the previous chapter, that is, framings of the wild that focus less on static historical assemblages of particular species in indigenous ranges and more on keeping key ecological and evolutionary processes—and our diverse relationships with wildness at a range of scales—intact.[62]

THE LEOPOLDIAN PROVISOS

In sum, then, I think we can say the following: first, Leopold's conservation philosophy, while anchored in an ecological view of the land, was nuanced and sensitive enough to allow for a strong attachment to the value and conservation of individual species; second, Leopold clearly supported experimental and preemptive conservation efforts, including those requiring significant manipulation of wildlife populations and their habitats; and, finally, Leopold held a more pragmatic attitude toward nonnative species than is often realized, focusing on the objective of conserving functional integrity and the wider goal of promoting land health rather than fixed notions of species purity and nativeness.

A discerning reading of Leopold's conservation thinking, all this is to say, suggests a cautious and provisional acceptance of conservation translocations like assisted colonization, at least under certain conditions. *If* the conservation-driven translocation

of a species (including to a system outside its indigenous range) is determined to be the only way to save it from rapid decline and extinction, and *if* doing so does not undermine ecological "integrity" understood functionally (rather than historically) as the maintenance of land health (i.e., the self-renewal capacity of the landscape), *then* assisted colonization could be deemed acceptable within the confines of Leopold's conservation philosophy. The same goes, I'd argue, for ecological replacement, a form of conservation introduction that, while emphasizing the restoration of ecological and evolutionary processes in the receiving system (that were lost by the extinction of an analogue species), is often also justified by secondary appeal to the conservation of the focal species.[63]

At the same time, though, I think there are two major stipulations to this conclusion that emerge from Leopold's writing. They're significant caveats, in no small part because they introduce critical ecological and moral constraints on human interventions in populations and ecosystems, even in situations where such efforts are potentially supportable according to many of the other managerial norms contained within Leopold's conservation philosophy.

The first is a clear preference in Leopold's writing for stretching traditional strategies of species conservation to their breaking point *before* adopting more radical techniques. This view can be summarized in the context of current debates over AC with a simple directive: *try native habitat expansion first*. "The combined evidence of history and ecology," Leopold wrote in 1939, "seems to support one general deduction: the less violent the man-made changes [in the land], the greater the probability of successful readjustment in the [biotic] pyramid."[64] In *Sand County*, Leopold's understanding of the structure and function of the biotic

community (influenced by Charles Elton, a British animal ecologist) translated into a specified strategy for managing wild species in situations where native habitat proved insufficient. "The most feasible way to enlarge the area available for wilderness fauna is for the wilder parts of the National Forests, which usually surround the [National] Parks, to function as parks in respect of threatened species," he wrote in his essay "Wilderness."[65]

I believe Leopold would therefore have encouraged the exhaustion of traditional, in situ approaches to species conservation (e.g., the expansion of protected areas, the construction of wildlife corridors, and native habitat modification to increase resilience, as we would call it today) before making the decision to move species preemptively into new environments, especially those habitats well outside their indigenous ranges. Such a view fits nicely within his broader commitment to the standard of land health and also provides a bridge to the preservationist reading of Simberloff and others who stress Leopold's abiding concern with ecological integrity and biological nativeness in his conservation outlook.

But one of the reasons why the more radical forms of translocation are being considered is because of the concern that traditional conservation approaches, such as the expansion of protected areas and increased landscape connectivity, will not be enough to protect species against intensifying anthropogenic threats like global climate change, which can make protected area size, even when multiplied, irrelevant. In such cases, I'd argue that Leopold's work suggests that the responsibility to maintain viable populations of vulnerable species (without destroying land health) overwhelms the commitment to traditional conservation methods. In other words, *elephants somewhere*.

FIGURE 4.5 "A conservationist is one who is humbly aware that with each stroke he is writing his signature on the face of his land" (Aldo Leopold).

Source: Courtesy of the Aldo Leopold Foundation, www.aldoleopold.org.

The second proviso is *don't let our tools run the show*. Leopold was deeply concerned, both in his early and late writings, that our technological proficiency would outstrip our ecological humility, caution, and self-possession (figure 4.5). He was wary of purported technological fixes to what were in fact much more complex and deep-seated moral and cultural maladies. This reminds us that efforts such as AC will prove meaningless—and maybe perversely counterproductive—if they convince us that

we've solved the underlying conservation problem by moving populations to more hospitable environments. That is, if proposed strategies such as AC end up taking the place of more serious attempts to control and mitigate our environmental destructiveness, then we'll have failed to meet Leopold's moral expectations, even if we believe otherwise. Without addressing the primary moral and cultural drivers of our environmental ills, the translocation of species to help them adapt to climate change and to escape other human-driven stressors will be tantamount to moving around deck chairs on the *Titanic*. The final result at the end of this process may very well turn out to be the particular moral hazard mentioned earlier—elephants nowhere.

It's a critical condition in Leopold's thinking because it serves as a moral safeguard, a governor that keeps the machinery of conservation from spinning so far out of control that it runs roughshod over environmental values (such as respect for wildness on a rapidly humanizing landscape). And it's why I'd argue that, even though Leopold's conservation philosophy would permit the cautious consideration of AC when deemed necessary to save species from newer anthropogenic threats (and if doing so was not reasonably expected to disrupt land health), it doesn't justify some of the more radical technocentric ideas traveling under the banner of "conservation" that have emerged in recent years, such as de-extinction. But I'll have much more to say about that in the next chapter.

"I have purposely presented the land ethic as a product of social evolution because nothing so important as an ethic is ever 'written.' . . . It evolves in the minds of a thinking community," Leopold wrote at the end of "The Land Ethic."[66] It's a reminder that although Leopold can point us in certain directions, in the end developing a responsible and "evolved" conservation ethic for

emerging ecological challenges and for controversial proposals such as assisted colonization will likely hinge on our own answers to a tough set of questions.

Can we develop a responsible ethics of intervention in rapidly changing ecosystems, one that can also hit the brakes when restraint is called for? Can we retain a Leopoldian spirit of humility—and a bracing sense of our own fallibility—even as our planetary influence inevitably grows? Will we be able to keep alive a vital sense of the wild (even in a qualified sense) as we reconfigure the natural world in new and previously unimaginable ways with an expanding assortment of tools, including efforts in the name of conservation? These are the questions our own "thinking community" needs to keep in the front of our minds as we calibrate conservation in the age of extinction—and especially, as we'll see next, the dawning age of de-extinction.

5

PROMETHEAN DREAMS

TASMANIA'S LOST TIGER

It wasn't a tiger, at least not in the biological sense. But in the cultural imagination of British and Irish sheepherders transplanted to "Van Diemen's Land" off the southeastern coast of Australia in the early nineteenth century, the carnivorous, striped creature with the stealthy nature certainly fit the bill.[1] Dubbed the Tasmanian tiger—or, alternatively, Tasmanian wolf (which it also was not)—the elusive animal was viewed as a threat to Tasmania's rapidly growing though ultimately ill-suited sheep industry, an unwanted varmint primarily seen as an impediment to the development of the island's wilderness (figure 5.1).

Neither tiger nor wolf, the thylacine (*Thylacinus cynocephalus*), as it became known after several taxonomic fits and starts, was a marsupial mammal roughly the size of a hyena. It was Australia's largest modern marsupial carnivore, a species believed to have been nocturnal and to have preyed upon an eclectic mix of rodents, birds, and smaller marsupials (wombats and smaller kangaroos), although we have limited knowledge of the animal's ecology and behavior in the wild. Most of what we do know comes from a scattering of historical accounts in newspapers and

FIGURE 5.1 Perhaps the most famous illustration of the thylacine, from the naturalist John Gould's *The Mammals of Australia* (1863).

Source: Public domain.

from Tasmanian "bushmen," the hunters who pursued the animal in the wild throughout the nineteenth century.[2]

The thylacine went extinct on the Australian mainland around 35,000 years ago, a period that corresponded with the arrival of the dingo. (The natural history of the species on the mainland, however, like in most other cases, is a bit foggy; a recent study using ancient DNA has suggested that climate change may actually have been the cause of the animal's extirpation there.)[3] Tasmania, an island state around the size of West Virginia, only ever held a small remnant population of thylacines, probably not more than five thousand at the time of British settlement in 1803.[4] The animal would be decimated in the nineteenth century by bounty hunters working at the behest of the Van Diemen's Land Company, a United Kingdom–based

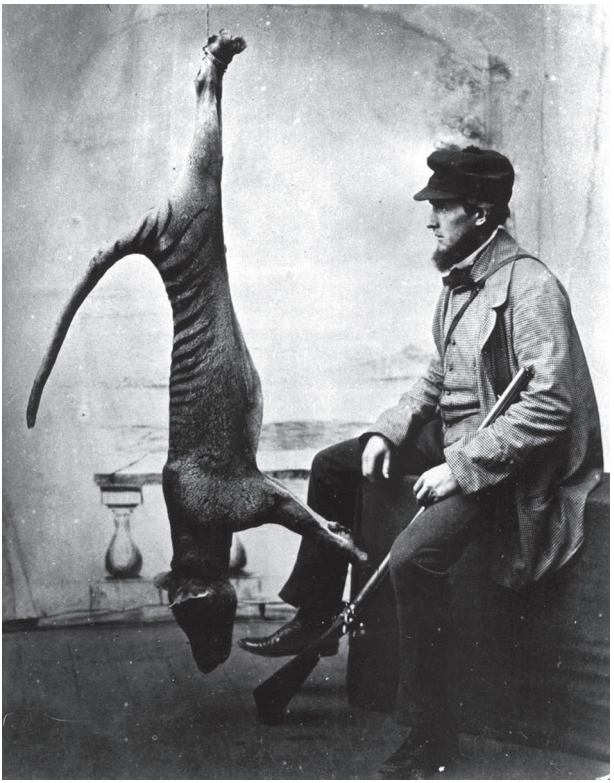

FIGURE 5.2 "Mr. Weaver bags a tiger." This photo, which is believed to have been taken by the photographer Victor Albert Prout in 1869, is one of the very few nineteenth-century images of a thylacine known to exist.

Source: Public domain.

wool-growing venture with a myopic desire for a predator-free landscape (figure 5.2). The Tasmanian sheep enterprise grew dramatically during the first decades of the nineteenth century, from just a few dozen head at the time of settlement to more than one million sheep by 1830.[5] The private bounties would eventually be joined by an official governmental bounty in

1888, which would record more than two thousand thylacine kills over the next two decades.

Despite its reputation as a bloodthirsty sheep killer, the empirical evidence doesn't seem to support the view that the thylacine was a significant predator of sheep on the island. Some historians have even suggested that the bounty systems and the exaggerated claims about thylacine predation were attempts to veil the failures of an untenable and inexpert sheep industry, a situation that had far more to do with human incompetence and voraciousness than it did with the actions of marauding marsupials.[6] Regardless, bounties and development drove the species into increasingly remote and hard-to-access territories by the late nineteenth century. By then, thylacine sightings, which had never been that common to begin with, were quite rare.

For decades, naturalists had been suggesting that the animal could be at risk of extinction if these trends continued. The British ornithologist and naturalist John Gould, a taxidermist for the Zoological Society of London (among other claims to fame, he acquired and named Darwin's legendary Galapagos finches)[7], went to Australia in the 1830s to document birds but also wrote about the state of the land's mammals, including the thylacine. Although he believed that the dense forests of Tasmania would spare the animal from its fate for some time, it was a stay of execution rather than a permanent safe harbor for the species. As he wrote in *The Mammals of Australia* (1863): "When the comparatively small island of Tasmania becomes more densely populated . . . the numbers of this singular animal will speedily diminish, extermination will have its full sway, and it will then, like the Wolf in England and Scotland, be recorded as an animal of the past."[8]

The thylacine would become a popular attraction in zoos, beginning in the 1850s at the London Zoo at Regent's Park and

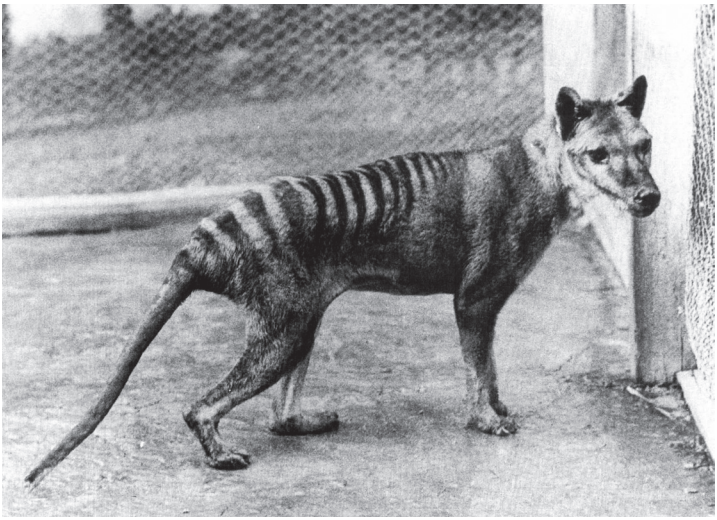

FIGURE 5.3 A thylacine at the Beaumaris Zoo in Hobart, Tasmania, in 1928. The animal was apparently ill and died the day after the photo was taken.

