Plumwood, though, also looks askance at white, privileged people engaging in hunting as mere recreation. How would she judge me, visiting family on Whidbey Island, Washington, sitting down to eat a portion of grilled salmon my sister-in-law and her family caught? I can't ask her, alas, as she died in 2008, becoming, as she would say, part of the feast. But I think she would want to know whether my family killed the fish with respect and gratitude, whether they made sure not to waste any of it. She might want to know my thoughts on reintroducing grizzly bears to Washington State, since embracing ecological embodiment means being willing to also share the world with those that would see us as prey.

Although I have never had an encounter with a predator as intense as Plumwood's, I did, on that Amazonian ridge top, have a brief but crystalline moment of understanding that my body could be food. As the woolly monkeys around us hollered their jaguar alarm cries, I remember feeling grateful to them for "warning us." Given that we were out looking to hunt them, the notion that we were on the "same side" seems absurd, but for that brief moment, my position in the forest had changed from potential predator to potential prey. I was no longer Emma Marris, environmental writer, defined by my mental activity and the words I've strung together over the years. I was a body that could be food, a packet of energy in a jungle full of hungry eyes.

11

Bloodshed for Biodiversity

Karl Campbell is a middle-aged, medium-sized Australian with a five-day beard and an intense gaze. He seems perpetually coiled, even angry, when at rest. He's smiling and relaxed only when his body is in motion—preferably fixing something, building something, or killing something.

Campbell lives in the Galápagos Islands, full time. Far off the coast of Ecuador, the island chain is a place of almost pure geology and biology, with no local gods, no legends, no human history before 1535, and no permanent residents before 1805. Human changes to the land are still fresh enough that much can be undone with work and money—and killing. Most of the original species remain, from marine iguanas shooting salt snot from their nostrils to waved albatrosses gliding on eight-foot-wide wings, scanning the sea with wet eyes like black tapioca balls.

This is where Charles Darwin collected the first inklings of what would become his theory of evolution. The slight differences in species from island to island suggested to him that perhaps they were all descended from a common ancestor. Tourists flock here now to see these species, to pay homage to Darwin's great discovery, to experience "nature" in a rawer form.

I flew into the airport on Baltra Island, and made my way to the archipelago's biggest city: bustling, knicknack-riddled Puerto Ayora, on Santa

Cruz Island. The next day, I took a ferry to Floreana, a volcanic island of 173 square kilometers with a human population of just 100—most of whom both farm and work in the tourist trade. Campbell, who works for an organization called Island Conservation, picked me up at the dock, upon which sea lions lolled and ruby-red marine iguanas regarded me with disinterest. Campbell wanted to show me some tortoises that live up the road in a sanctuary. We hopped in the back of a truck, which functions as a kind of tourist shuttle, and headed up the side of the island's central volcano.

Campbell is extremely driven. He prizes efficiency and logic. He has done the math on stopping extinctions. The roughly 465,000 islands in the world represent just 5.3 percent of the Earth's landmass, but 75 percent of bird, mammal, amphibian, and reptile extinctions since 1500 have been island species. Why? Animals on islands evolve in unique directions, especially when there are few or no predators to worry about. Birds may lose the ability to fly and the instinct to flee. Island animals don't need to spend so much energy on fighting for survival. The rules are different on islands.

In recent centuries, though, humans have changed the rules. Firstly, we hunted out many island species ourselves. It is all too easy to go overboard when your prey just sits there blinking at you when you try to hunt them. In this way, we lost the great auk, a majestic black-and-white flightless bird that lived on rocky islands in the Atlantic, and the famous dodo, which lived only on the island of Mauritius. In this way, we lost the Falkland Islands wolf, the Caribbean monk seal, and nine species of New Zealand moas, those long-necked flightless birds whose bones I saw in a natural history museum. This is how the Galápagos lost the Floreana tortoise, the last specimen of which was turned into soup in about 1850.

Secondly, we made islands functionally less remote by installing seaports and airports and visiting them and leaving and coming back. Just as we have reconnected continents separated by plate tectonics with our globalized trade and travel networks, reuniting Pangea in practice, so have we pulled archipelagos together and closer to continents. In the twenty-first century, almost nowhere is really far away. And where we go, so go our pets, our crops, our livestock, our medicines, our synanthropes

and our kleptoparasites—the whole human entourage. Island animals often just as defenseless against smart, flexible killers like cats, foxes, rats, and snakes as they are against us.

The placid reptiles at the Asilo de la Paz—the "Peace Haven" sanctuary—are not strictly speaking native to this place. They are retired pets brought from other islands along with their offspring—a proxy for what is missing. The Galápagos tortoises from Floreana had "saddleback" shells with a high arch in the front, which allowed them to stretch their necks way up high to nibble on cactus fruits several feet above the ground. The tortoises I am looking at now mostly have the classic dome shape, because their ancestors came from islands with more low-lying vegetation. Campbell and I watch them eating iceberg lettuce as if they have all the time in the world—and with a life span of well over 100 years, why not be leisurely? Their bumpy limbs and seemingly sour expressions are inexpressibly charming, but they are penned up, not free-roaming.

