# Rambunctious Garden

*Saving Nature in a Post-Wild World*

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# CONTENTS

*To my mother, Kathrine Beck, for sending me to Audubon Day Camp.*

# 1 | Weeding the Jungle

We have lost a lot of nature in the past three hundred years—in both senses of the word *lost*. We hav lost nature in the sense that much nature has been destroyed: where there was a tree, there is a hous where there was a creek, there is a pipe and a parking lot; where there were passenger pigeons ar Steller's sea cows, there are now skins and bones in dimly lit museum galleries. But we have also lo nature in another sense. We have misplaced it. We have hidden nature from ourselves.

Our mistake has been thinking that nature is something "out there," far away. We watch it on TV we read about it in glossy magazines. We imagine a place, somewhere distant, wild and free, a plac with no people and no roads and no fences and no power lines, untouched by humanity's great grubb hands, unchanging except for the season's turn. This dream of pristine wilderness haunts us. It blind us.

Many ecologists spend their lives studying the most pristine places they can find, and man conservationists spend their lives desperately trying to stop wilderness from changing. We cling t fragments of "virgin" or "old growth" forests, to the "last great places," the ever-rarer "inta ecosystems," but they slip through our fingers. Like slivers of soap, they shrink and disappear. And w mourn. We are always mourning, because we can't make more of such places. Every year there ar fewer of them than the year before.

This book is about a new way of seeing nature. Yes, nature is carefully managed national parks an vast boreal forest and uninhabited arctic. Nature is also the birds in your backyard; the bees whizzin down Fifth Avenue in Manhattan; the pines in rows in forest plantations; the blackberries an butterfly bushes that grow alongside the urban river; the Chinese tree-of-heaven or "ghetto paln growing behind the corner store; the quail strutting through the farmer's field; the old field overgrow with weeds and shrubs and snakes and burrowing mammals; the jungle thick with plants labele "invasive" pests; the carefully designed landscape garden; the green roof; the highway median; th five-hundred-year-old orchard folded into the heart of the Amazon; the avocado tree that sprouts f your compost pile.

Nature is almost everywhere. But wherever it is, there is one thing that nature is not: pristine. 2011 there is no pristine wilderness on planet Earth. We've been changing the landscapes we inhab for millennia, and these days our reach is truly global. Inhale. That breath has 36 percent mo molecules of carbon dioxide than it would have had in 1750.[1] There is no going back. Certain stori are especially symbolic of this: bobcat families moving into foreclosed suburban homes;[2] Yellowsto moose birthing calves by roads where human presence protects them from bears,[3] songbirds givin full throat to complex car alarm sequences. But more significant are global phenomena like clima

change, species movements, and large-scale transformations of land.

We are already running the whole Earth, whether we admit it or not. To run it consciously an effectively, we must admit our role and even embrace it. We must temper our romantic notion o untrammeled wilderness and find room next to it for the more nuanced notion of a global, half-wi rambunctious garden, tended by us.

This garden isn't restricted to parks and protected areas. The rambunctious garden is everywher Conservation can happen in parks, on farms, in the strips of land attached to rest stops and fast-foo joints, in your backyard, on your roof, even in city traffic circles. Rambunctious gardening proactive and optimistic; it creates more and more nature as it goes, rather than just building wal around the nature we have left.

Many conservationists are opening up their definitions of nature and embracing a whole suite possible goals beyond the familiar "pristine wilderness" goal. They find that when they do, they ca use all sorts of new tools and approaches, the stories of which will be told in the chapters to come. A they experiment, they are finding that the values that got them into conservation in the first place a still relevant. We can cherish evolution in action even if all the species struggling for existence aren "native." We can protect ecological processes like soil formation and water filtration that benefit u We can marvel at the diversity of life and fight its disappearance, even if that diversity occurs i unfamiliar places. We can find beauty in nature, even if signs of humanity are present. We can see th sublime in our own backyards, if we try.

But changing our ideas about nature isn't easy. It's hard for you and me; it's probably hardest fo those who have spent their lives studying and protecting wilderness. The scientists who are trained be dispassionate are often the most passionate and opinionated when it comes to what counts as natu and what is worth saving.