Source: Photo by Benjamin Sheppard. Public domain.

soon in Europe and the United States, as well (figure 5.3). But although there were scattered calls for the conservation of Tasmanian wildlife and habitat at the turn of the century, there were very few efforts to breed the species in captivity and not much in the way of measurable progress in getting people to care about its plight.[9] When William T. Hornaday's *Our Vanishing Wild Life* appeared in 1913, the American conservationist had all but concluded that this "most interesting carnivorous marsupial of Australia" was doomed and that its "untimely end" would be cause for great regret.[10]

The following year, amid growing concerns within scientific circles that the species was on its last legs, the Tasmanian biologist Thomas T. Flynn (father of the swashbuckling actor Errol

Flynn) proposed the establishment of a thylacine sanctuary, a last-ditch effort to stave off extinction. The idea went nowhere.[11] When a farmer named Wilf Batty shot a thylacine he caught eating his poultry in May 1930, it proved to be the last documented kill of the animal on the island.

In July 1936, the thylacine would finally receive full protection in the form of a governor's proclamation. But by then it was only a symbolic gesture. The last known thylacine died in the Hobart Zoo in September that same year, enjoying, as the historian Robert Paddle has observed, complete and unequivocal protection for its last fifty-nine days of existence.[12]

BRING 'EM BACK ALIVE!

How far should we go to bring back lost species? It isn't a straightforward question, in part because of a key semantic ambiguity: what do we mean by "lost"? Until very recently, recovering lost species meant either the reintroduction of a population that had disappeared from a local range but that was still extant elsewhere (e.g., the return of the gray wolf to Yellowstone National Park using animals translocated from Canada) or the reintroduction of a species that had become extinct in the wild but that still persisted in ex situ conservation facilities (e.g., the reintroduction of the Arabian oryx discussed earlier).

But there is now a third understanding of bringing back lost species, one that takes us into somewhat different scientific and philosophical territory than restoring wolves and condors to their historic ranges. It's one that until recently seemed unthinkable because it was undoable: the idea of rousing extinct species—including some that vanished thousands of years ago—from their evolutionary graves.

Called "de-extinction"—or, if you prefer a more transcendental register, "resurrection biology"—the controversial idea is premised on a set of established and newer techniques in molecular biology and genetic engineering.[13] One of the more familiar methods is "back-breeding," or the selective breeding of an extinct animal's living relatives to carry forward traits resembling the phenotype of the lost species (but not necessarily the genes present within the extinct forms). It's a technique currently being employed to breed a strain of domestic cattle into something resembling the aurochs, a species of wild European cattle (and ancestor of modern domestic cow) that went extinct in the first half of the seventeenth century.[14] And as I wrote in the opening chapter, it may also allow us to bring back the Pinta Island tortoise following its presumed demise with the death of Lonesome George.

A more complicated form of de-extinction technology is the cloning of extinct species via somatic cell nuclear transfer, a laboratory technique for creating an ovum (egg) with a nucleus transplanted from another cell; the embryo, with genetic material from the extinct species, is then implanted into a living surrogate to produce a genetically identical copy of the extinct form. This method is currently being used in an effort to bring back the Pyrenean ibex, a Spanish wild goat that went extinct in 2000.[15]

Much of the de-extinction discussion, though—especially as it has played out in the media—has been dominated by discussion of newer, advanced techniques in genetic engineering and synthetic biology, particularly the technological breakthroughs allowed by the ability to rapidly sequence long-extinct genomes.[16] These techniques, which are fast developing, could allow scientists to create something resembling long-lost species, perhaps even those that have been extinct for thousands of years. By using

ancient DNA taken from museum specimens, material that was previously thought to be unusable, scientists can now sequence the extinct genomes and "edit" the DNA of closely related species to come up with a genetic blueprint very similar to the extinct forms. For example, an Asian elephant could in theory have genes for a woolly mammoth spliced into its DNA and be "reintroduced" as a proxy species for its vanished Pleistocene relative.[17]

Defenders of de-extinction tend to make a common set of arguments for bringing back vanished biota. One group of claims highlights the ecological and evolutionary benefits: the revived species, we are told, will perform vital (and often lost) ecological functions when returned to the landscape.[18] For example, the resurrected mammoth could become a keystone species in the restoration of the "mammoth steppe" in northern Siberia, a "Pleistocene Park" containing a spate of reintroduced and revived wildlife in an attempt to reset the ecological and evolutionary clock in this part of the Arctic.[19]

But broader cultural, aesthetic, and moral reasons are also given for bringing back lost species. Supporters argue that de-extinction will evoke a powerful sense of wonder and awe as we witness species raised from the dead and returned to the landscape.[20] Advocates also point to the sense of wonder that the revival of extinct species could encourage among the public. As Aldo Leopold wrote in his elegy for the lost passenger pigeon in *A Sand County Almanac*, although we will always have them in museums and books, "book-pigeons," Leopold lamented, "cannot dive out of a cloud to make the deer run for cover, or clap their wings in thunderous applause of mast-laden woods."[21] The chance to return species to their "rightful" place in nature thus promises to restore an aesthetic and emotional source of great power on the landscape.

On moral grounds, restoring extinct animals has been promoted as our opportunity finally to "put things right," to balance the moral accounts and make amends for our past ecological transgressions.[22] It's therefore not surprising that many of the leading de-extinction candidates, from the great auk to the passenger pigeon, are species driven to their mortal ends by human exploitation and/or persecution, including some of the most guilt-inducing biota populating conservation's obituaries.[23]

Perhaps because of its sad history, which probably had something to do with the animal's reemergence as a conservation icon in Australia in the late twentieth century, the thylacine is one of the more popular candidates for de-extinction. The idea of trying to revive the species, though, is not entirely new. In 1999, scientists at the Australian Museum in Sydney began a project that attempted to clone the species using fragments of ancient DNA from preserved specimens. Cost and technological limitations of the time apparently led to the cessation of the project in 2005. Today, many scientists and supporters are now taking a more sanguine view of the feasibility of bringing the thylacine back.[24]

So let's imagine, then, that we could use these cutting-edge techniques in conservation genomics to create something close enough to a thylacine (stripes and all) to call it a thylacine. And let's also imagine that a suitably large number of the animals could be created to the point that a viable population could be introduced into the Tasmanian eucalypt forests and grasslands. If we could somehow manage to do all of that, well, why *shouldn't* we, especially given the clear and direct human role in the destruction of the species?

It turns out that not everyone thinks de-extinction is such a great idea. Some prominent ecologists and conservationists, for

example, have raised the concern that the introduction of the revivified wildlife into contemporary habitats would be more likely to bring ecological destruction than salvation. Native fauna and flora would, they argue, pay the price as the engineered creatures invade and alter ecosystems, environments that have inevitably changed (in some cases, rather dramatically) in their absence. Others fret about the limited genetic diversity of any "de-extinguished" species and the assumption that reviving a genome is the same thing as recovering the behavior and identity of an animal that evolved over millennia.[25] And there's a concern about public acceptance of the new forms, especially if they're ultimately released into the wild.

The financial cost of de-extinction has also been a point of contention, with some conservationists expressing the worry that the limited funds available for traditional species protection (e.g., buying lands to shield them from development) would be diverted to these more glamorous and trendy revivalist projects. A recent study using New Zealand and New South Wales as hypothetical cases for the "re-introduction" of revived species concluded that resources devoted to this enterprise over the long run would result in a net biodiversity loss compared with scenarios in which the same funds were used for the conservation of extant species.[26] Other skeptics have also raised the worry that if de-extinctionists were to be successful, they would erode popular support for more traditional conservation initiatives. After all, why worry about endangered species if extinction is no longer an evolutionary death sentence?

These are important reservations, even if they aren't all equally compelling (e.g., although the economic concerns are troubling, it's probably also true that at the research-and-development level, the benefactors of de-extinction are not likely to be the same crowd writing twenty-five-dollar checks to the Defenders of

Wildlife). But even if a thylacine (proxy) could be created and introduced into today's Tasmanian landscape without significant negative ecological, economic, and social consequences, there are other implications of the de-extinction agenda, concerns that I think cut more deeply into our environmental character.

THE TECHNOLOGICAL SUBLIME

The capacity of wild nature to produce a sense of awe and wonder—even something approaching fear—defined the aesthetic response of many eighteenth- and nineteenth-century artists and philosophers to the natural world. It was the language of the sublime, a reaction to the power, mystery, and beauty of a world beyond human making, understanding, and control. Take, for example, the ornithologist and painter John James Audubon's description of the vast flocks of passenger pigeons blotting out the sun in the Kentucky sky in 1831:

> The noise which they made, though yet distant, reminded me of a hard gale at sea. . . . The pigeons, arriving by thousands, alighted everywhere, one above another, until solid masses as large as hogsheads were formed on the branches all round. Here and there the perches gave way under the weight with a crash. . . . I found it quite useless to speak, or even to shout to those persons who were nearest to me.[27]

The birds elicited a similar response from Audubon's fellow naturalist and illustrator Alexander Wilson: "I was suddenly struck with astonishment at a loud rushing roar, succeeded by instant darkness, which, on the first moment, I took for a tornado, about to overwhelm the house, and everything around in destruction."[28]

Although de-extinctionists claim that revived species will be proper objects of aesthetic appreciation, awe, and wonder, I'd argue that they are in fact trading this aesthetic regard for the sublime qualities of wild nature for a celebration of our own technological ingenuity, power, and control. It's a move anticipated by the philosopher Immanuel Kant, who thought the unique human faculty of reason ultimately allowed us to separate ourselves and transcend the forces of nature. "Sublimity," he wrote in his *Critique of Judgment*, "does not reside in any of the things of nature, but only in our own mind, insofar as we may become conscious of our superiority over nature within, and thus also over nature without us."[29] Leo Marx, in his widely influential 1964 book *The Machine in the Garden*, revealed how this tension between the lure of nature as an alternative set of values and the siren call of technology animated the work of some of the leading lights of the American literary tradition, from Jefferson and Thoreau to Melville, Twain, and Fitzgerald. The embrace of the technological over the natural, in other words, has deep cultural roots.[30]

A familiar story or not, it's an aesthetic and philosophical expression that has reached something of a zenith in the hands of the more ardent de-extinctionists, where the sense of wonder and respect once directed at nature has become instead a regard for our own technological prowess. Here's how the Harvard geneticist George Church, a leading de-extinction proponent, describes the proposal to bring back the heath hen, which I discussed in the opening to this book: "I'm particularly attracted to the heath hen because it's basically a slam dunk. . . . We can just make a few adjustments to the DNA of the greater prairie chicken by synthesizing heath hen DNA. That would take days, thousands [of dollars], nothing. As an engineering project, birds are easy."[31]

Reading these words, I'm reminded again of the conservationist-philosopher Aldo Leopold's assessment of how the modern preoccupation with technology frustrates the development of a more meaningful environmental ethic, an idea we touched on at the end of the previous chapter. "Our tools are better than we are, and grow faster than we do," he wrote in 1938. "They suffice to crack the atom, to command the tides. But, they do not suffice for the oldest task in human history: to live on a piece of land without spoiling it."[32] Church may be right that engineering extinct birds is easy (though I have my doubts). But living sustainably and responsibly with other species on the planet, well, that has proved to be anything but.

FLIPPING THE SCRIPT

But there are further issues with de-extinction considered from the vantage point of conservation ethics. Species revivalists like Stewart Brand try to frame the effort to bring back extinct species as a gesture of ecological recompense and an opportunity to revise a shopworn and tragic conservation narrative. That traditional account, we're told, is an unpleasant and discouraging tale of environmental destruction and loss. De-extinction promises a much cheerier story, a more uplifting narrative driven by sunny acts of biological creation and ecological recovery.

I respect Brand's long and impressive career as a tech-friendly enviro-maverick, but I think he's wrong about this. De-extinction isn't really a conservation strategy, and it doesn't reflect a sound conservation ethic. In fact, I believe pursuing it will seriously undercut an important source of the value we attach to wild species. Even worse, it could undermine the moral lessons of extinction at a critical time in our environmental history.

For example, Brand believes that bringing back the passenger pigeon will allow us to "reverse the founding human mistake that inspired modern conservation" and that in doing so the narrative of conservation can break free of the "constant whining and guilt-tripping" that has defined its moral temperament.[33] But it's not "guilt-tripping" to reflect responsibly on our environmental losses and to absorb the moral lessons of extinction. Admittedly, it's not always pleasant to dwell on the mistakes of the past, but being honest about the history of ecological destruction and maintaining a clear-eyed fidelity to this chronicle (especially in the face of efforts, both well intended and otherwise, to unravel it) is vital to cultivating and safeguarding a meaningful ecological ethic.

We also can't reverse the "founding human mistake" by simply bringing back a few or even a few scores of lost species (as difficult as that would be to pull off). That's because wiping out the passenger pigeon, the heath hen, the thylacine, and so on, as regrettable as these events were, wasn't the real mistake. It was only the indicator of a deeper moral and cultural malady.

The foundational mistake was and remains the embrace of a self-regarding worldview in which we see ourselves as masters of a world thought to be increasingly of our own making. That boisterous anthropocentric ethos is the philosophical engine pulling the train when it comes to extinction and other destructive environmental practices. It's a belief system that will continue to make mischief even if we're able to engineer facsimiles of long-lost animals. And it will grow even stronger if our technological wizardry gulls us into forgetting the difference between the original and the "remake."