There is some hope of "rewilding" the Floreana tortoise. That may sound bizarre, since I just said it was extinct. And it is. But in 1994, a biological expedition on the remote Wolf Volcano on Isabela Island, more than 100 miles from where I stand, found saddlebacked tortoises. Later, scientists determined that these individuals were hybrids—a mix of different island species with some Floreana tortoise parentage. Apparently, this population was descended from a living meat cache set up by whalers or buccaneers in the 19th century. The seafarers nabbed tortoises from across the islands and stashed them on Wolf as emergency rations. In 2015, 32 tortoises with pronounced saddles were captured and airlifted back to Puerto Ayora. The plan is to breed them carefully, maximizing the genes from Floreana, and eventually return them to Floreana.

Before they can be set free to live out their slow lives in the Equatorial sun, though, Floreana needs some ecological adjustments. Rats eat Galápagos tortoise eggs and babies. And Floreana is crawling with rats. Campbell would like to change that.

Because the changes to the Galápagos are so fresh, conservationists see a real opportunity to prevent extinctions there through vigorous action, to do the right thing by at least one ecosystem. At the same time, the archipelago exhibits the characteristic conservation problems of islands, including introduced predators and vulnerable native species that sometimes seem determined to perish. And Campbell's approach to fixing it is the standard approach for islands: kill the interlopers, undo new ecological dynamics, and try to prevent extinctions at all costs. Island conservation is all about killing these days. What I wanted to know was whether preventing these extinctions was always worth the price in blood.

When humans first came to the Galápagos, they brought beasts of burden, animals for meat, and the clever and voracious rat, hidden in the holds of their ships. The animals of the Galápagos, like island species everywhere, had let down their defenses over evolutionary time and simply could not cope with these bulldozing newcomers. Even when the animals humans brought didn't eat the native fauna, they did damage in other ways. Free-roaming goats ate so many plants that one estimate claimed that 60 percent of the Galápagos' 194 endemic plants were threatened with extinction—not to mention the islands' giant tortoises, which were starving to death with no plants to eat.

Rats have already killed off all the populations of the ironically named Indefatigable Galápagos mouse on Santa Cruz Island. In 2005, a single cat was found to be responsible for eating seven endangered Galápagos penguins every month at one breeding site on Isabela Island—a rate of decline the colony could not have sustained if researchers hadn't killed the cat. Rats, cats, and dogs exiled the Floreana mockingbird—a chocolate brown bird with a perky tail—to two minuscule offshore islets.

This pattern is not unique to the Galápagos. Non-native species are implicated in 62 percent of amphibian, reptile, bird, and mammal extinctions (although many had more than one cause listed). But importantly, of those cases where "alien species" were listed as a driver of extinction, a whopping 86 percent of the species lost were "island endemics"—occurring only on islands.

It is important to note that introduced species are much less likely to cause extinctions on continents, because there's time and space for the native species to adapt to the new presence. Newcomers may well cause declines in *abundance*—the sizes of native species' populations. For example, free-ranging domestic cats kill up to 4 billion birds and 22.3 billion mammals every year in the United States, according to one analysis. But as of 2020, cats haven't caused any extinctions in continental North America. Meanwhile, on islands—even islands as large as Australia—cats have driven dozens of species extinct. Cats have been a factor in 63 extinctions—every single one of which was Australian or an "island endemic." In fact, *all* the species driven extinct since 1500 by non-native animal predators were either Australian or island endemics.

To me, this suggests that our thinking around "invasive species" needs to be fine-tuned. Instead of a paradigm where we see all "foreign" species as malevolent invaders that should be considered threats to ecological integrity unless proven otherwise, maybe we should instead see islands species as particularly vulnerable to newly arriving species.

Indeed, the overall concept of the "native" has some fundamental problems. It derives from precisely that frozen-in-time idea of "ecosystem integrity" that, as we've seen, is riddled with conceptual shortcomings. Ecologists have spent decades assigning "native ranges" to species, usually based on where they were when the first white scientist showed up to take notes. These ranges are pegged to an arbitrary point in time, a moment in the long evolutionary and geographical journey of a particular lineage.

For example, ancestors of the Virginia opossum evolved in South America, then entered North America after the continents joined up, about 800,000 years ago. They've been slowly ambling north ever since. By the 1600s, they had made it to Ohio and by the 1920s, opossums had made it to southern Michigan. Today, you can find them as far as southeastern Ontario. This recent range expansion has been enhanced by climate change and human changes to the landscape, but they are doing it without being physically moved by people. So what part of the Americas should count as their "native" range?