Even those who are interested in expanding their conception of nature run into problems. Th notion of a stable, pristine wilderness as the ideal for every landscape is woven into the culture ecology and conservation—especially in the United States. Take the *baseline*. Virtually ever scientific study of environmental change uses or assumes a baseline. Baselines are reference state typically a time in the past or a set of conditions, a zero point before all negative changes. In the pas a place's default baseline was often before Europeans arrived. Today, as we learn more about ho indigenous inhabitants of places from Australia to the Americas changed their surroundings, it sometimes set to before any humans arrived. For many conservationists, restoration to a prehuman pre-European baseline is seen as healing a wounded or sick nature. For others, it is an ethical duty. W broke it; therefore we must fix it. Baselines thus typically don't just act as a scientific *before* compare with an *after*. They become the *good*, the goal, the one correct state.

When conservationists restore a site or manage a park this way, they first set a baseline. Then the characterize the site at that time. What species existed then, in what proportion? Where were th rivers? How deep and wide were they, and how fast did they flow? Where was the shoreline? Wh properties did the soil have? Once they have picked a baseline and characterized it, they have to g

down to the heavy lifting of wrestling the area backward in time. Some species are removed, othe reintroduced. Rivers are engineered, islands are built of sand, trees are killed and left to provi rotting habitat for beetles, and so on.

But ecosystems are slippery, and setting a baseline is not straightforward. Take Hawaii, some of th remotest islands in the world, home to hundreds of species that live nowhere else, many of which a rare and at risk for extinction. Earlier ecologists might have used 1778, the year Captain James Coo landed in Hawaii, as the baseline date for the island chain. But restoring the islands' ecosystems to th way they were in 1777 would be restoring them to a state very much shaped by the Polynesians wh had been living there for at least one thousand years: a semidomesticated landscape filled with speci the Polynesians brought with them, including taro, sugarcane, pigs, chickens, and rats, and missin others, including at least fifty species of birds, who were hunted out by the first arrivals.[4]

But if we set a date thousands of years back, safely before any humans arrived, we run into anoth problem. Ecosystems are always changing, whether humans are involved or not. Ancient forests wi trees thousands of years old may feel timeless to us. We are a short-lived species with a notoriousl bad grasp of timescales longer than a few of our own generations. But from the point of view of geologist or paleoecologist, ecosystems are in a constant dance, as their components compete, reac evolve, migrate, and form new communities. Geological upheaval, evolution, climatic cycles, fir storms, and population dynamics see to it that nature is always changing. On Hawaii, volcanic activi wipes the slate clean on any given slope every few hundred years, and occasional new arrivals to th islands, washed ashore or drifting in on the wind, adapt to their new home and find a place f themselves in its ecosystems.

Once we pick a date from amid this muddle, another problem emerges. Even when we use all th scientific tools available to look backward in time, from fossil pollen records to the clima information enshrined in tree rings, we don't always know what places looked like thousands or eve hundreds of years ago.

The final and perhaps most vexing issue with prehuman baselines is that they are increasing impossible to achieve—either through restoration or management of wild areas. Every ecosyster from the deepest heart of the largest national park to the weeds growing behind the local big-bo store, has been touched by humans. We have stirred the global pot, moved species around, turned u the thermometer, domesticated a handful of plants and animals, and driven extinct many more. W have definitively changed the entire planet, and it is getting increasingly difficult to undo all the changes at any one place.

I saw the scale of the challenge first hand when I visited Hawaii in 2009. The lush tropical plan out the hotel window looked gorgeous, but I knew that many of them had been introduced by peop and were now considered a threat to the native species. I also knew that Hawaii has been called "th extinction capital of the world," and that many of its beautiful birds are either gone or near gone. He was "the biggest ecological catastrophe in the United States," in the words of a *St. Louis Pos Dispatch* reporter,[5] and yet the islands are thick with conservationists who have not given up on th

ideal of Hawaii as it once was.

My first stop was a group of experimental field plots testing the feasibility of restoring lowla forests on the Big Island's wet side. The plots are hidden in a forest on the Hawaii Army Nation Guard Keaukaha Military Reservation. Growing on flat land with plenty of rain, most forests of th type had been cleared for agriculture. What was left, or what grew back, is now dominated by plan from places other than Hawaii.