Although the elegiac narrative in conservation can be depressing at times—a miserable parade of species lost and sacred places ruined—our stubborn refusal to absorb it neither lessens

its importance nor challenges its truths about the difficult episodes in our ecological history.[34] And taking stock of this history is, I believe, an important part of our developing an authentic ecological conscience.

Furthermore, you don't have to be an essentialist about the meaning of "natural" or cling to outmoded notions of species purity to recognize that there are, as we might say, morally significant differences between the extinct species and the synthesized versions. One key distinction hinges on the coevolutionary natural history of the lost forms. Although the engineered reproductions may hold other values for conservationists, unlike their progenitors they will not have evolved in relationship with other species and within a given ecological setting over millennia. And that unique coevolutionary and ecological narrative is, I believe, an important part of how and why we value wild species. It's a character that simply can't be recreated in a modern genomics lab.

In other words, the back story is wrong, at least from a conservation perspective. A living species' natural history is only one reason why we value them, but it's a profoundly important one to conservationists (or at least it should be). In part, this is because our understanding of an unengineered species' natural history encourages the adoption of an attitude of humility toward them. As Leopold again reminds us, "Men are only fellow-voyagers with other creatures in the odyssey of evolution."[35]

That doesn't mean that a novel natural history for the revived forms couldn't be compiled over the coming centuries. There's no "rule" specifying how many generations it takes for a species to accrue a distinctive natural history or for one to lose it, as in the case of animals bred in captivity and reintroduced to the wild after an absence (the California condor is again a good example here). But there's also no denying that many of the revived

"fellow voyagers" would appear long after their unengineered analogues walked the earth or soared in the skies and lacking the coevolutionary narrative that partly defined the natural history of their progenitors. That is, they simply won't have the unique evolutionary character that was part of why we valued the "originals" in the first place—an identity that vanished with them. If they're fellow voyagers, then, they'll be arriving with suspiciously blank passports.

PRAGMATISM UNBOUND

Lurking within some of the more fervent pro-de-extinction arguments is an even more troubling moral and cultural vision, however: a view of humans as all-powerful creators and the presumptive governors of planetary life. It's telling, I think, that Brand has resurrected and slightly revised his familiar motto from the *Whole Earth Catalog* in his pitch for de-extinction: "We are as gods and *have* to get good at it."[36]

I take his point—it would be foolish to deny our species' outsize influence and power on the planet. Still, it's a deeply unsettling notion. The last thing we need to do right now, it seems to me, is to spur ourselves to be even more aggressive in taking the planetary reins. Instead, we need somehow to find the will to embrace an ethic of collective self-control and ecological restraint. It's an attitude that's especially vital today given our growing recognition that we're writing our signature deep into the folds of geological history.

Interestingly, and as I mentioned briefly in the first chapter, Brand has written that he considers himself a "capital P" pragmatist in environmental and conservation matters. But again, a truly authentic pragmatism (i.e., in the philosophical sense, that

is, the late-nineteenth- and early-twentieth-century school of American philosophy led by William James and John Dewey, among others) is distinguished not by Brand's aggressively anthropocentric and technocentric view of the universe but by the recognition of our own imperfections, our awareness of the contingency of experience, and our sense of human limits in nature. It's an outlook that, in Dewey's work, required the careful adaptation to and cooperation with natural forces as much as it necessitated adjustment and transformation of them.[37] Brand's intellectual mooring is not pragmatism. It's a twenty-first-century spin on Prometheanism: a celebration and justification of human creation, power, and the control of nature in the engineering age.

The most troubling aspect of de-extinction, I therefore believe, is not its ecological riskiness (though I think that is considerable), its cost (which may be prohibitive), its divorce from natural history (not good), or even its jumbling of conservation priorities (hard won, all of them). It's what it might mean for *us*. Attempting to revive lost species is in many ways a refusal to accept our moral and technological limits in nature. De-extinction reflects a new kind of Promethean spirit that attempts to leverage our boundless cleverness and powerful tools for conservation rather than for human enhancement (figure 5.4). But things did not end well for Prometheus.

De-extinction, then, fails to satisfy the demands of a responsible conservation ethic. But it also collapses as a conservation *strategy*. Even if we could get past its myriad moral and cultural challenges (and I don't think we can), it is difficult to see how it could ever play a significant role in the conservation of (extant) vulnerable species or in the protection of ecological systems. It will do very little, for example, to address the current crisis of global biodiversity decline and habitat fragmentation and

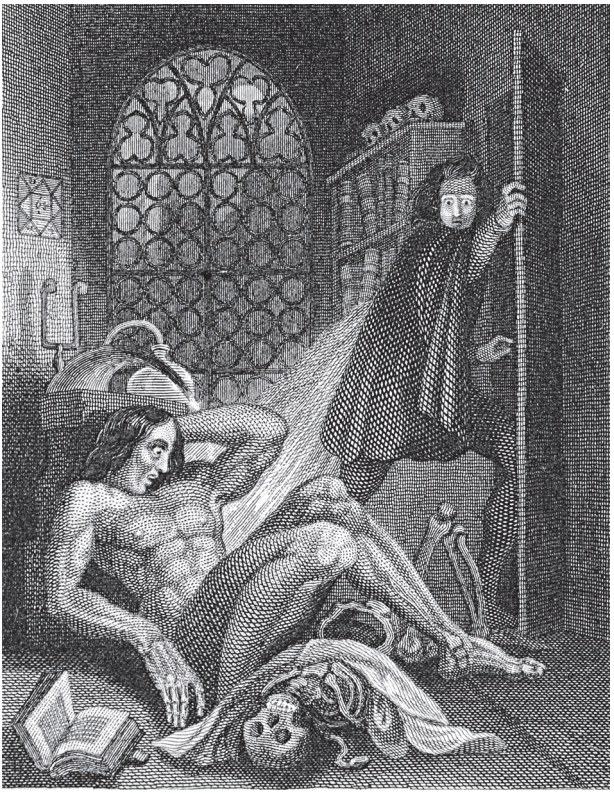

FIGURE 5.4 "A new species would bless me as its creator and source; many happy and excellent natures would owe their being to me."

Source: Frontispiece to the revised 1831 edition of Mary Wollstonecraft Shelly, *Frankenstein; Or, the Modern Prometheus*. Public domain.

destruction. That's not to say that some of the technologies at the core of the idea don't have scientific value for conservation; the study of ancient DNA to understand ecological and evolutionary history and processes, for example, is certainly relevant to contemporary conservation science.[38] And there is a range of other applications of the techniques of synthetic

biology outside of de-extinction that may have positive implications for the conservation of extant species and ecosystems, even if ethical questions surrounding the extent of and implications of their use remain to be explored fully.[39]

But de-extinction can't be considered a plausible conservation approach, despite the desire of Brand and others to make it one. It's only a curio. High-tech fantasies like de-extinction will certainly not do much to address the ratcheting up of the rate of current global species losses, which as we saw in the previous chapter are perhaps a thousand times the background or "normal" rate. It's hard to see how a heroic, costly, and (many-) decades-long effort to create, breed, condition, introduce, and manage a handful of species will make a significant dent in the extinction crisis proportionate to the energy and resources devoted to them.[40]

Responding deliberately and effectively to the global conservation challenge demands an extraordinary and unprecedented effort. Hard decisions will have to be made. For example, in many cases intensive and aggressive conservation actions will be required to protect biodiversity in the coming decades. As we've seen, these might even include translocating climate-vulnerable populations outside their historical ranges to novel habitats deemed more suitable as the environment changes, which is a significant departure from the traditional conservation approach emphasizing the protection of species in their historical habitat.[41] But to my mind there is a clear and bright line separating this class of dramatic efforts to save extant species (especially when grounded in a Leopoldian sense of humility and skepticism toward technological "fixes") and the goals of de-extinction, which display little of the restraint and caution that define what I believe to be the very best moral instincts of the American conservation tradition.

I'm especially worried about the sense of inevitability shaping the ethical assessment of de-extinction, and to me it seems that efforts to explore its full moral implications have been scotched in favor of more accepting, small-bore analyses that only tinker at the margins while eliding the deeper questions. The result, I believe, is moral normalization, in which the goal is to make de-extinction "less bad" rather than to subject it and its purported conservation credentials to serious moral engagement.[42]

This accommodationist attitude is on display, unfortunately, in the 2016 IUCN guidelines for de-extinction ("Guiding Principles on Creating Proxies of Extinct Species for Conservation Benefit"), which for the most part simply attempts to fold de-extinction into existing conservation frameworks and risk protocols, including those for species translocations and ex situ conservation.[43] According to the guidelines, the biotechnological "creation" of proxy species (de-extinction) for conservation ends is permissible as long as it doesn't detract from efforts to conserve existing species. The deeper questions about the moral implications of this technology, however, remain bracketed. Much better is the roundtable analysis produced the Hastings Center, a leading bioscience ethics research institute that recently released an excellent overview of the ethical, scientific, and societal aspects of de-extinction. Importantly, their special report includes a range of skeptical and critical voices alongside the more familiar mix of de-extinction boosters (including some of the contributors to the IUCN document).[44]

Let me be clear. My concerns about de-extinction should not be read as a rejection of all significant conservation interventions or a shying away from bold action in the face of what appears to be a rapidly growing tear in the fabric of planetary life. As I wrote in the previous chapter, there are compelling arguments for

adopting a cautious and solicitous pragmatism in species conservation in our time of accelerating species declines and extinctions.

But I also believe there is great virtue in keeping extinct species extinct. Meditation on the loss of species like the passenger pigeon, the heath hen, and the thylacine forces us to remember our fallibility and our finitude. We are a wickedly smart species and occasionally a heroic and even exceptional one. But we are also a species that can become mesmerized by its own power. It would be silly to deny the reality of that power. But we should cherish and protect the capacity of nature, including species no longer with us, to teach us something profound (and something quite old) about the value of collective self-restraint in the purported "Age of Humans."[45]

Despite some good intentions and the claims of promoters like Stewart Brand, the attempt to revive extinct species isn't a proper act of ecological contrition. It is yet another example of the refusal to recognize moral and technological boundaries in nature, to, as Thoreau would put it, observe "some life pasturing freely where we never wander."[46] And again, although I know it cuts against the progressive aims of science and technology to say it, there can sometimes be real wisdom in fighting the impulse to control and manipulate, in questioning the belief that we can "fix" nature.

Resisting the Promethean urge to resurrect lost biological forms will show that we understand the value of setting at least some limits on human intervention in environmental systems even as our global influence grows. The recognition of our unique impact on the land, the honest acknowledgment of the size and depth of the human planetary footprint, doesn't require giving up on the view that many species and ecosystems do and should continue to exist free from significant human manipulation.

Drawing this line is necessary if we're serious about keeping alive a meaningful ethic of nature conservation and protecting a rich and diverse ecological mosaic in this century. It will hopefully also remind us that some of the most ennobling and transformative applications of human power are not found in displays of technological mastery or environmental control. They reside instead in acts of restraint and forbearance, including the creation of moral boundaries in nature that we do not cross, even if we can.

The thylacine was officially declared extinct by the International Union for Conservation of Nature (IUCN) in 1986, fifty years after the last known individual died in the Hobart Zoo. Over the years, the species has become a powerful environmental symbol on the island, an emblem appearing on everything from postage stamps and license plates to beer bottles. It's a form of mass cultural atonement, perhaps, for a widely acknowledged and lamented environmental mistake. Even though repeated organized searches for proof of its existence have produced no definitive evidence that the animal still roams the Tasmanian wilds, alleged thylacine sightings have been reported regularly on the island since the 1930s (and recently, even on the Australian mainland),[47] against all odds and, one might also conclude, all reason.

Somehow, then, the animal has managed to morph into something else in the Tasmanian moral imagination, that is, something other than a tragic icon of human destructiveness and loss. It's become a symbol of a kind of stubborn environmental hope, though not the false hope promised in the dreams of the de-extinctionists. It's the collective wish that nature retains just enough mystery—and just enough power—still to surprise us, even in the age of humans.

6

HEAVEN AND EARTH

As I write this final chapter, de-extinction is still mostly a boutique idea in conservation. Yet it's also part of a larger and growing engineering agenda in biology and environmental science, an agenda that trumpets the potential of emerging technologies to address a range of ecological and human concerns, from species decline and extinction to urban and agricultural sustainability, human health, and global climate change.[1] Although they vary in scale and application, many of these practices and proposals share a common worldview: the jettisoning of older constraints on our manipulation of nature and the transformation of norms and ethical relationships premised on our exercise of restraint on the landscape.

What I've tried to promote in this book is an alternative environmental ethic, what might be called "pragmatic preservationism." It's a clunky term, I know, and probably to many an oxymoron. But I think it captures an important, if not easy pairing of two core ideas regarding conservation in the extinction age: the growing need to intervene more aggressively to save species in a rapidly changing environment and an acknowledgment of our responsibility to preserve a convincing sense of the wild and a respect for nature as we undertake (or choose not

to pursue) these interventions. My interest, as I said at the outset, has been in the moral implications of controversial efforts to study, recover, conserve, and create species. These well-intentioned practices and proposals, some of which I cautiously support (assisted colonization), some of which I reject (specimen collecting in vulnerable populations, de-extinction), raise hard questions about the proper limits of the intensive manipulation of nature for scientific and conservation ends. And they expose the moral friction that emerges when our powerful desire to save and restore species (and bring people closer to them, as in the case of Zootopia) chafes against venerable conservation commitments eschewing ecological control and transformation, regardless of how noble the motivation behind these efforts may be.