In the Northern hemisphere, many species have shifted ranges over and over as glaciers have advanced and receded over the millennia. Every single species in Canada today arrived there less than 20,000 years ago, because before that the entire country was covered by a solid block of glacial ice. The same goes for much of Northern Europe. As the climate began to warm, species began to move north—though some moved east, west, or even south—and they all moved at different speeds. Arctic ptarmigan used to roam Central Europe; Greenland collared lemmings once lived in what's now the United States.

When humans move species, those new areas never count as part of the "native" range, because of the fallacious idea that humans aren't part of nature. This makes things confusing when those movements happened so long ago that it has become impossible to untangle human influence. Kukui, or candlenut, a tree with a nice fatty seed you can eat, burn for fuel or light, or turn into moisturizer, was so useful to people that they moved it all over the Southeast Asian tropics and Oceania. No one knows where its "native" range was. It is now the state tree of Hawai'i.

The camel family evolved in North America, then spread out. The ancestor of *Camelus dromedarius* ended up in the Middle East and North Africa, where it was domesticated about 2,000 years ago. Then the wild dromedaries went extinct. Today, descendants of domestic dromedaries brought to Australia by colonists as work animals in the 19th century roam free in the Outback. They are considered "invasive." Government sharpshooters regularly cull them from helicopters.

Climate change is shifting species all over the planet—although they still rarely cross oceans without human aid. But as continental flora and fauna shift polewards, the idea that everything "should" stay in its native range becomes increasingly untenable. In North America, beavers are moving into the Arctic tundra, completely reengineering the hydrology of the landscape.

In April 2020, an ecologist named Mark C. Urban published a paper in the journal *Nature Climate Change* entitled "Climate-Tracking Species Are Not Invasive," seeking to differentiate species that are moving on their own

in response to rising temperatures from those moved by people. "The same climate-tracking species arriving and disrupting a local community might also be threatened in their original range. Preventing shifts in species and ecosystems in favour of local, historic patterns is not only likely to be futile, but could cause range collapses or extinctions at broader scales . . . During climate change, we should keep nature alive, even if it happens to be in a different place."

I think Urban could have gone even further. Plenty of species that humans moved, such as the dromedary, are endangered or extinct in their "native" range. Don't they deserve to be kept alive too?

The idea of ecosystems as "stable" and of humans as forces that can only destroy "naturalness" come together in the war on "invasive" species. I honestly hate the term. It suggests the incoming organisms are showing up intentionally, with actively malicious intent. It bears repeating: So-called "invasive" species do not know they are in the "wrong" place. They are not trying to cause harm. They are just trying to live. If their success in a new location causes undesirable effects, there may be a good argument to try to move them, maybe even kill them. But they are not morally blameworthy. When an animal is trapped and killed simply because it is not native to a place, and despite the fact that its presence isn't causing any real problems, our instinct to protect "ecosystem integrity" or to keep the place "natural" is leading us to some morally dubious decisions.

So the places where we are most likely to see compelling arguments for killing non-native species are islands, because of the special vulnerability of the species that inhabit them and their restricted size—an introduced predator can kill them all before they have time to adapt. These island eradications are Campbell's specialty. It's a grueling job, preventing the catastrophe of irreversible extinction with a tide of blood. He kills goats and rats and other human-introduced animals that threaten rare island creatures, but his tools—traps, long-range rifles, and poisons—are brutal, deployable only on a small scale, and often all too indiscriminate. To excise

the rat, say, from an ecosystem, conservationists typically distribute poison that can kill many species.

Around the world, conservationists routinely and increasingly kill free-ranging animals to protect endangered species. One particularly massive operation was undertaken to save rare birds on South Georgia Island in the South Atlantic. There, conservationists dropped 300 metric tons of poison bait on the sub-Antarctic island to exterminate rats. The operation cost $13 million and was declared a success in 2018. The birds are already bouncing back, with the endemic South Georgia pipit—a speckled songbird—exploding in numbers after the rats were dead.

Some conservationists aren't just willing to kill animals to save species. They are willing to use other animals as the weapon. Consider the "death row dingoes" of Pelorus Island. In 2016, several dingoes were set loose on this Australian island to kill introduced goats that were allegedly eating the native plants to nubbins. The biologists who planned the project didn't want dingoes on the island either, however, so they planned to shoot the canines once they had killed all the goats. But dingoes can be tricky to hunt down, so just in case, the biologists borrowed a plot point from John Carpenter's 1981 film *Escape from New York*: The dingoes were implanted with capsules of a poison called 1080 that would break down over time, eventually killing them.