Rebecca Ostertag of the University of Hawaii at Hilo explained why these "invaders" are prevalent on Hawaii. Hawaiian plants, having evolved in isolation for up to 30 million years generally grow slowly and use resources less efficiently than continental plants, which evolved wi more competition. Similarly, Hawaiian birds and animals are mostly helpless against introduce diseases. Avian malaria has knocked off many bird species; there were no mosquitoes on the island until recently, so birds there never evolved any defenses to the mosquito-borne disease. Hawaiia raspberries and roses have even lost their thorns, and Hawaiian mints their minty defense chemical because there were no plant-eating animals around to fend off.[7] Such mellow Hawaiian species a pushovers for the scrappier mainland species that humans brought to the islands. Today half of th plants in Hawaii are nonnative.[8] In many lowland forests only the large trees are native; under the grows a carpet of introduced seedlings, just waiting for the day the giant natives fall. Some ecologis call such places "forests of the living dead."

At the army base, mynah birds from Asia stood in the road. The air was soft and humid. Osterta and I met up with her colleague, Susan Cordell of the U.S. Forest Service, and a graduate stude named Joe Mascaro from the University of Wisconsin, Milwaukee. Together we headed out to th study plots. After hopping a fence intended to keep out feral pigs, we pushed through a jungle foliage from everywhere: trumpet tree with its huge star-shaped leaves, a native of Mexico, Centr America, and Colombia; bingabing, a small tree with big parasol-like leaves, from the Philippine tasty strawberry guava, from the Atlantic Coast of Brazil; purple-flowered Asian melastom "Koster's curse," a little shrub originally from Mexico and parts of South America; and albizi another immigrant from Southeast Asia. Many of these species were introduced not only deliberatel but methodically—aerially seeded in the 1920s and 1930s after large forest fires to prevent erosio The experts figured that Hawaiian plants would grow too slowly to do the job effectively. Th resulting cosmopolitan forest is green and dense, with creepers hanging everywhere. Underfoot, dea leaves like starched, crumpled brown napkins made a terrific crunch.

Suddenly we stepped into a clearing. Here plants were spaced widely apart, with black lava roc covered in chartreuse moss visible in between. This was one of the study plots: small squares in whic every single nonnative plant had been ripped out by hand. To get these spaces to a purely native stat researchers had to pull up and remove almost half the vegetation, a process that took about a week worth of labor per thousand square feet for the initial clearing and epic bouts of weeding thereafte As a result, the plots look a bit sad and empty, like someone's living room in the middle of a move out.

Here, I could get a better look at the typically less showy Hawaiian natives, including tree fern
lama, a hardwood in the ebony family; the vaguely Mediterranean-looking ʻōhiʻa tree with feathe
bunches of bright red stamens; and the sweet-smelling maile vine, used for making fragrant leis.

The plots weren't created to be showplaces, however, but as experiments to see whether a nativ
Hawaiian forest would bounce back if all the introduced species were removed. With all thos
aggressive tropical invaders exiled, would the native flora tap into the soil nutrients, rain, and new
available sunlight and grow vigorously to fill up the space? When I visited, it had been five yea
since the experiments began. Disappointingly, the mature native trees had grown very little. A
Ostertag and Cordell put it, "The native trees may either be responding to the treatments very slow
and still undetectably, or they may be unable to respond at all."[10] The researchers were please
however, to see quite a few native seedlings appear on the sun-dappled forest floor.

These removal plots were weeded out for a specific experiment. But they also represent,
miniature, what many conservationists would love to do for huge swaths of the planet: rip out th
introduced species, make way for the natives, and return the area to the way it used to be, making th
baseline the goal.