But as we've seen, many of those earlier commitments haven't aged well. Some, such as longstanding attachments to historical integrity and notions of species nativeness, appear to be crumbling.[2] It's enough to make one a pessimist about the prospects for traditional nature protection in our highly technological and increasingly human-defined age.

That's especially because one of the most relentless critiques in the conservation tradition focuses on our love of technology and our desire to control nature. This line of argument can be traced back at least to Thoreau's grousing about the Fitchburg Railroad in *Walden* (1854): the engine's whistle, he complained, "penetrates" his solitude and contemplation of the pastoral beauty of the New England countryside.[3] A century later, Aldo Leopold wrote derisively of the agricultural engineers who brought their heavy-handed notions of "progress" to Wisconsin's marshes by draining them and destroying critical wildlife habitat.[4] And at the dawn of the modern US environmental movement in the early 1960s, Rachel Carson assailed the agro-technological

system responsible for producing "biocides" such as DDT (dichlorodiphenyltrichloroethane), which she warned posed a deadly, multigenerational threat to wildlife and humans. It was a technology, moreover, that was the product of a pathological environmental ethic and culture. "The 'control of nature,'" she wrote in *Silent Spring* (1962), "is a phrase conceived in arrogance, born of the Neanderthal age of biology and philosophy, when it was supposed that nature exists for the convenience of man."[5]

Out of these sympathetic critiques emerged a common call for ethical limits, a sharper sense of environmental thresholds, and the argument, variously stated, that human activities should not subvert, in Leopold's words once again, the "integrity, stability, and beauty" of the natural world.[6] Modern environmental writers such as Carson and Leopold stressed the urgency of catalyzing a deeper transformation in our collective ethical sensibilities toward other species and ecosystems, of adopting an attitude of respect toward wild populations and landscapes. Trained as scientists yet skilled at cutting to the philosophical and cultural core of environmental problems, they wrote powerfully about the need for us to assume a cooperative and life-affirming role on the planet rather than a despotic and destructive one. And they spoke of the broader societal responsibility to critique rather than support the development of aggressive scientific and technological developments that threatened to undermine the integrity of ecological systems.

But the times they are a-changin'. Earth, we're now told, is spinning through the Anthropocene, the "Age of Humans." The idea, which I've mentioned in various places and ways throughout this book, maintains that our current geological age (the Holocene) reflects the profound influence of human activities, especially the burning of fossil fuels but also extensive land transformation, large-scale water diversion, mass extinctions,

disruption of the nitrogen cycle, and other markers of human influence and impact on the planet.[7] The global extent and significance of these actions have promoted not just a discussion about renaming a geological epoch but a larger and potentially transformative conversation about the place of humans in the natural world and about the possibilities and limits of human technology, imagination, and ambition.

The Anthropocene idea is a particularly bitter pill to swallow for many nature conservationists today, heirs of the tradition of Thoreau, Muir, Leopold, and Carson. The fear is that the declaration of the age of humans is not just an impartial, scientific sounding of the depth of our global activities; it's a moral and cultural acquiescence to them. That is, there is a concern that further development and technological growth is now viewed as inevitable, perhaps even desirable. An uncritical embrace of the Anthropocene, the more preservation-minded conservationists worry, can too quickly devolve into a license to "finish the job" when it comes to exploiting species, denuding ecological communities, converting wildlands, and all the rest (figure 6.1).[8] When you toss in the familiar political and economic interests aligned against nature protection, including newly emboldened efforts to weaken the Endangered Species Act and open public lands to more intensive energy development, it's easy to understand why use of the term "Anthropocene" is so unwelcome to many nature conservationists and so polarizing in environmentalist discussions generally.

Regardless, the technological optimism coursing through a flurry of popular science books published over the past decade exploring the Anthropocene idea in one form or another, works with titles like *The God Species*, *Earth in Human Hands*, and *The Unnatural World*, is unmistakable, despite the fact that these authors attempt (more or less) to inject a degree of caution

FIGURE 6.1 The Anthropocene has become a Rorschach test for conservationists.

Source: Mark Klett, "Trails of Weekend Explorers," used by permission.

into their celebrations of human ingenuity and inventiveness.[9] Even the poet and naturalist Diane Ackerman, a writer who wouldn't normally be mistaken for Stewart Brand, finds reason to marvel at the possibilities of a "good" Anthropocene. Despite our many ecological (and human) failures and ills, we are still "laced with invention," she writes, a species able to think and build its way out of messes and light out toward a brighter future.[10]

In this brave new world, extinction no longer casts as dark a shadow. Species resurrection will begin to reverse the historical process of biological destruction. And rather than sounding the death knell for species, the Anthropocene has ushered in a grand "biogenesis" (as the conservation biologist Chris Thomas puts

it) in which animals and plants will continue to adapt and hybridize in response to human changes, thus producing novel forms of biodiversity in the human age.[11] Astonishingly, one biodiversity scientist has even gone so far as to say we shouldn't worry as much about trying to save endangered species because "extinction is the engine of evolution" and because, if we're being completely honest, conservation is really "needed for ourselves and only ourselves."[12] It would be hard to find a more unabashed and arrogant anthropocentrism traveling under the name of "conservation science" than this.

But species aren't the only beneficiaries of the new techno-optimism. Wilderness, too, may get a high-tech makeover. Thanks to advances in robotics and advanced algorithms, some scientists (including the ecologist and "good" Anthropocene booster Erle Ellis) are exploring the idea of using machines to design and run "wilderness" areas in the future, novel systems "curated" by artificial intelligence(s) and independent, at least to a large extent, from humans.[13] The sunlight of human ingenuity and ecological possibility will thus cut through the shadow of species extinction, wilderness destruction, and countless other ecological miseries we thought we would continue to be saddled with in this century.

And it turns out even the sunlight will bend to our will. The premier expression of the Anthropocene's incitement of techno-optimism and environmental mastery is surely geoengineering, a proposal to combat the effects of anthropogenic climate change by deliberately intervening in the climate system (to counter our "unplanned" interventions of burning fossil fuels and emitting other greenhouse gases into the atmosphere). It's a degree and perhaps a kind of environmental control and technological intervention in nature that Thoreau, Leopold, and Carson could not have envisioned.

Whether they're focused primarily on carbon dioxide removal (e.g., capturing and storing carbon) or, more likely, on solar radiation management (e.g., injecting aerosols into the stratosphere to reflect sunlight), the more ambitious geoengineering activities will clearly result in the extensive human modification and control of global environmental systems: a managed Earth complete with a thermostat.[14] The heroic, planetary scale of geoengineering, its litany of possible environmental impacts (increased ocean acidification, alteration of regional weather patterns, increased acid rain deposition),[15] and especially its seemingly perfect embodiment of the human-mastery-of-nature ethos puts geoengineering at odds with the moral narrative of environmental responsibility in the conservation tradition.

Supporters of geoengineering, such as the Harvard physicist David Keith, counter that *something* has to be done to reduce the risks posed by global climate change and that even if we were able to enact massive and global emissions cuts today (a prospect that seems unlikely), the inertia in the climate system means that the planet would continue to warm for more than a century.[16] Keith argues that although solar geoengineering is no substitute for mitigation efforts to reduce emissions, it should be explored as an additional option in the climate response portfolio if we're serious about addressing the predicted impacts of climate shifts in the coming decades.[17] He also poses an interesting question, directly relevant to the discussion at hand:

> If solar geoengineering reduces the climate and ecological effects of accumulated carbon dioxide, is its implementation a step toward cleaning up our mess in a process of ecological management at planetary scale? Or is it yet another step toward the subjugation of nature for human ends? Which analogy fits best: reintroducing wolves to Yellowstone? Restoration of the Florida Everglades

> in arguably the world's largest and most costly environmental engineering effort? Reviving wooly [*sic*] mammoths? Or is geoengineering more akin to indoor ski slopes in Dubai, the creation of artificial environments to suit human whims?[18]

I'd say the latter (i.e., the subjugation-of-nature, reviving-woolly-mammoths, Dubai-ski-slopes deal). Keith is right to raise concerns about the impacts of a warming world on wild species, ecosystems, and people and to worry about our failures to address these risks in a timely and effective manner. I share that worry. But if we end up sacrificing core environmental and moral values in the process, such as our respect for nature's wildness and a sense of human proportion on the landscape, I think that as we tighten our grip on the atmospheric wheels, we will lose something vital to our conservation ethic.

Plus, it's far from clear that geoengineering is an unalloyed good when it comes to the conservation of ecological systems and species. In fact, it may present a new order of threat to global biodiversity from some unintended—and disconcerting—consequences. In a recent computational analysis of long-term geoengineering, a team of climate scientists and ecologists modeled a situation in which we manipulate the climate through stratospheric injection of sulfur dioxide over a period of fifty years—and then stop abruptly. It's a scenario that might play out for any number of reasons, from the natural (a future burst of volcanic eruptions could lead us to think we no longer need to shield the planet artificially from solar radiation) to the geopolitical (the geoengineering system might be "hacked" by a rogue actor/state, or one or more countries experiencing differential impacts of geoengineering on their climate and economies might make a successful push to halt the practice).[19]

The researchers' results are worrisome, to say the least: they determined that rapid warming and global precipitation changes would ensue once the aerosol injections ceased, resulting in multiple times the current and projected rates of change in key biodiversity areas, or "hotspots." These conditions would overwhelm the capacity of most species and ecosystems to adapt, setting in motion a series of ecological disruptions and extinctions in the face of the new climate velocities. After decades of use, the planet's biota, in other words, would be "hooked" on geoengineering; its termination would result in a cascading series of ecological withdrawal effects. And these would likely be disastrous from a biodiversity protection point of view.

Effective conservation and responsible environmental behavior in the Anthropocene must acknowledge the real need for action, especially given the human hand in imperiling species and wildlands and in altering the climatic matrix in which these challenges run. But I believe this interventionist impulse should be checked when it poses a moral hazard by threatening to undermine concern for those environmental goods and relationships it is also our responsibility to maintain as a commitment both to wild nature for its own sake and to the intergenerational community of which we are just a part, albeit a part obliged to bequeath as broad and rich an ecological endowment as possible.[20]

What we need in this historical moment is to articulate and embrace an environmental ethic marked by solicitude for species and ecosystems that can accommodate significant and in some cases unprecedented human interventions in nature—and that will apply as well to those wild species and places we wish to shield from our more aggressive incursions. It will, no doubt, require a difficult balancing act. Not to mention constant vigilance. As Paddy Woodworth writes in *Our Once and Future*

Planet, his fine study of ecological restoration in a world defined more by change than by nostalgia for a lost past, as we try to manage our impulses both to preserve and transform, we need to resist those "siren calls of an engineering tradition that suggest we can turn nature into a designer shopping mall of human-orientated functions and services."[21]

The great challenge of environmental responsibility in the human age, then, is whether we can retain the sense of restraint

FIGURE 6.2 "If all were as it seems, and men made the elements their servants for noble ends!" (Henry David Thoreau).

Source: Public domain.

and moral regard for nature that we think of as being the best of the conservation tradition while at the same time being pragmatic and clear-eyed about the global impact of human activities and technologies—and the partial eclipse of venerable cultural ideals of wilderness and the autonomy of a natural world beyond our ken.

In the end, I believe one of the most troubling consequences of the Anthropocene may prove to be its implications for our environmental character, especially our respect for ecological distinctiveness and our ability to hold on to a sense of humility in the human age. At worst, de-extinction, geoengineering, and similar high-tech ventures to try to fix the grave environmental mistakes of the past and present could play a significant role in extinguishing the final flickering of the "fierce green fire" that Leopold wrote about so movingly in "Thinking Like a Mountain," his elegiac (and personal) account of wolf eradication in the American West.[22] Although it might no longer be tenable or desirable to argue for strict preservation in the Anthropocene, it is also not clear that we have yet developed an ecological ethic that can serve as a strong rejoinder to Thoreau's challenge about "noble ends" (figure 6.2).[23]

We might wonder what will encourage us to embrace such values—and their evocation of human limits in the face of nature—if we revive lost species, automate the wild, and turn back the sun.

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My ruminations on Denmark's Zootopia in chapter 3, "The Call of the Quasi Wild," derive from an article originally published in *Slate* ("The Real Zootopia") and from my chapter "The Parallax Zoo" in *The Ark and Beyond: The Evolution of Zoo and Aquarium Conservation*, ed. Ben A. Minteer, Jane Maienschein, and James P. Collins (Chicago: University of Chicago Press, 2018). Many of the ideas and arguments in chapter 5, "Promethean Dreams," originally appeared in "Is It Right to Reverse Extinction?" *Nature* 509 (2014): 261; in my essay "When Extinction Is a Virtue" in *After Preservation: Saving American Nature in the Age of Humans*, ed. Ben A. Minteer and Stephen J. Pyne (Chicago: University of Chicago Press, 2015); in *Slate* ("Extinct Species Should Stay Extinct"); and as part of the Center for Humans and Nature's series on de-extinction (https://www.humansandnature.org/conservation-extinction-ben-minteer#minteercontinued), including "The Perils of De-Extinction," which appeared in the center's journal, *Minding Nature* 8 (2015): 11–17. A very special thank you to the Center for Humans and Nature's Brooke Hecht, Bruce Jennings, Anja Claus, and Kate Cummings, for their vision and support, and to CHN, the Hastings Center, and the American Museum of Natural History's Center for Biodiversity and Conservation for cosponsoring the event on de-extinction and rewilding in New York City in the fall of 2014 that I discuss in chapter 1. The assessment of geoengineering in chapter 6, "Heaven and Earth," borrows from "Geoengineering and Ecological Ethics in the Anthropocene," *BioScience* 62 (2012): 857–58.