Conservation biology has, from its beginnings, always explicitly stated that its concern is with populations, not individuals. In his famous 1985 paper where he lays out the core values of conservation biology, Michael Soulé rejects the inclusion of any "normative postulate" concerning individuals. "It may seem logical to extend the aversion of anthropogenic extinction of populations to the suffering and untimely deaths of individuals because populations are composed of individuals," he writes. "I do not believe this step is necessary or desirable for conservation biology. Although disease and suffering in animals are unpleasant and, perhaps, regrettable, biologists recognize that conservation is engaged in the protection of the integrity and continuity of natural processes, not the welfare of individuals."

There's no comprehensive figure for how many animals conservationists kill each year, but it is almost certainly in the hundreds of thousands at least. Australia culled approximately 211,560 cats in twelve months in 2015–2016 alone, a pretty typical annual death toll. Also in 2015, conservationists eradicated red deer from the Fiordland Islands of New Zealand, rats and mice from South Georgia near Antarctica, rabbits and mice from the Madeira Islands of Portugal, a songbird called the Madagascar red fody and the common myna from islands in the Seychelles, the Polynesian rat from the Tongatapu Group of Tonga, mule deer from the Channel Islands of California, sheep from the Kerguelen Islands in the Indian Ocean, rats and cats from the Tuamotus and Gambiers in French Polynesia, and rats from the Kelp Islands of the Falkland Islands. Since 2015, the number and scope of these eradications has only increased. These days, I'd guess it is in the millions every year.

Arguing whether killing sentient animals is bad may sound absurd, but there's a real philosophical disagreement between those who see instant, painless killing as morally neutral for some animals and those who do not. As we saw, Peter Singer falls into the former camp. Singer is focused on sentient creatures satisfying their preferences. Some, he says, don't really understand that they are an individual with a past and a future; they don't make plans for the day after tomorrow. Therefore, he says, "a being which cannot see itself as an entity with a future cannot have a preference about its own future existence." If you kill them quickly and neatly, there's no wrong done.

Others argue that even if some animals don't prefer to exist in the future, killing an introduced rat or cat deprives them of years of well-being they might have had if you had not killed them. This focus on lost well-being brings up another way all deaths might not be equal. The premature deaths of elephants in zoos strikes us as sad and perhaps unjust in part because these long-lived animals are deprived of many years of life. Thus the deaths of long-lived animals or young animals with their "whole lives ahead of them" might be worse than the deaths of short-lived animals or animals that are nearing the end of their days anyway. The mice and rats that are so often

the targets of conservation killing do have short lives compared to the giant tortoises and large seabirds they are eating. Rats live a year or two, maybe seven at the very most; albatrosses can make it to at least 70; giant tortoises routinely see their 100th birthday and some have approached 200.

Pain and suffering are arguably much more straightforward than death, ethically speaking. On the whole, they are bad for any sentient creature. Some conservation killing—via well-placed traps or at the hands of a very good shot—is nearly instant and painless. A lot of it, though, is not.

On Floreana, the rats' destruction will be brought about by a carpet-bombing of poisoned cereal pellets: Some 300 tons will be dumped from helicopters, enough to kill every rat on the island. The poison Campbell will use is called brodifacoum. It is an "anticoagulant poison," which means that it stops the rats' blood from coagulating. The rats bleed from internal organs and sometimes their eyes, nose, gums, and other orifices in the course of about six agony-filled days. In lab tests, rats that ate the poison hunched up, stopped moving, and bled externally. Some became completely paralyzed. It took them about a week to die. During the last 11 hours or so before death, they "remained conscious but unmoving . . . except for some occasionally pushing or pulling themselves along the floor." Unsurprisingly, this type of poison is consistently rated as causing the absolute most suffering out of all pest-control methods, but it works. Part of why it works is that the rat doesn't feel bad right after eating the bait. It takes hours or even days to start bleeding out. So the clever mammals never learn to associate the tasty cereal pellets with sickness, as they often do with faster-acting poison. The slow death is a feature, not a bug.

When Campbell was a kid there was a show on Australian TV called *Wombat*, named after a native Australian animal that looks a bit like a furry ottoman with a teddy bear face. Once, the show featured a segment on the captive breeding of rare birds. At age seven, Campbell was entranced. He began to practice breeding birds at home—quails, doves, parrots, finches. He liked that it was an active way to help endangered species.

Although his parents "probably had the resources" to fund his education—Campbell says he never asked—he didn't want to rely on anyone, so to pay for college, Campbell joined the Australian Army Reserves, hopping on a bus to go to recruit training just 12 days after his high school graduation. There he learned to shoot and repair vehicles. After a year of full-time soldiering, he started college in Wildlife Management. To support himself, he worked construction. During college he took time off to recover from an elbow injury he says he got from a combination of rock climbing, rugby, and changing truck tires. After that he spent a month in Malawi arresting poachers, "to clear my head."