But Ostertag and Cordell's lowland wet forest, like just about everywhere else on the planet, ha
baseline problems. The area was burning-hot lava no more than fifteen hundred years ago,[11] so there
a chance that humans had already arrived on the island by the time plants were reestablishing the are
leaving no clean prehuman window of time to look back to. However, the researchers can get aroun
that by looking at nearby, similar forest that predates human arrival. More problematic is th
characterization of that moment in time. No one catalogued this kind of forest early enough, so the
may have been other native species here that disappeared without a trace, lost to record or memor
"There are only about five native tree species here," said Ostertag, as she looked around at th
unassuming native plants. "It seems to me there probably would have been more than five."

And the final problem is the sheer amount of work involved. Their baseline just isn't achievab
without spending a huge amount of money and time. "I think that people that are interested
protecting Hawaii's flora and fauna have resigned themselves to it being in postage-stamp-siz
reserves," said Cordell, sadly.

Of course, Osterag and Cordell's forest is in particularly bad shape. But are ecosystems that aren
so trashed perhaps redeemable? The answer is no, at least not in Hawaii. Nothing is going to go all th
way back to the way it used to be, not even the Laupahoehoe Natural Area Reserve, so valued for i
pristineness that it is used as a reference area—a contemporary baseline—for all similar forest
Scientists have erected a data-recording tower as tall as the canopy of the forest for characterizing th
ecosystem. The idea is that instead of recreating the past, they will use this place as a proxy for th
past. But even as they built their tower, scientists knew they were grasping at straws. The forest is ju
changing too fast.

I visited Laupahoehoe after leaving Ostertag and Cordell's poignant little plots. My guide wa
Christian Giardina, a lean, silver-haired government ecologist. To reach the data-recording tower, w

had to drive up the side of a mountain. As we climbed, the most obvious human influences fell awa one by one. Down low, pheasants from India scampered across the dirt road. We drove by dens forests of nonnative strawberry guava, until they thinned out. At some point we passed beyond th reach of the mosquitoes that bear avian malaria (they can't take the cold). We made a quick stop at th "valley of the giants" to look at enormous hundreds-of-years-old native ʻōhiʻa and koa trees. Ta straight koa, prized and liberally used for canoe building, are now rare on the islands.[12] These gian towered above an increasingly tangled understory of introduced plants like ginger and strawber guava.

At last, up on the heights, we found the reference forest. Compared to the bustling jungle belo everything growing here felt large, well established, widely spaced, and dripping with moisture. Th result was an impression of tranquillity. Tree ferns unrolled their fronds five feet above Giardina head, and we walked on spongy dark turf littered with the perfect crescent-moon leaves of the ko tree. For him, this is Hawaii at its best. But visits are bittersweet. Even here, in the most unchange place on the Big Island, its native character may already be anachronistic. "We know it is no pristine," said Giardina. "The carbon dioxide is elevated; key fruit dispersers and pollinators a extinct. But it is the best that we have." He mused on the inevitable changes that would occur when th "invasion front" we passed on the road up made it to the top of the mountain and the climate warme Already there were signs. Between the koa leaves, the forest floor was pinpointed with tiny seedling of introduced species poised to inherit the space. "This will be transformed," he said. "Aesthetically will be very different. The species composition will be different. You won't be able to walk through. get sad thinking about it: a forest type unique on the planet, and it will just get snuffed out."

Despite knowing in their hearts that they cannot turn back the clock, many conservation and mo restoration projects explicitly try to recreate a former time, like Ostertag and Cordell's plots, but on larger scale. This still seems like the most obvious goal to many conservationists. But these projec are often incredibly difficult and expensive, which means that unless the governments of the wor suddenly decide to spend vastly more money on conservation, they will always be small, like litt islands of the past. Or at least little islands *like* the past.

Such "islands like the past" spangle the planet here and there. Many U.S. national parks a managed to look as they did in colonial or frontier days. This has often meant that managers focus o stopping things from changing—which in these days of climate change means much more tha keeping hands off. But other places have been actively restored, and it is here that things get mo difficult and expensive.

In the summer of 2009 I visited one of the thousands of such restoration projects. The Australia Wildlife Conservancy is attempting to return a small area of the outback to the conditions of 177 when Captain Cook (same Cook; he got around) first landed in Australia, some 40,000 years aft people first arrived. "Australia can give up on a pre-aboriginal landscape, but there is a chance to g back to pre-European times," says Matt Hayward, an Australian Wildlife Conservancy ecologis Easier said than done.