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NOTES

1. OUR VANISHING (AND REAPPEARING) WILDLIFE

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23. See, for example, the "Ecomodernist Manifesto" promulgated by the Breakthrough Institute at http://www.ecomodernism.org/ and its appraisal in Michelle Nijhuis, "Is the 'Ecomodernist Manifesto' the Future of Environmentalism?," *New Yorker*, June 2, 2015, https://www.newyorker.com/tech/elements/is-the-ecomodernist-manifesto-the-future-of-environmentalism.
24. Ben A. Minteer, *Refounding Environmental Ethics: Pragmatism, Principle, and Practice* (Philadelphia: Temple University Press, 2012). Philosophically, pragmatism is a theory of meaning, truth, and value that emphasizes the practical consequences of ideas, acknowledges the plurality of human values and ethical commitments (rather than attempting to settle on a single and universal notion of right and good), and that supports an experimental process of inquiry into *both* facts and values. One of the best and most engaging (i.e., readable) accounts of American pragmatism is Louis Menand's Pulitzer Prize–winning history *The Metaphysical Club: A Story of Ideas in America* (New York: Farrar, Straus and Giroux, 2001).
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26. As Dewey put it, "Humanity is not, as was once thought, the end for which all things were formed. It is but a slight and feeble thing, perhaps an episodic one, in the vast stretch of the universe." Although the pragmatists were anthropocentric in the sense that they focused primarily on the cares and concerns of human experience and viewed all values as human values in one way or another, they were not what philosophers would call "ontologically anthropocentric" given their acceptance (especially Dewey's) of a Darwinian account of humans as one species evolved among many. Dewey's remarks appear in *The Public and Its Problems* (1927), collected in *The Later Works of John Dewey, 1925–1953*, ed. Jo Ann Boydston (Carbondale: Southern Illinois University Press, 1984), 345.
27. "Threatened species" obviously also includes plants as well as animals. My focus in this book, however, is primarily on animal conservation, though of course this only captures a part of biodiversity of interest to conservationists. Plants and ecosystems—including both biotic and

abiotic features and processes—are obviously also important targets of study and conservation action.

2. A BIRD IN THE HAND

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21. Brian Kubicki, "Rediscovery of the Critically Endangered Frog, *Craugastor angelicus*, in Costa Rica," *Mesoamerican Herpetology* 3 (2016): 1070–71. I thank Robert Puschendorf for bringing this rediscovery to my attention.

22. Franck Courchamp et al. call this the "anthropogenic Allee effect," referencing a principle in population dynamics whereby small population densities lead to decreased individual reproduction and survival. In this case, the researchers argue, perceptions of the rarity of a species may elevate interest in collecting that species among both amateurs/commercial exploiters and scientific collectors. See Franck Courchamp et al., "Rarity Value and Species Extinction: The Anthropogenic Allee Effect," *PLOS Biology* 4 (2006): e415, https://doi.org/10.1371/journal.pbio.0040415. For an entertaining history of the collecting impulse, see Richard Conniff, *The Species Seekers: Heroes, Fools, and the Mad Pursuit of Life on Earth* (New York: Norton, 2011).
23. Ben A. Minteer et al., "Avoiding (Re)Extinction," *Science* 344 (2014): 260–61, doi:10.1126/science.1250953.
24. See L. A. Rocha et al. [123 authors], "Specimen Collection: An Essential Tool," *Science* 344 (2014): 814–15, doi:10.1126/science.344.6186.814. In the letter, the authors were also at pains to point out the value of specimens for all sorts of science, including future questions that we can't even anticipate. Our critique was focused, however, on the narrower instance of species identification and description in the case of new and rediscovered species. Although there is certainly a discussion to be had about the tradeoffs between the risks of collecting and the uses of specimens to understand a range of scientific questions, that was not the focus of our commentary. Rocha et al. also raised what we called (in our rebuttal) the "red herring" of individualism versus holism in the study of populations, a way to suggest that we were cryptically advancing what many scientists believe to be an emotional and anti-scientific animal rights–centered argument about the wrongness of killing an individual animal in the name of science. Again, although there are important discussions to be had on that score, the focus of our essay was clearly on the conservation concerns raised at the population and species level.
25. Nell Greenfieldboyce, "Is Collecting Animals for Science a Noble Mission or a Threat?" *National Public Radio*, June 18, 2014, http://www.npr.org/2014/06/18/318307574/is-collecting-animals-for-science-a-noble-mission-or-a-threat.
26. Ben A. Minteer, James P. Collins, and Robert Puschendorf, "Reply," *Science* 344 (2014): 816.

27. See, e.g., Christopher Kemp, *The Lost Species: Great Expeditions in the Collections of Natural History Museums* (Chicago: University of Chicago Press, 2017).
28. Timothy Y. James et al., "Disentangling Host, Pathogen, and Environmental Determinants of a Recently Emerged Wildlife Disease: Lessons from the First 15 Years of Amphibian Chytridiomycosis Research," *Ecology and Evolution* 5 (2015): 4079–97, doi:10.1002/ece3.1672.
29. See, e.g., Frank T. Krell and Quentin D. Wheeler, "Specimen Collection: Plan for the Future," *Science* 344 (2014): 815–16, doi:10.1126/science.344.6186.815.
30. Clemann et al., "Value and Impacts of Collecting." The authors do go on to say that collecting in these ecologically dire circumstances can provide data that may help recover the species in the future. This strikes me as among the weakest (and most disingenuous) of defenses of collecting, given the authors' desire to collect when they know the species is circling the drain. The motivating worry clearly seems to be that species will disappear before specimens can be procured.
31. I should mention that this particular argument for collecting in bleak ecological circumstances appeared in an article attempting to promote the "ethical" collection of voucher specimens, a rhetorical incongruity almost Orwellian in character.
32. Joseph Grinnell, "Conserve the Collector," *Science* 41 (1915): 229–32, doi:10.1126/science.41.1050.229. Grinnell also felt that "the present tendency toward extermination of the collector bears obvious close relationship to the increasing number of sentimentalists."
33. Grinnell, "Conserve the Collector," 230.
34. Grinnell, "Conserve the Collector," 230.
35. Stephen A. Marshall and Neal L. Evenhuis, "New Species Without Dead Bodies: A Case for Photo-Based Descriptions, Illustrated by a Striking New Species of *Marleyimyia* Hesse (Diptera, Bombyliidae) from South Africa," *ZooKeys* 525 (2015): 117–27, doi:10.3897/zookeys.525.6143.
36. This argument seems to me to be a very slippery slope: by opening the door to photo-only taxonomy in cases where a specimen escapes before collection takes place, the authors clearly affirm that digital collection

is in fact an acceptable means to document a new species (they do so even as they defend the traditional gold standard of the voucher specimen). Where they disagree is with my (and my original coauthors') point that collecting can have negative conservation impacts on the focal population, in some cases raising an extinction risk (especially when combined with other threats). As should be clear in my discussion in this chapter, I think that argument is wrong. Furthermore, if we can properly identify flies with photos, I think we can certainly identify birds, amphibians, reptiles, mammals, and so on, especially when photographic information is combined with molecular data and other materials that don't require whole-specimen collection. So the issue is again tossed back to whether there can be a biological risk collecting from small and vulnerable populations, especially absent a reliable population estimate (but reason to believe it is small). Simply put, I believe there can be.

37. See Dalton S. Amorim et al., "Timeless Standards for Species Delimitation," *Zootaxa* 4137 (2016): 121–28, doi:http://dx.doi.org/10.11646/zootaxa.4137.1.9; and Luis M. P. Ceríaco et al. and Jean-Pierre Hugot, "Photography-Based Taxonomy Is Inadequate, Unnecessary, and Potentially Harmful for Biological Sciences," *Zootaxa* 4196 (2016): 435–45, http://dx.doi.org/10.11646/zootaxa.4196.3.9. I thank my ASU colleague Nico Franz for bringing this exchange to my attention.
38. See Thomas Pape, "Species Can Be Named from Photos," *Nature* 537 (2016): 307, doi:10.1038/537307b; Charles Morphy D. Santos et al., "On Typeless Species and the Perils of Fast Taxonomy," *Systematic Entomology* 41 (2016): 511–15, doi:http://dx.doi.org/10.1111/syen.12180; and Giorgi Chaladze, "Taxonomy Should Be More Photography Based—Eliminate Need of Physical Specimen to Study Morphology," *Zootaxa* 4247 (2017): 331–31, doi:http://dx.doi.org/10.11646/zootaxa.4247.3.6.
39. See, for example, Brian T. Henen, "Do Scientific Collecting and Conservation Conflict?" *Herpetological Conservation and Biology* 11 (2016): 13–18.
40. Rachel Perez et al., "Field Surveys in Western Panama Indicate Populations of *Atelopus varius* Frogs Are Persisting in Regions Where *Batrachochytrium dendrobatidis* is now Enzootic," *Amphibian & Reptile Conservation* 8 (2014): 30–35, doi:http://hdl.handle.net/10088/22654.

41. Patrick O. Waeber et al., "On Specimen Killing in the Era of Conservation Crisis—A Quantitative Case for Modernizing Taxonomy and Biodiversity Inventories," *PLoS ONE* 12 (2017): e0183903, doi:10.1371/journal.pone.0183903.
42. David Lindenmayer and Ben Scheele, "Do Not Publish," *Science* 356 (2017): 800–1, doi:10.1126/science.aan1362.
43. See Ben A. Minteer and James P. Collins, "Ecological Ethics: Building a New Tool Kit for Ecologists and Biodiversity Managers," *Conservation Biology* 19 (2005): 1803–12, doi:10.1111/j.1523–1739.2005.00281.x; "Why We Need an Ecological Ethics," *Frontiers in Ecology and the Environment* 3 (2005): 332–37, doi:10.1890/1540-9295(2005)003[0332:WWNAEE]2.0.CO;2; and "From Environmental to Ecological Ethics: Toward a Practical Ethics for Ecologists and Conservationists," *Science and Engineering Ethics* 14 (2008): 83–501, doi:10.1007/s11948-008-9087-0.
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3. THE CALL OF THE QUASI WILD

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2. See Andrew C. Isenberg, *The Destruction of the Bison: An Environmental History, 1750–1920* (Cambridge: Cambridge University Press, 2000), and Mark V. Barrow Jr., *Nature's Ghosts: Confronting Extinction from the Age of Jefferson to the Age of Ecology* (Chicago: University of Chicago Press, 2009).
3. Vernon N. Kisling Jr., "Our Vanishing Wild Life Centennial and William T. Hornaday's Legacy," *International Zoo News* 60 (2013): 127–35. Bison in private herds in Texas, Oklahoma, and elsewhere persisted alongside the public herd remnants and were also important in the recovery of the species in the early twentieth century. See Barrow, *Nature's Ghosts*.

4. William Temple Hornaday, *The Extermination of the American Bison* (1889; Washington, DC: Smithsonian Institution Press, 2002); see also Mary Anne Andrei, "The Accidental Conservationist: William T. Hornaday, the Smithsonian Bison Expeditions, and the US National Zoo," *Endeavour* 29 (2005): 109–13, doi.org/10.1016/j.endeavour.2005.05.002.
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6. Andrei, "Smithsonian Bison," 110. Quote from Hornaday, *Extermination*, 529.
7. Barrow, *Nature's Ghosts*, 109.
8. Barrow, *Nature's Ghosts*, 113.
9. Douglas Brinkley, *The Wilderness Warrior: Theodore Roosevelt and the Crusade for America* (New York: Harper Collins, 2009); and Gregory J. Dehler, *The Most Defiant Devil: William Temple Hornaday and His Controversial Crusade to Save American Wildlife* (Charlottesville: University of Virginia Press, 2013).
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controversial decision that prompted another round of criticisms about the existence of zoos and the treatment of zoo animals. See, e.g., Bekoff, "Why Was Harambe."

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4. ELEPHANTS SOMEWHERE

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10. Jamie Lorimer et al., "Rewilding: Science, Practice, and Politics," *Annual Review of Environment and Resources* 40 (2015): 39–62, doi:10.1146/annurev-environ-102014-021406; Ross Anderson, "Welcome to Pleistocene Park," *Atlantic*, April, 2017, https://www.theatlantic.com/magazine/archive/2017/04/pleistocene-park/517779/; and Jens-Christian Svenning et al., "Science for a Wilder Anthropocene: Synthesis and Future Directions for Trophic Rewilding Research," *PNAS* 113 (2016): 898–906, http://www.pnas.org/content/113/4/898.
11. See, e.g., Dustin R. Rubenstein et al., "Pleistocene Park: Does Re-Wilding North America Represent Sound Conservation for the 21st Century?" *Biological Conservation* 132 (2006): 232–38, doi:10.1016/j.biocon.2006.04.003; and Tim Caro, "The Pleistocene Re-Wilding Gambit," *Trends in Ecology & Evolution* 22 (2007): 281–83, doi:https://doi.org/10.1016/j.tree.2007.03.001.
12. David Bowman, "Conservation: Bring Elephants to Australia?" *Nature* 482 (2012): 30, doi:10.1038/482030a.
13. Philip J. Seddon et al., "Reversing Defaunation: Restoring Species in a Changing World," *Science* 345 (2014): 406–12, doi:10.1126/science.1251818.
14. And also for some environmental philosophers who have taken up the issue. See, e.g., Ronald Sandler, "The Value of Species and the Ethical Foundations of Assisted Colonization," *Conservation Biology* 24 (2010): 424–31, doi:10.1111/j.1523-1739.2009.01351.x; and his fine book, *The Ethics of Species: An Introduction* (Cambridge: Cambridge University Press, 2012).