Linda Cayot, former project coordinator for Project Isabela, a goat eradication drive on three Galápagos islands, recalled that when she picked Campbell for an internship with the organization back in the late 1990s, one of his virtues was a "certain macho army roughness." Campbell had learned to shoot firearms and repair vehicles in the Reserve. He was well suited to the demands of the work on the islands: Once he slashed open his thumb and had a friend stitch it up in the field; another time he came back from a visit to Wolf Volcano with most of the skin on his feet peeling off. He didn't bother to mention it.

For Project Isabela, Campbell shot goats with semiautomatic .223-caliber AR-15 rifles, mostly from helicopters, occasionally on foot with dogs. But he quickly recognized the imperfections of these methods. You could never get those last few goats, and they would quickly breed and restock any island. He came up with a strategy for inducing sexual receptivity in females in order to lure other goats out of hiding so they could be shot. The resulting "Mata Hari" goats were a big success and propelled Campbell to a kind of fame in the conservation world—and earned him a PhD from the University of Queensland.

In 2006 Campbell went to work for Island Conservation, taking his skills beyond the Galápagos. He has helped rid San Nicolas Island, California, of feral cats; Choros Island, Chile, of rabbits; and Desecheo Island, Puerto Rico, of rhesus macaques. Campbell had found his true calling. He told me he realized that breeding endangered species isn't much different from

collecting antiquities unless there's some real chance of reintroducing them to the wild someday—unless the major threats are dealt with. "I was doing all this work breeding birds and I should have been learning to kill shit," he says.

Campbell is now focusing on Floreana's cats and rats, aiming to eradicate them completely by 2021. Once the cats and rats are gone, the Floreana mockingbird could be brought back from those two offshore islets to the place for which it was named. Removing cats and rats will also clear the way for the return of saddleback tortoises with at least a healthy chunk of Floreana tortoise DNA. It will safeguard other threatened species as well: the Galápagos petrel, 60 percent of which nest on Floreana, and twenty species of endemic land snail.

The biggest problem for Campbell is that brodifacoum poison also kills farm animals and some native animals. So he can't just dump it on the island willy-nilly. Everything that people want to keep alive must be kept indoors, moved off island, or otherwise protected from the rain of death. And so Campbell has to work with every single household and farm on the island to prepare.

The morning after our tortoise visit, Campbell and I hopped in a local farmer's battered Toyota Land Cruiser and headed for the highlands of Floreana. Rats are no friends to farmers either, and Campbell pointed to some corn that had been nibbled away by sharp rodent teeth. Campbell estimates the famers here lose as much as 40 percent of their crop to rodents. Farmer Claudio Cruz, a smiling middle-aged man with reading glasses pushed up on the top of his head, showed me the poison bait he strings like a necklace of pearls around his crops. Even with all this poison, rats burrow into his yucca, he says, hollowing them out from the inside. "A Floreana without rats would be marvelous," Cruz said in Spanish.

On the day of my visit, Cruz was showing off his spread to Campbell and two farmers from another Galápagos island, San Cristóbal. Both were named José; they were shopping for calves. After showing us an ingenious compost system of his own design, Cruz called in his cattle. After a few minutes of hollering, the cattle emerged from banana groves, brown and white, single file. They were attended by white cattle egrets, a species that

has managed to conquer the world on its own, spreading along with cattle from continent to continent, a quiet avian version of us. As the cattle lumbered through the grass, a panicked rat made a run for it, dashing under Cruz's truck.

After looking over the calves the group stopped by an orange tree heavy with fruit and one of the Josés climbed up and began tossing fruit down to Campbell, who packed them up in a feed sack. Nearby, Cruz had parked a couple bright red shipping containers up on blocks—one a gift from Island Conservation, one he bought himself. They will protect his animal feed when the poison comes.

Island Conservation will also build coops, sties, and stables for the island's chickens, pigs, and horses. It will buy "sentinel pigs" that will live outside the sties and be slaughtered at intervals so their livers can be tested for poison. The other pigs won't be able to emerge until the sentinel pigs' livers are clear. This might take three years. Parents will have to keep close watch over small children lest they eat pellets off the ground. Scores of native animals—likely including finches and short-eared owls—will be captured and held in aviaries both on and off the island. These aviaries have been built, and they've been home to some captive finches as a trial run. Campbell expects it will take 10 years, $26 million, and 35 shipping containers full of poisoned cereal to clear Floreana of rats. "Rodent eradication requires getting in every habitat," Campbell said. "You can't exclude any area. It has to be 100 percent or you fail."

Afterward, the island will have to inspect every incoming ship carefully forever, to prevent new rats from coming ashore. The long-term success of the plan relies on the Ecuadorian government following through with intensive biocontrol in perpetuity. They already have a biocontrol station. When I arrived, I checked in there and watched as two young men pawed through my suitcase in a desultory fashion.