Scotia Sanctuary is a 250-square-mile tract of land about 90 miles upstream of the confluence the Murray and Darling rivers, northeast of Melbourne, Australia.[13] Many species of eucalyptus gro here, emerging from red sand and splitting at ground level into many small trunks, each shedding ba and sporting branches with small, tough leaves adapted to the arid heat. Underground, these trunks a grow from a swollen root called a lignotuber, some of which are perhaps one thousand years ol which will survive even if fire destroys the aboveground tree. In between the trees are fairy rings dagger-sharp spinifex grass.

The Sanctuary includes two fifteen-mile-square areas enclosed by what looks like a prison fence- serious, sturdy, tall, and electrified. The landscape inside these fences looks much like that outsid except the ground is pitted with numberless fist-sized holes, the traces of several threatened species mostly nocturnal marsupials, including woylies, boodies, numbats, bilbies, and wallabies. These litt creatures have been declining continentwide since Europeans—and their favorite animal companio —arrived. They have two strikes against them: they evolved without many predators to keep the survival skills up, and they aren't terribly bright. Some scientists argue that the poor soils of Austral created a world where big brains were just too energetically expensive.[14]

Several of these marsupials were brought here from their last wild haunts, offshore islands free introduced predators. Cats and foxes, introduced as pets and for hunting, respectively, are devastatin predators for the crew. Some species have only a few hundred individuals left. A population of bridle nailtail wallabies, kept inside another fence within the main fence, are the "backup" reserve for th whole species, which is poised on a knife's edge.

Over coffee at the communal table at Scotia's main building, I interviewed Tony Cathcart, a mild eyed fellow in thick glasses, a V-neck sweater, and baseball cap who got rid of all the introduced cat rabbits, goats, and foxes in Stage Two, the second of the two fenced blocks. His previous jobs ha included bellhop, computer technician, and painter, but feral animal control may be his true callin The job requires an incredible patience and commitment. Leave just two rabbits alive inside the fenc and in a few years the nibbling hordes will be back. You have to get every last animal.

Cathcart told me how he cleared Stage Two. He was able to shoot out the goats in a matter of day Rabbits were harder. Every day he put out carrot bait, so that every rabbit's hole—and there wer thousands of them—was within about five hundred feet of some carrots. The rabbits would tentative nibble and learn to trust the new food source. On the third or fourth day, the carrots would b poisoned. Cathcart repeated this routine three times, running through 12,500 pounds of carrots, killi the majority of the rabbits. Then he switched to "spot cleaning" to get the remaining few.

Foxes have large ranges, so only about a dozen lived inside the fence. But they are also smart. F each fox, he learned its habits and was eventually able to find perfect places to trap or poison them. H also trapped the cats. But they too are smart. "The average in Australia is that it takes one hundre nights per cat," he said. "My first cat took one hundred eighty-seven nights." When he finally arrive one dawn, at the trap to find a gray figure inside, he had mixed feelings.

The whole process took eighteen months, and the key to making it work, he says, w

"perseverance, perseverance, perseverance." Eighteen months is actually pretty darn fast. It too
Cathcart's predecessor five years to clear Stage One.

"It isn't really about the killing," he said, as we rinsed out our coffee cups. "It's about seeing th
grass come back or the animals you haven't seen before—the little cute-and-furries." There are furth
effects as well. All that digging the cute-and-furries do turns the earth; their holes catch organ
detritus and moisture. Scientists at Scotia are looking at how these changes affect soil nutrie
turnover, bugs, and plant growth.

More than six years of effort for about thirty square miles: unless the whole country decides that i
number-one priority is ridding Australia of feral animals, these little fenced islands are all th
pristine-focused conservationists can hope for. Luckily for the marsupials, they'll never know the
territories are inside de facto zoos. And the cats, foxes, and rabbits are a continuing threat, just outsi
the fence. To hold the blocks to a simulacrum of 1770, conservationists must shoot, poison, tra
fence, and watch, forever watch, lest the excluded species find their way back in.