15. Richard Monastersky, "Life—a Status Report," *Nature* 516 (2014): 158–61, http://www.nature.com/news/biodiversity-life-a-status-report-1.16523.
16. National Audubon Society, *Audubon's Birds and Climate Change Report: A Primer for Practitioners*, version 1.3 (New York: National Audubon Society, 2015), http://climate.audubon.org/sites/default/files/NAS_EXTBIRD_V1.3_9.2.15%20lb.pdf.
17. Douglas J. McCauley et al., "Marine Defaunation: Animal Loss in the Global Ocean," *Science* 347 (2015): 6219, doi:10.1126/science.1255641.
18. S. L. Pimm et al., "The Biodiversity of Species and Their Rates of Extinction, Distribution, and Protection," *Science* 344 (2014): 1246752, doi:10.1126/science.1246752.
19. See, e.g., Elizabeth Kolbert, *The Sixth Extinction: An Unnatural History* (New York: Henry Holt, 2014); and Gerardo Ceballos et al., "Accelerated Modern Human–Induced Species Losses: Entering the Sixth Mass Extinction," *Science Advances* 1 (2015): e1400253, doi:10.1126/sciadv.1400253. Not everyone in the biodiversity science and conservation community is convinced, however, that we are in the middle of a mass-extinction episode. Among the notable skeptics include the futurist/environmentalist Stewart Brand and Doug Erwin, a paleontologist at the American Museum of Natural History. Stewart Brand, "Rethinking Extinction," *Aeon*, April 21, 2015, https://aeon.co/essays/we-are-not-edging-up-to-a-mass-extinction; Peter Brannen, "Earth Is Not in the Midst of a Sixth Mass Extinction," *Atlantic*, June 13, 2017, https://www.theatlantic.com/science/archive/2017/06/the-ends-of-the-world/529545/.
20. Rodolfo Dirzo et al., "Defaunation in the Anthropocene," *Science* 345 (2014): 401–6, doi:10.1126/science.1251817; and Gerardo Ceballos, Paul R. Ehrlich, and Rodolfo Dirzo, "Biological Annihilation Via the Ongoing Sixth Mass Extinction Signaled by Vertebrate Population Losses and Declines," *PNAS* 114 (2017): E6089–E6096, doi:10.1073/pnas.1704949114.
21. WWF, *Living Planet Report 2016. Risk and Resilience in a New Era* (Gland, Switzerland: WWF International, 2016), http://wwf.panda.org/about_our_earth/all_publications/lpr_2016/.
22. See Pimm et al., "Biodiversity of Species"; and David Tilman et al., "Future Threats to Biodiversity and Pathways to Their Prevention," *Nature* 546 (2017): 73–81, doi:doi:10.1038/nature22900.

23. One of the earliest and most influential assessments of the threat climate changes poses to biodiversity is Chris D. Thomas et al., "Extinction Risk from Climate Change," *Nature* 427: 145–48, doi:10.1038/nature02121. The study was later revisited and refined in the collection *Saving a Million Species*, ed. Lee Hannah (Washington, DC: Island Press, 2012). See also Ilya M. D. Maclean and Robert J. Wilson, "Recent Ecological Responses to Climate Change Support Predictions of High Extinction Risk," *PNAS* 108 (2011): 12337–342, doi:10.1073/pnas.1017352108; and Mark C. Urban, "Accelerating Extinction Risk from Climate Change," *Science* 348 (2015): 571–73, doi:10.1126/science.aaa4984.
24. Terry L. Root et al., "Fingerprints of Global Warming on Wild Animals and Plants," *Nature* 421 (2003): 57–60; Anthony D. Barnosky, *Heatstroke: Nature in an Age of Global Warming* (Washington, DC: Shearwater/Island Press, 2009); Stanley W. Burgiel and Adrianna A. Muir, *Invasive Species, Climate Change and Ecosystem-Based Adaptation: Addressing Multiple Drivers of Global Change* (Washington, DC, and Nairobi, Kenya: Global Invasive Species Programme, 2010); and Sonia Altizer et al., "Climate Change and Infectious Diseases: From Evidence to a Predictive Framework," *Science* 341 (2013): 514–19, doi:10.1126/science.1239401.
25. Marlee A. Tucker et al., "Moving in the Anthropocene: Global Reductions in Terrestrial Mammalian Movements," *Science* 359 (2018): 466–69; doi:10.1126/science.aam9712.
26. Jason S. Mclachlan, Jessica J. Hellmann, and Mark W. Schwartz, "A Framework for Debate of Assisted Migration in an Era of Climate Change," *Conservation Biology* 21 (2007): 297–302, doi:10.1111/j.1523–1739.2007.00676.x; O. Hoegh-Guldberg et al., "Assisted Colonization and Rapid Climate Change," *Science* 321 (2008): 345–46, doi:10.1126/science.1157897; and Seddon et al., "Reversing Defaunation."
27. Stephen G. Willis et al., "Assisted Colonization in a Changing Climate: A Test-Study Using Two UK Butterflies," *Conservation Letters* 2 (2009): 46–52, doi:10.1111/j.1755-263X.2008.00043. See also Emma Marris, *Rambunctious Garden: Saving Nature in a Post-Wild World* (New York: Bloomsbury, 2011), esp. chap. 5; and Brichieri-Colombi and Moehrenschlager, "Alignment of Threat."
28. See, e.g., Alejandro E. Camacho et al., "Reassessing Conservation Goals in a Changing Climate," *Issues in Science and Technology* 26 (2010):

21–26, http://issues.org/26-4/p_camacho/; Chris D. Thomas, "Translocation of Species, Climate Change, and the End of Trying to Recreate Past Ecological Communities," *Trends in Ecology and Evolution* 26 (2011): 216–21, doi:10.1016/j.tree.2011.02.006; and Seddon et al., "Reversing Defaunation."

29. Ben A. Minteer and James P. Collins, "Move It or Lose It? The Ecological Ethics of Relocating Species Under Climate Change," *Ecological Applications* 20 (2010): 1801–4, doi:10.1890/10–0318.1.
30. See especially the series of critiques of assisted colonization (and other "conservation introductions") put forward by the biologists Anthony Ricciardi and Daniel Simberloff, including "Assisted Colonization Is Not a Viable Conservation Strategy," *Trends in Ecology & Evolution* 24 (2009): 248–53, doi:10.1016/j.tree.2008.12.006; "Assisted Colonization: Good Intentions and Dubious Risk Assessment," *Trends in Ecology & Evolution* 24 (2009): 476–77, doi:10.1016/j.tree.2009.05.005; and "Fauna in Decline: First Do No Harm," *Science* 345 (2014): 884, doi:10.1126/science.345.6199.884-b. See also Bruce L. Webber, John K. Scott, and Raphael K. Didham, "Translocation or Bust! A New Acclimatization Agenda for the 21st Century?" *Trends in Ecology & Evolution* 26 (2011): 495–96, doi:10.1016/j.tree.2011.06.007.
31. Danwei Huang, "Assisted Colonization Won't Help Rare Species," *Science* 322 (2008): 1049, doi:10.1126/science.322.5904.1049a. See also Ben A. Minteer and James P. Collins, "Species Conservation, Rapid Environmental Change, and Ecological Ethics," *Nature Education Knowledge* 3, no. 14 (2012), https://www.nature.com/scitable/knowledge/library/species-conservation-rapid-environmental-change-and-ecological-67648942.
32. Hoegh-Guldberg et al., "Assisted Colonization and Rapid Climate Change"; Mark W. Schwartz et al., "Managed Relocation: Integrating the Scientific, Regulatory, and Ethical Challenges," *BioScience* 62 (2012): 732–43, https://doi.org/10.1525/bio.2012.62.8.6; see also David M. Richardson et al., "Multidimensional Evaluation of Managed Relocation," *PNAS* 106 (2009): 9721–24, doi:10.1073/pnas.0902327106. In 2013 the IUCN also published its own guidelines for decision making involving assisted colonization and other conservation translocations.

See IUCN/SSC, *Guidelines for Reintroductions and Other Conservation Translocations*, version 1.0 (Gland, Switzerland: IUCN Species Survival Commission, 2013), https://www.iucn.org/content/new-guidelines-conservation-translocations-published-iucn.

33. IUCN/SSC, "Guidelines for Reintroductions."
34. Elisabeth Long and Eric Biber, "The Wilderness Act and Climate Change Adaptation," *Environmental Law* 44 (2014): 623–94, http://scholarship.law.berkeley.edu/facpubs/2390/.
35. The classic review of the concept of moral hazard is Tom Baker, "On the Genealogy of Moral Hazard," *Texas Law Review* 75 (1996): 237–92.
36. See Schwartz et al., "Managed Relocation." The working group was formed and led by Jessica Hellmann, Jason McLachlan, Dov Sax, and Mark Schwartz. Dale Jamieson and Jay Odenbaugh joined me in assessing the ethical dimensions of the proposal.
37. Examples of this thinking include Ted Nordhaus and Michael Shellenberger, *Break Through: Why We Can't Leave Saving the Planet to Environmentalists* (New York: Mariner, 2009); Peter Kareiva, Michelle Marvier, and Robert Lalasz, "Conservation in the Anthropocene: Beyond Solitude and Fragility," *Breakthrough Journal*, Winter 2012, https://thebreakthrough.org/index.php/journal/past-issues/issue-2/conservation-in-the-anthropocene/; and Erle C. Ellis, "Too Big for Nature," in *After Preservation: Saving American Nature in the Age of Humans*, ed. Ben A. Minteer and Stephen J. Pyne (Chicago: University of Chicago Press, 2015).
38. For example, American wildlife scientists debated many of the same questions about the implications of translocating (or "transplanting," as they termed it) species as far back as the 1960s, in the run-up to the Endangered Species Act. See Johnny Winston, Ben A. Minteer, and James P. Collins, "Old Wine, New Bottles? Using History to Inform the Assisted Colonization Debate," *Oryx* 48 (2014): 186–94, https://doi.org/10.1017/S0030605312001500.
39. Wallace Stegner, "The Legacy of Aldo Leopold," in *Companion to* A Sand County Almanac, ed. J. Baird Callicott (Madison: University of Wisconsin Press, 1987), 233.
40. Curt Meine's pioneering biography on Leopold is still the most comprehensive and insightful volume on the great author of *A Sand County*

Almanac. Curt Meine, *Aldo Leopold: His Life and Work*, rev. ed. (Madison: University of Wisconsin Press, 2010). But see also the excellent book by Julianne Lutz Warren, *Aldo Leopold's Odyssey: Rediscovering the Author of* A Sand County Almanac (Washington, DC: Island Press/Shearwater, 2006). For a sampling of Leopold's influence across the disciplines and conservation professions, see Curt Meine and Richard L. Knight, ed., *The Essential Aldo Leopold: Quotations and Commentaries* (Madison: University of Wisconsin Press, 1999); and Richard L. Knight and Susanne Riedel, eds., *Aldo Leopold and the Ecological Conscience* (New York: Oxford University Press, 2002).

41. I discuss Leopold and his influence on environmental ethics in greater detail in my book *The Landscape of Reform: Civic Pragmatism and Environmental Thought in America* (Cambridge, MA: MIT Press, 2006). See also J. Baird Callicott, *In Defense of the Land Ethic: Essays in Environmental Philosophy* (Albany: SUNY Press, 1989); Bryan G. Norton, *Toward Unity Among Environmentalists* (New York: Oxford University Press, 1991); and Bryan G. Norton, *Sustainability: A Philosophy of Adaptive Ecosystem Management* (Chicago: University of Chicago Press, 2005).
42. Marris, *Rambunctious Garden*.
43. Aldo Leopold: *A Sand County Almanac and Other Writings on Ecology and Conservation*, ed. Curt Meine (New York: Library of America, 2013), 188. For an alternative reading of Leopold's environmental philosophy, see Bryan G. Norton, *Sustainability: A Philosophy of Adaptive Ecosystem Management* (Chicago: University of Chicago Press, 2005).
44. I take up this challenge in more detail in Ben A. Minteer, *Refounding Environmental Ethics: Pragmatism, Principle, and Practice* (Philadelphia: Temple University Press, 2012).
45. For more on novel ecosystems and their implications for conservation, see Richard J. Hobbs, Eric S. Higgs, and Carol M. Hall, eds., *Novel Ecosystems: Intervening in the New Ecological World Order* (West Sussex: John Wiley & Sons, 2013); and Curt Meine, "Restoration and 'Novel Ecosystems': Priority or Paradox?" *Annals of the Missouri Botanical Garden* 102 (2017): 217–26, https://doi.org/10.3417/2016037.
46. Meine and Knight, *The Essential Aldo Leopold*, 131.
47. Leopold, *A Sand County Almanac and Other Writings*, 97.
48. Leopold, *A Sand County Almanac and Other Writings*, 120–121.