Ecology is complex, even on small islands, and things don't always go according to plan. In 2012, for instance, Campbell helped round up the 60 Galápagos hawks that lived on Pinzón Island, a steep volcanic nubbin in the Galápagos chain, so they wouldn't get sick from eating the rats that Campbell

was about to poison to save the island's "tiny and very soft" tortoise hatchlings. But when the rare raptors were released back into the wild after a couple of weeks, they began dropping like flies. It turned out the poison was still lurking in lava lizards—and the hawks were preying on the lizards and getting poisoned that way. "I was getting beaten up by pretty much fucking everybody," Campbell says. Just a dozen of the birds nest there now. But Campbell pointed out that baby tortoises have been born to the ancient tortoises that live there—the first to survive in more than 150 years. If a small percentage of native animals die, that's fine with him, because that's better than 100 percent going extinct.

Project Isabela was widely hailed as a success. With the goats gone, endangered giant daisy trees grew back—but on Santiago Island so did huge, Sleeping-Beauty-esque tangles of non-native blackberry. Removing non-natives doesn't always magically and completely restore an island, especially when other introduced species have made it home as well. Though the project was lauded, there are some who feel the organization should have budgeted an extra million for blackberry removal.

"It continues to unveil itself," Campbell said about Santiago, with a shrug. "It is unrealistic to put a system back 500 years." For Campbell the goal isn't time travel, it is stopping extinctions.

Perhaps because of his disdain for comfort, Campbell has thrived in the harsh volcanic landscape of the Galápagos, with its strange and wonderful wildlife. He married an Ecuadorian jewelry designer, and they have a daughter. But Campbell is frustrated with the slow pace of the work. There are thousands of islands out there—and so many of them are in the midst of an ecological crisis. "We are barely scratching the surface," he said. "I will never, in my lifetime, run out of a job."

His job might change, though. While most people are generally cool with killing mice and rats, many are squeamish about killing them in such a painful way. And the acceptability of killing rodents at all is potentially declining. Recently, 25,000 Parisians signed a petition to stop the "genocide" of rats in the City of Lights. In addition, the mass-poisoning eradication approach has logistical limits—and if he's already approaching those limits

California condor. SUSAN HAIG, U.S. GEOLOGICAL SURVEY

Protestors outside the L.A. Zoo on November 30, 1986. Many objected to the plan to take every wild California condor captive in order to breed them and save the species. Protestors felt the plan would sacrifice the birds' wildness. MIKE SERGIEFF, PHOTO COLLECTION/LOS ANGELES PUBLIC LIBRARY

The Gundestrup cauldron, featuring the antlered god Cernunnos. On display at the National Museum (Nationalmuseet) in Denmark. MALENE THYSSEN, WIKIMEDIA COMMONS

Orlando Yassene with a wild greater honeyguide in northern Mozambique. Humans and honeyguides work together. The bird locates a beehive; the human opens the hive; the humans eat the honey and the birds eat the wax. CLAIRE SPOTTISWOODE

on an island with just 100 humans, it looks like a nonstarter for larger, more populous islands.

Campbell and Island Conservation focus on introduced species on islands. But some conservation killing happens on continents—and the species that are killed aren't always from across the ocean. Sea lions that eat endangered salmon on the West Coast are trapped and given lethal injections. To save threatened herds of caribou, the government of Alberta has shot more than 1,000 wolves from helicopters.

To protect some rare songbirds, conservationists kill brown-headed cowbirds. The cowbird is a nest parasite: It lays its eggs in the nests of other bird species, then takes off and repeats the trick, laying as many as three dozen eggs in various borrowed nests. When these cowbird chicks are born, usually before the biological chicks of the nest's builders, they grow quickly and out-compete the parent's real babies, and sometimes even heave them out of the nest. Cowbirds evolved this trick back when they followed huge bison herds across the plains, feeding on goodies in their dung. When those herds were systematically hunted out in the 1870s as part of an unofficial military strategy against the continent's Indigenous people, the cowbirds took up with domestic cattle, and fanned out across the continent to every place cattle were—which is to say nearly everywhere. So conservationists protecting the Kirtland's warbler in Michigan's jack pine forests trapped and killed cowbirds there every year for four decades.

In the United States, barred owls moving west on their own are shot because they compete for nesting sites with the threatened spotted owl. Here, the birds being shot are so closely related to spotted owls that they can mate and have fertile offspring. And those hybrid offspring might arguably be better adapted to the current state of the Pacific Northwest. Spotted owls require old growth habitat, eat a smaller set of prey items, and are shier and less aggressive. Barred owls can live more places, eat more things, defend their territory better. Whether you see the interaction between the cousins as an "invasion" of foreign owls that will "contaminate" the spotted owl

genome and drive them extinct or whether you see it as hybridization creating adaptive diversity in a rapidly changing environment depends on your values. In the meantime, federal officials have shot some 3,135 owls.