49. Meine and Knight, *The Essential Aldo Leopold*, 141–142.
50. Leopold, *A Sand County Almanac and Other Writings*, 289.
51. Aldo Leopold, *Game Management* (Madison: University of Wisconsin Press, 1933), 405.
52. Aldo Leopold, *The River of the Mother of God and Other Essays*, ed. Susan L. Flader and J. Baird Callicott (Madison: University of Wisconsin Press, 1991), 190 (emphasis added).
53. Leopold, *A Sand County Almanac and Other Writings*, 492.
54. Ricciardi and Simberloff, "Assisted Colonization Is Not a Viable Conservation Strategy."
55. Daniel Simberloff, "Integrity, Stability, and Beauty: Aldo Leopold's Evolving View of Nonnative Species," *Environmental History* 17 (2012): 487–511, doi:10.1093/envhis/ems044.
56. Flader and Callicott, *River of the Mother of God*, 309.
57. Warren, *Aldo Leopold's Odyssey*, 267.
58. William R. Jordan and George M. Lubick, *Making Nature Whole: A History of Ecological Restoration* (Washington, DC: Island Press, 2011), 91.
59. Flader and Callicott, *River of the Mother of God*, 310 (emphasis added).
60. Simberloff, "Integrity, Stability, and Beauty," 504.
61. See, e.g., Mark A. Davis et al., "Don't Judge Species on Their Origins," *Nature* 474 (2011): 153–54, doi:10.1038/474153a. The science journalist Fred Pearce documents this shift toward a more positive view of nonnative species—and pushes it into even bolder territory—in his book *The New Wild: Why Invasive Species Will Be Nature's Salvation* (Boston: Beacon, 2015).
62. Harry W. Green, "Rewilding the Lifeboats," in *The Ark and Beyond: The Evolution of Zoo and Aquarium Conservation*, ed. Ben A. Minteer, Jane Maienschein, and James P. Collins (Chicago: University of Chicago Press, 2018).
63. Even though Pleistocene rewilding sets its clock much earlier than conventional reintroduction and restoration proposals, its advocates routinely evoke the goal of species conservation (e.g., expanding the range of a vulnerable species by translocation) alongside a desire to restore the ecological and evolutionary forces operant before the megafauna extinctions of the late Pleistocene. See, e.g., Donlan et al., "Rewilding North America"; and Greene, "Rewilding Our Lives." Pleistocene rewilding is the most well-known (and controversial) ecological replacement

proposal; however, as it has evolved its proponents (including some of its original authors) have also elaborated parallel modes of ecological replacement, such as "trophic rewilding," that do not necessarily entail a Pleistocene timeframe. See, e.g., Svenning et al., "Science for a Wilder Anthropocene." Longtime critics of Pleistocene rewilding, however, remain dismissive. See Dustin R. Rubenstein and Daniel I. Rubenstein, "From Pleistocene to Trophic Rewilding: A Wolf in Sheep's Clothing," *PNAS* 113 (2016): E1, doi:10.1073/pnas.1521757113.

64. Flader and Callicott, *River of the Mother of God*, 270.
65. Leopold, *A Sand County Almanac and Other Writings*, 168.
66. Leopold, *A Sand County Almanac and Other Writings*, 188. Curt Meine, the premier Leopold scholar and conservation historian, has stressed this aspect of Leopold's thought in some of his public lectures on Leopold's life and legacy. I thank him for bringing it to my attention.

5. PROMETHEAN DREAMS

1. David Owen, *Tasmanian Tiger: The Tragic Tale of How the World Lost Its Most Mysterious Predator* (Baltimore, MD: Johns Hopkins University Press, 2004), 9.
2. See the description of thylacine biology and behavior compiled by the online "Thylacine Museum," which has become a valuable repository of information about the species: http://www.naturalworlds.org/thylacine/index.htm.
3. Lauren C. White, Kieren J. Mitchell, and Jeremy J. Austin, "Ancient Mitochondrial Genomes Reveal the Demographic History and Phylogeography of the Extinct, Enigmatic Thylacine (*Thylacinus cynocephalus*)," *Journal of Biogeography* (2017), doi:10.1111/jbi.13101 (online publication in advance of print).
4. Carol Freeman, *Paper Tiger: How Pictures Shaped the Thylacine* (Hobart, Tasmania: Forty South, 2014), 5.
5. Owen, *Tasmanian Tiger*, 74.
6. Robert Paddle, *The Last Tasmanian Tiger: The History and Extinction of the Thylacine* (Cambridge: Cambridge University Press, 2000), 129.
7. Frank J. Sulloway, "Darwin and His Finches: The Evolution of a Legend," *Journal of the History of Biology* 15 (1982): 1–53, https://doi.org/10.1007/BF00132004.

8. Quoted in Paddle, *Last Tasmanian Tiger*, 223. See also Sarah Broadhurst, "The Last Thylacine," Zoological Society of London website: https://www.zsl.org/blogs/artefact-of-the-month/the-last-thylacine; and Owen, *Tasmanian Tiger*.
9. The record indicates that thylacines were bred successfully only once, at the Melbourne Zoo in 1899. See the discussion at http://www.naturalworlds.org/thylacine/biology/reproduction/reproduction_8.htm; and also Paddle, *Last Tasmanian Tiger*.
10. William T. Hornaday, *Our Vanishing Wild Life*: *Its Extermination and Preservation* (New York: New York Zoological Society, 1913), 39.
11. Owen, *Tasmanian Tiger*.
12. Paddle, *Last Tasmanian Tiger*, 184.
13. See Carl Zimmer, "Bringing Them Back to Life," *National Geographic*, April 2013, http://ngm.nationalgeographic.com/2013/04/125-species-revival/zimmer-text; Jacob S. Sherkow and Henry T. Greely, "What If Extinction Is Not Forever?" *Science* 340 (2013): 32–33, doi:10.1126/science.1236965; and Beth Shapiro, *How to Clone a Mammoth: The Science of De-Extinction* (Princeton, NJ: Princeton University Press, 2015). Two books exploring de-extinction from the vantage point of its boosters (and to a lesser extent its critics) are Helen Pilcher's engaging and quirky *Bring Back the King: The New Science of De-Extinction* (London: Bloomsbury, 2016); and Britt Wray's *Rise of the Necrofauna: The Science, Ethics, and Risks of De-Extinction* (Vancouver: Greystone, 2017).
14. For a good, succinct overview of the various methods that travel under the de-extinction banner, see Beth Shapiro, "Pathways to De-Extinction: How Close Can We Get to Resurrection of an Extinct Species?" *Functional Ecology* 31 (2017): 996–1002, doi:10.1111/1365-2435.12705.
15. Kai Kupferschmidt, "Can Cloning Revive Spain's Extinct Mountain Goat?" *Science* 344 (2014): 137–38, doi:10.1126/science.344.6180.137.
16. The use of these new genome editing/engineering techniques, such as CRISPR/Cas9 (Clustered Regularly Interspaced Short Palindromic Repeats), is not confined to the attempted revival of extinct wild species. It's opened the floodgates to a number of possibilities, from eradicating pest species like the mosquito (via a technique referred to as "gene drives") to therapeutic uses in human medicine. A lively debate about these new genetic technologies and techniques, including their risks in the environmental context, has ensued. See especially,

Kenneth A. Oye et al., "Regulating Gene Drives," *Science* 345 (2014): 626–28, doi:10.1126/science.1254287; National Academies of Sciences, Engineering, and Medicine, *Gene Drives on the Horizon: Advancing Science, Navigating Uncertainty, and Aligning Research with Public Values* (Washington, DC: National Academies Press, 2016), doi:10.17226/23405; Gregory E. Kaebnick et al., "Precaution and Governance of Emerging Technologies," *Science* 354 (2016): 710–11, doi:10.1126/science.aah5125; and Carl Zimmer, "'Gene Drives' Are Too Risky for Field Trials, Scientists Say," *New York Times*, November 16, 2017, https://www.nytimes.com/2017/11/16/science/gene-drives-crispr.html.

17. The Harvard geneticist George Church has spearheaded the project to create a proxy for the woolly mammoth that could be "designed" as a cold-adapted species. See Sarah Kaplan, "'De-extinction' of the Woolly Mammoth: A Step Closer," *Washington Post*, April 24, 2015, https://www.washingtonpost.com/news/morning-mix/wp/2015/04/24/de-extinction-and-the-wooly-mammoth-genome; and Britt Wray, *Rise of the Necrofauna*. Given its science-fiction resonances and Michael Crichton–esque trappings, it's not surprising that de-extinction and Church's work in particular have also recently been quasi fictionalized as a scientific thriller. See Ben Mazrich's *Woolly: The True Story of the Quest to Revive One of History's Most Iconic Extinct Creatures* (New York: Atria, 2017).
18. See, e.g., Philip J. Seddon, Axel Moehrenschlager, and John Ewen, "Reintroducing Resurrected Species: Selecting DeExtinction Candidates," *Trends in Ecology and Evolution* 29 (2014): 140–47, doi:10.1016/j.tree.2014.01.007.
19. Ross Anderson, "Welcome to Pleistocene Park," *Atlantic*, April 2017, https://www.theatlantic.com/magazine/archive/2017/04/pleistocene-park/517779/.
20. Sherkow and Greely, "What If Extinction Is Not Forever?"
21. Aldo Leopold, *A Sand County Almanac and Other Writings on Ecology and Conservation*, ed. Curt Meine (New York: Library of America, 2013), 97.
22. See, e.g., Stewart Brand, "The Case for De-extinction: Why We Should Bring Back the Woolly Mammoth," *Yale Environment 360*, January 13, 2014, http://e360.yale.edu/features/the_case_for_de-extinction_why_we_should_bring_back_the_woolly_mammoth.

23. The passenger pigeon is "patient zero" for de-extinction, but the list of candidate species has been growing and recently has expanded to include the great auk. See, e.g., Henry Bodkin, "Plot Hatched to Reintroduce Extinct Great Auk to British Shores," *Telegraph*, August 19, 2016, http://www.telegraph.co.uk/science/2016/08/19/plot-hatched-to-reintroduce-extinct-great-auk-to-british-shores/.
24. See, e.g., Seddon et al., "Reintroducing Resurrected Species." Earlier attempts to clone a thylacine seem to have been resurrected with the recent development of advanced genetic technologies. Leading the charge is Michael Archer, an Australian paleontologist, and his "Lazarus Project," which he describes in a 2013 TED Talk: https://www.ted.com/talks/michael_archer_how_we_ll_resurrect_the_gastric_brooding_frog_the_tasmanian_tiger.
25. E.g., Stuart Pimm, "Opinion: The Case Against Species Revival," *National Geographic*, March 12, 2013, https://news.nationalgeographic.com/news/2013/03/130312--deextinction-conservation-animals-science-extinction-biodiversity-habitat-environment/; and Paul R. Ehrlich, "The Case Against De-extinction: It's a Fascinating but Dumb Idea," *Yale Environment 360*, January 13, 2014, http://e360.yale.edu/features/thyalee_case_against_de-extinction_its_a_fascinating_but_dumb_idea.
26. Joseph R. Bennett et al., "Spending Limited Resources on De-extinction Could Lead to Net Biodiversity Loss," *Nature Ecology and Evolution* 1 (2017): 0053, doi:10.1038/s41559-016-0053.
27. John James Audubon, *Ornithological Biography* (1831–39), collected in *John James Audubon: Writings and Drawings* (New York: Library of America, 1999), 266.
28. Alexander Wilson, *American Ornithology; or, The Natural History of the Birds in the United States* (New York: Collins & Co., 1829), 8.
29. Immanuel Kant, *Critique of Judgment*, rev. ed. (1790; New York: Oxford University Press, 2009), 94.
30. Leo Marx, *The Machine in the Garden: Technology and the Pastoral Ideal in America* (New York: Oxford University Press, 1964).
31. Nathaniel Horwitz, "Heath Hen's Boom Could Echo Again on Martha's Vineyard," *MV Times*, July 16, 2014, http://www.mvtimes.com/2014/07/16/heath-hens-boom-echo-marthas-vineyard/. See also the

heath hen project page at Revive and Restore: http://reviverestore.org/projects/heath-hen-project/.

32. Leopold's words appear in his essay "Engineering and Conservation," in Leopold, *A Sand County Almanac*, 410.
33. Brand, "The Case for De-extinction."
34. And conservation has of course never been a one-dimensional story of destruction, loss, and guilt. It has always contained a more positive and counterbalancing tradition of restoration, recovery, adaptation, and ethical advance—a more hopeful narrative distinct, it should be emphasized, from the extreme techno-optimism of many de-extinction advocates and technologists in the environmental movement. I thank Curt Meine for drawing my attention to this important point.
35. Leopold's remark appears in his essay "On a Monument to the Pigeon," in Leopold, *A Sand County Almanac*, 97.
36. Nathaniel Rich, "The Mammoth Cometh," *New York Times Magazine*, February 27, 2014, http://www.nytimes.com/2014/03/02/magazine/the-mammoth-cometh.html.
37. As Dewey reminded us in his 1934 book *A Common Faith*, "Our successes are dependent on the cooperation of nature." In *John Dewey: The Later Works, 1925–1953*, ed. Jo Ann Boydston (Carbondale: Southern Illinois University Press, 1986), 9:18. I discuss this more circumspect and restrained version of philosophical pragmatism more fully in my book *Refounding Environmental Ethics: Pragmatism, Principle, and Practice* (Philadelphia: Temple University Press, 2012).
38. L. Cooper and A. Cooper, "Using Ancient DNA to Understand Evolutionary and Ecological Processes," *Annual Review of Ecology, Evolution, and Systematics* 45 (2014): 573–98; and Duane Froese et al., "Fossil and Genomic Evidence Constrains the Timing of Bison Arrival in North America," *PNAS* 114 (2017): 3457–62, doi:10.1073/pnas.1620754114.
39. See National Academies, *Gene Drives on the Horizon*; and Antoinette J. Piaggio et al., "Is It Time for Synthetic Biodiversity Conservation?" *Trends in Ecology & Evolution* 32 (2017): 97–107, doi:10.1016/j.tree.2016.10.016.
40. Especially since the risks appear to overwhelm de-extinction's spurious conservation credentials. See, e.g., Ronald Sandler, "The Ethics of

Reviving Long Extinct Species," *Conservation Biology* 28 (2014): 354–60, doi:10.1111/cobi.12198.