The barred owl case brings up an uncomfortable fact: Many people see species as having final value, but the borders between species can be fuzzy because the term "species" itself has several possible meanings. Some use the "biological species concept," which says that if any two individuals can mate and produce fertile offspring, then they are the same species. Some take an ecological approach, classifying together organisms that act the same way and do the same things in the environment. Some look at the physical details of the organism, its colors, shapes, number of spots. And some simply run the genome through a computer and assign it to a species based on genetic similarity. There's no one right answer to the question of how to define species; it really depends on what kind of questions you are asking about them. Ultimately, "species" is a human concept rather than a biological reality.

If you ask whether a California condor and a Floreana mockingbird are different species, any of these definitions would tell you they are distinct. But whether mockingbirds from various Galápagos islands should be considered separate species or merely subspecies is a scientific debate that has continued since Darwin's day.

Complicating matters is the fact that many lineages that split off from one another re-encounter each other later, hybridizing and coming back together. The tendency of plants to "naturally" hybridize has been well-known for generations. Hybridization in animals was for a long time considered rare. When biologists found hybrids, their first hypothesis was often that the mixing had to have been caused by humans, and hybridization was automatically assumed to be a threat to species integrity. Hybrid animals were also generally thought to be "less fit" and thus to jeopardize the survival of the species. But recent work has shown that hybrids are common. Some 10–30 percent of multicellular animal and plant species hybridize regularly, according to evolutionary biologists. Even in the animal kingdom, related species often re-encounter one another after a period of separation of

millennia or more, and then interbreed. And their offspring are not always less fit. Indeed, an influx of genes at the right moment can increase fitness and *prevent* extinctions—as seems to be the case when California tiger salamanders got a dose of new genes from barred tiger salamanders. A new pool of genetic diversity to draw from can help a lineage adapt to changing conditions. This has even happened in the family tree of Galápagos mockingbirds. The Genovesa mockingbird looks to be a sister species of the Española and San Cristóbal mockingbirds, but with some extra genes it picked up when it mated with mockingbirds from Isabela and surrounding islands.

One approach to sorting out whether animal hybrids are "good" or "bad" in terms of biodiversity is to ask whether the resulting organisms will be more resilient and likely to persist in the face of the ongoing processes of environmental change that we humans have kicked off. Another way is to investigate whether the individual hybrids themselves will be more or less able to be happy and flourish. Every case is different, but without being too flip about it, I tend to think that if two populations create hybrids that are more fit, then the two parent populations were probably pretty closely related to begin with and so their intermixing is not very high on my list of environmental problems to worry about. Put another way, I'm willing to accept old growth forests filled with "sparred owls" because it's better than no owls at all.

We ourselves are hybrids. Within the last million years or so, many of our ancestors mated with at least two other species: the Neanderthals and the Denisovans. Those of us with Oceanic and Asian heritage might be as much as 7 percent Denisovan. Those of us with mostly non-African heritage are between 1–4 percent Neanderthal, and at about 20 percent of the total Neanderthal genome is floating around in the human gene pool somewhere. Some of these genes are for hair and skin traits, suggesting that these hybridization events helped populations of *Homo sapiens* adapt to new climates and altitudes they encountered as they migrated northwards out of Africa. Genes from these other species may have also helped protect us against new diseases.

In addition, most cells in animal, plant, and fungal bodies include mitochondria—a structure enclosed in a membrane that converts broken-down

bits of sugars into adenosine triphosphate (ATP), which carry energy throughout our bodies to power everything we do. Mitochondria used to be an independent, free-living bacteria, until it was absorbed by one of our very distant ancestors and took up residence inside our cells. To this day, mitochondria have their own DNA, separate from our main packet of chromosomes. When we reproduce, the mitochondria reproduce in parallel. Thus even *individual* organisms are amalgams of at least two individuals working as a unit. (Lichen, similarly, is actually a partnership between an algae or a cyanobacteria and a fungus acting as a single organism.)

On top of that, animal bodies host bacteria, fungi, protozoa and viruses, whose cells outnumber our own by a large margin. Many of these organisms are symbiotic. We provide them with an environment and nutrition and they help us digest food, fight infection, and more. An animal completely stripped of their microbiome is a sick animal. If the dividing lines between species are blurry, so too are the dividing lines between individuals.