41. Ben A. Minteer and James P. Collins, "Species Conservation, Rapid Environmental Change, and Ecological Ethics," *Nature Education Knowledge* 3, no. 10 (2012), http://www.nature.com/scitable/knowledge/library/species-conservation-rapid-environmental-change-and-ecological-67648942.
42. The "horse has already left the barn" attitude toward de-extinction seems pretty common in the scientific commentary. See, e.g., Sherkow and Greely, "What If Extinction Is Not Forever?"; Seddon et al., "Reintroducing Resurrected Species"; and Philip J. Seddon, "The Ecology of De-extinction," *Functional Ecology* 31 (2017): 992–95, doi:10.1111/1365–2435.12856. Interestingly, Seddon has also coauthored a paper arguing that the financial cost of de-extinction may result in the long-term loss of biodiversity (see Bennett et al., "Spending Limited Resources on De-extinction"), leaving one to wonder how you can be both an enthusiastic supporter of its development for conservation purposes and a critic of its predicted outcomes for species protection.
43. IUCN SSC, *IUCN SSC Guiding Principles on Creating Proxies of Extinct Species for Conservation Benefit*, version 1.0 (Gland, Switzerland: IUCN Species Survival Commission, 2016), https://portals.iucn.org/library/node/46248.
44. See the special report edited by Gregory E. Kaebnick and Bruce Jennings, "Recreating the Wild: De-extinction, Technology, and the Ethics of Conservation," *Hastings Center Report* 47 (2017), http://onlinelibrary.wiley.com/doi/10.1002/hast.2017.47.issue-S2/issuetoc.
45. See also Curt Meine, "De-extinction and the Community of Being," *Hastings Center Report* 47 (2017): 9–17, http://onlinelibrary.wiley.com/doi/10.1002/hast.2017.47.issue-S2/issuetoc.
46. Henry David Thoreau, *Walden*, in *Henry David Thoreau: A Week on the Concord and Merrimack Rivers/Walden; or, Life in the Woods/The Maine Woods/Cape Cod* (New York: Library of America, 1985), 575.
47. See, e.g., Elle Hunt, "'Sightings' of Extinct Tasmanian Tiger Prompt Search in Queensland," *Guardian*, March 27, 2017, https://www.theguardian.com/environment/2017/mar/28/tasmanian-tiger-sighting-search-thylacine-queensland-australia.

6. HEAVEN AND EARTH

1. See, e.g., Diane Ackerman, *The Human Age: The World Shaped by Us* (New York: Norton, 2014); and David Biello, *The Unnatural World: The Race to Remake Civilization in Earth's Newest Age* (New York: Scribner, 2016).
2. These trends are described in Nigel Dudley, *Authenticity in Nature: Making Choices About the Naturalness of Ecosystems* (Oxford: Earthscan, 2011); Emma Marris, *Rambunctious Garden: Saving Nature in a Post-Wild World* (New York: Bloomsbury, 2011); and Fred Pearce, *The New Wild: Why Invasive Species Will Be Nature's Salvation* (Boston: Beacon, 2015).
3. Thoreau's complaint about the railroad whistle appears in the chapter "Sounds" in *Walden* (1854). See *Henry David Thoreau: A Week on the Concord and Merrimack Rivers/Walden; or, Life in the Woods/The Maine Woods/Cape Cod* (New York: Library of America, 1985), 414.
4. See Leopold's essay, "Marshland Elegy," in *A Sand County Almanac* (1949), collected in *A Sand County Almanac and Other Writings on Ecology and Conservation*, ed. Curt Meine (New York: Library of America, 2013). Leopold, of course, was far from an antiagrarian. He wrote extensively about the close and balanced relationship to the land offered by farming, though he had in mind a mode of agriculture that was governed by a concern for land health, wildness, and wider conservation values, not by an engineering mentality focused solely on commodity production. See his "The Farmer as a Conservationist" and other essays collected in *For the Health of the Land*, ed. J. Baird Callicott and Eric T. Freyfogle (Washington, DC: Island Press, 1999).
5. Rachel Carson, *Silent Spring* (1962; New York: Houghton Mifflin, 2002).
6. Aldo Leopold, "The Land Ethic," in *A Sand County Almanac*, 188.
7. The Anthropocene idea was brought to the masses (relatively speaking) in 2002 when Paul J. Crutzen published his essay "Geology of Mankind," *Nature* 415, doi:doi:10.1038/415023a. Scores of papers advancing the concept have appeared over the past dozen or so years, including Will Steffen, Paul J. Crutzen, and John R. McNeill, "The Anthropocene: Are Humans Now Overwhelming the Great Forces of Nature?" *Ambio* 36 (2007): 614–21, http://www.jstor.org/stable/25547826;

and Simon L. Lewis and Mark A. Maslin, "Defining the Anthropocene," *Nature* 519 (2015): 171–80, doi:10.1038/nature14258. For a discussion of the implications of the Anthropocene construct for nature preservation, see the essays collected in *After Preservation: Saving American Nature in the Age of Humans*, ed. Ben A. Minteer and Stephen J. Pyne (Chicago: University of Chicago Press, 2015).

8. See, e.g., George Wuerthner, Eileen Crist, and Tom Butler, eds., *Keeping the Wild: Against the Domestication of Nature* (Washington, DC: Island Press, 2014); and Minteer and Pyne, *After Preservation*. One of the most cutting critiques of the Anthropocene idea from within the preservationist community comes from the writer and activist Dave Foreman. Confronting the "Anthropoceniacs," Foreman asks: "Where is the grief? Where is the shame? Where is the passion to save what's left? Where is the outrage? Where is the sadness for the loss of so many of our neighbors?" Dave Foreman, "The Anthropocene and Ozymandias," in *After Preservation*, 55.
9. Mark Lynas, *The God Species: Saving the Planet in the Age of Humans* (Washington, DC: National Geographic, 2011); David Grinspoon, *Earth in Human Hands: Shaping Our Planet's Future* (New York: Grand Central, 2016); and David Biello, *The Unnatural World*.
10. Ackerman, *The Human Age*, 13. The notion of a "good" Anthropocene has been advanced by a number of academics and writers in the media, including the landscape ecologist Erle Ellis, who put it this way: "A good, or at least a better, Anthropocene is within our grasp. Creating that future will mean going beyond fears of transgressing natural limits and nostalgic hopes of returning to some pastoral or pristine era. Most of all, we must not see the Anthropocene as a crisis, but as the beginning of a new geological epoch ripe with human-directed opportunity." Erle Ellis, "The Planet of No Return," *Breakthrough Journal*, Winter 2012, http://breakthroughjournal.org/content/authors/erle-ellis/the-planet-of-no-return.shtml. See also the relevant discussions and links on Andy Revkin's *Dot Earth* blog for the *New York Times*, including "Exploring Academia's Role in Charting Paths to a 'Good' Anthropocene," https://dotearth.blogs.nytimes.com/2014/06/16/exploring-academias-role-in-charting-paths-to-a-good-anthropocene/.

11. Chris D. Thomas, *Inheritors of the Earth: How Nature Is Thriving in the Age of Extinction* (New York: Public Affairs, 2017).
12. R. Alexander Pyron, "We Don't Need to Save Endangered Species. Extinction Is Part of Evolution," *Washington Post*, November 22, 2017, https://www.washingtonpost.com/outlook/we-dont-need-to-save-endangered-species-extinction-is-part-of-evolution/2017/11/21/57fc5658-cdb4-11e7-a1a3-0d1e45a6de3d_story.html. Apparently, Pyron attempted to walk back his editorial shortly after it was published. See his mea culpa at http://www.colubroid.org/. The backpedaling, at least on my reading, seems to be explained more by how his op-ed was received by his academic peers than by any change of heart. He also claims to have been misquoted in the editorial's headline, even though it reflects the general thrust of his arguments in the piece. It's a reminder that, as authors, we—rather than our colleagues or anyone else—are ultimately responsible for what we put our names on.
13. See Bradley Cantrell, Laura J. Martin, and Erle C. Ellis, "Designing Autonomy: Opportunities for New Wildness in the Anthropocene," *Trends in Ecology and Evolution* 32 (2017): 156–66, doi:10.1016/j.tree.2016.12.004; and Ed Yong, "Artificial Intelligence: The Park Rangers of the Anthropocene," *Atlantic*, March 24, 2017, https://www.theatlantic.com/science/archive/2017/03/artificial-intelligence-the-park-rangers-of-the-anthropocene/520713/. When I first read this proposal, I'll confess that I thought immediately of the 1972 cult sci-fi film *Silent Running*, in which robotic drones tended Earth's surviving ecosystems on postapocalyptic space "arks." Not surprisingly, the venture didn't fare too well, though in this case the humans (especially the character played by Bruce Dern), rather than the machines, were largely to blame.
14. For an overview of geoengineering techniques and their possible benefits and risks, see David Keith, *A Case for Climate Engineering* (Cambridge, MA: MIT Press, 2013); Mike Hulme, *Can Science Fix Climate Change? A Case Against Climate Engineering* (Cambridge: Polity, 2014); National Research Council, *Climate Intervention: Carbon Dioxide Removal and Reliable Sequestration* (Washington, DC: National Academies Press, 2015), https://doi.org/10.17226/18805; and Oliver Morton, *The Planet Remade: How Geoengineering Could Change the World* (Princeton, NJ: Princeton University Press, 2015). Even

though much of the scientific and policy attention has shifted to solar radiation management approaches, carbon removal remains a live option in many quarters. See Elizabeth Kolbert, "Can Carbon-Dioxide Removal Save the World?" *New Yorker*, November 20, 2017, https://www.newyorker.com/magazine/2017/11/20/can-carbon-dioxide-removal-save-the-world.

15. See, e.g., Alan Robock, "20 Reasons Why Geoengineering May Be a Bad Idea," *Bulletin of the Atomic Scientists* 64 (2008): 14–18, 59, doi:10.2968/064002006; Clive Hamilton, *Earthmasters: The Dawn of the Age of Climate Engineering* (New Haven, CT: Yale University Press, 2013); and Hulme, *Can Science Fix Climate Change?*
16. David W. Keith, "Toward a Responsible Solar Geoengineering Research Program," *Issues in Science and Technology* 33 (2017): 73, http://issues.org/33-3/toward-a-responsible-solar-geoengineering-research-program/. See also Keith, *A Case for Climate Engineering*.
17. Research on geoengineering is moving forward in China and Germany, and a new project exploring solar geoengineering started in the fall of 2017 at Harvard University. Although it identified many of the risks (ecological and human) surrounding the implementation of geoengineering technologies, the US National Research Council endorsed research into albedo modification in their 2015 report on geoengineering (*Climate Intervention*). See also Henry Fountain, "Panel Urges Research on Geoengineering as a Tool Against Climate Change," *New York Times*, February 10, 2015, https://www.nytimes.com/2015/02/11/science/panel-urges-more-research-on-geoengineering-as-a-tool-against-climate-change.html.
18. Keith, "Toward a Responsible Solar Geoengineering Research Program," 73.
19. See Christopher H. Trisos et al., "Potentially Dangerous Consequences for Biodiversity of Solar Geoengineering Implementation and Termination," *Nature Ecology and Evolution* 2 (2018): 475–82, doi:10.1038/s41559-017-0431-0; and also Matt Simon, "How Engineering Earth's Climate Could Seriously Imperil Life," *Wired*, January 22, 2018, https://www.wired.com/story/how-engineering-earths-climate-could-seriously-imperil-life/.
20. A good discussion of these intergenerational obligations, including both conservation and broader sustainability commitments as part of

an understanding of community and the public interest, can be found in two books by the environmental philosopher Bryan Norton, *Sustainability: A Philosophy of Adaptive Ecosystem Management* (Chicago: University of Chicago Press, 2005) and *Sustainable Values, Sustainable Change: A Guide to Environmental Decision Making* (Chicago: University of Chicago Press, 2015).

21. Paddy Woodworth, *Our Once and Future Planet* (Chicago: University of Chicago Press, 2013), 437.
22. Aldo Leopold, "Thinking Like a Mountain" (1949), in *A Sand County Almanac*.
23. A recent and compelling reading of Thoreau's work and legacy is Laura Dassow Walls, *Henry David Thoreau: A Life* (Chicago: University of Chicago Press, 2017).

FURTHER READING

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