More recently, microbiologists have studied "horizontal gene transfer" (HGT) in microbes, where genes from one species pass directly into the genome of another species. This is most common in bacteria and archaea, but plants are known to have dabbled, too. Ferns somehow copied a gene from a mosslike species of hornwort which allowed them to sense low levels of light in deep shade, helping them thrive in the dark, moist environments so many ferns occupy today. And animals have collected genes from other species as well. One 2015 study took advantage of the boom in whole-genome sequencing to look for bacterial genes in the DNA of 10 primates, 12 flies, and 4 nematodes; genes likely acquired from bacteria were found in all of them. The authors concluded, "Far from being a rare occurrence, HGT has contributed to the evolution of many, perhaps all, animals and that the process is ongoing in most lineages. Between tens and hundreds of foreign genes are expressed in all the animals we surveyed, including humans."

Together, compound organisms, horizontal gene transfer, and hybridization create a picture of evolution operating not like as a branching tree with a perfect, unchanging fruit on the end of each branch, but as fungal

network, with genes flowing sideways between lineages as well as "vertically" from parents to offspring. Species drift apart, then back together; they dead-end often. Sometimes one swallows another whole. It is less like a tree and more like the complex networks in forest soils, a dense tangle of mycelium and roots and bacteria, splitting and merging and growing into one another. And the species we see today are not the final products. On the contrary, we live in one moment in somewhere near the middle of a story billions of years in the telling. When we are tempted to stop lineages from changing or stop species from hybridizing, we must ask ourselves: are we really preserving biodiversity with these actions, or are we thwarting it?

After visiting the farm on Floreana, Campbell and I hit the beach by my hotel, white sand bordered by black volcanic rocks spangled with crimson Sally lightfoot crabs. Offshore, sea turtles popped their heads above the waves. Opuntia cactus were outlined against a cloudless sky. I saw Eden. Campbell saw trouble. He pointed at an almost imperceptible depression in the sand, about the size of a silver dollar. It was the footprint of a cat, and it was less than a meter away from the unprotected ground-level burrow of an endangered Galápagos petrel. Campbell and his team are also working on a cat sterilization campaign. "I know the name of every pet cat on this island," Campbell said with grim determination. "There's one fertile cat left."

Campbell had some more work to do, so I decided to go snorkeling, even though the water was pretty cold. Most tourism in the Galápagos is through organized cruises, and none of them were on the beach at the moment, so I had the whole place to myself. The water was just a bit murky, which I knew meant that it was filled with nutrients. I watched sea turtles feed with joy. A juvenile sea lion came to say hello. I backed up, trying to keep my distance, like a good tourist, but he or she was having none of it. The sea lion turned playful circles around me in the water and looked me right in the face. I felt a soft, slick body against my stomach then my back. I was thrilled but felt guilty about "letting" the animal come so close—although I'm so clumsy in

the water all I could really do is stay as still as possible. I found myself thinking, "You wouldn't be so friendly if you knew what monsters we humans are"—the same old misanthropic environmental narrative I absorbed as a kid. Humans are the virus, etc.

I swam to shore and sat on the rubble of a million broken and weathered sea urchin spines, collecting my thoughts, shivering. Here on Floreana, humans are trying to undo the damage they have caused, to repopulate the island with the species (or subspecies) that are missing. Their intentions are good. Maybe some of those involved are motivated by the idea that human influence must be cut out of ecosystems like a melanoma, but Campbell seems simply to act from an impulse to fight extinction, preserve the diversity of life. And if things go as planned, all the rats will die at once during the poisoning, and no one will have to kill any more in the future. The killing can stop. Claudio Cruz won't have to spend a fortune on poison to protect his yucca. Rats won't die on the edges of his fields every year. Baby tortoises will hatch and grow old. Long after I'm dead, they could walk this island, taking their unhurried steps, nibbling opuntia cactus fruit. Maybe it would all be worth it.

12

The Friendly Toutouwai

When I visited Campbell, he was still in the planning stages of the Floreana eradication. I wanted to see what it was like when the killing started. So I went to another Pacific Island that struggles with introduced predators: Aotearoa, also known as New Zealand. Campbell had told me that Kiwis are the world's experts in killing non-native predators.

Aotearoa broke off from the mega-continent known as Gondwanaland about 85 million years ago—before the age of mammals—and has been isolated ever since. Before humans arrived, there were no four-footed mammals at all—just a few bats, seals, and sea lions—animals that could make it to the islands on their own. Many ecological roles filled by mammals in other places were here filled by birds. Five-hundred-pound flightless Moa were like deer or gazelle, grazing and browsing. They were hunted not by wolves or lions but by massive hawks and eagles. Haast's eagles had an eight-and-a-half-foot wingspan and talons big enough to comfortably grasp a human head. Roles taken by rodents in other places were here filled by giant flightless crickets called wētā, some as big as adult mice. (Weta Digital, the special effects company co-founded by Peter Jackson, of *Lord of the Rings* fame, is named after these admirable beasts.)

Aotearoa was the last large landmass on Earth to be discovered by humans, who arrived in a fleet of oceangoing canoes launched from the