The day after a rare rain, I went out into the reserve with Matt Hayward and his family. Streame
of bark blew in the wind. Dead leaves and twigs rot very slowly here, so they blow about and for
little drifts in marsupial holes or against the base of spinifex clumps. The wet had brought o
countless shiny brown cockroaches, and Hayward's girls—Madeleine, three and a half, and Zo
nearly two—were intrigued. They ran around after them and asked their daddy to pick them up. The
watched as a scorpion pulled one into his burrow—at which point their mother suggested they p
shoes and socks on. We visited a malleefowl nest—a huge raised platform of earth and sticks an
leaves, maybe six feet across, all made by one male malleefowl, a bird the size of a chicken. Zo
patted the nest thoughtfully with a stick. In some mud, we spotted kangaroo and emu tracks. In an od
way, these girls are just as oblivious as the marsupials. They are spending their childhood in a
anachronism, an Australia where numbats and malleefowl are all around them, where bilbies come o
at night with shining eyes.

Holding small areas like Scotia to states that resemble historical baselines may be possibl
depending on where the area is and what date one would like to return it to. But to do it will tal
human intervention, both in the beginning and indefinitely into the future. A historically faithf
ecosystem is necessarily a heavily managed ecosystem. It is not quite the "pristine wilderness" ma
nature lovers look to as the ideal. And there's the paradox that unravels the idea of "pristi
wilderness." If we define *wild* as "unmanaged," then the ecosystems that look the most pristine a
perhaps the least likely to be truly wild.

To be sure, this is not to say that reserves like those at Scotia are not worth having, or that Cathca
spent eighteen months chasing a dream. Even if we don't care about 1770, we may need such fence
islands if we want to avoid the extinctions of the cute-and-furries. Managed, fenced areas may well b
the only places that many native Australian animals can live, given the unlikelihood of ridding th
whole continent of foxes and cats. "Maybe in a hundred or a thousand years they evolve resistance
says Hayward. "That's more likely than eradication of predators."

But managing to avoid extinctions is subtly different from managing to recreate 1770. For on
thing, managing to avoid extinctions is actually achievable.

In the last ten years or so, many scientists have moved beyond the notion that the goal for any pie
of land is returning it to an unobtainable baseline. They are rejecting a view of the world that says
place must be completely "pristine" to count as nature; that view would imply that there are only tw
possible future states for most ecosystems: perpetual weeding and perpetual watching, or total failur
They are embracing instead a wider vision of nature managed for a wider array of goals. Instead
focusing on the past, they are looking to the future and asking themselves what they'd like it to loo
like.

Back on Hawaii's Big Island, as we thrashed through the nonnative-dominated forest that encircle
the weeded plots, Ostertag and Cordell mostly saw failure. But Joe Mascaro, the grad student wh
accompanied us, saw something less value-laden. He saw the future, and as an ecologist, he found
interesting. He saw plants interacting together in new ways, with new creatures dispersing their seed
new competitions for resources. He expects that there will be some casualties when species come
contact for the first time—"local extinctions and whole ecosystem types that will evaporate," h
predicts—but he does not expect that the resulting ecosystems will be worthless just because they a
changed. They will still store carbon in the bodies of their trees, keeping it out of the atmosphe
where it would contribute to global warming. They will still harbor many species. They will still sme
cool and green. At the very least, he says, they should be studied, because they are probably mo
representative of today's Earth than any so-called "pristine" forest. "These ecosystems, like it or no
are going to be driving most of the natural processes on Earth," he says.

Forests like the one we walked through can be managed to achieve a smorgasbord of alternati
goals, based on the various things that people care about. One section might be managed as part of
carbon-sequestration project tied into the global carbon-trading market. This wouldn't require nati
trees, just lots of them. Other sections might be semiweeded into quasi-gardens where Hawaiians ca
gather plants of cultural importance to make leis, canoes, and so on. Another section might look a b
like Ostertag and Cordell's plots and be used to teach schoolchildren about the ecological history
their home state. And if there are any species in the forest at special risk for extinction, such as bir
threatened by avian malaria, sections could be managed by scientists specifically to support them.

Around the world, no single goal will provide for a sensible, well-rounded conservation progra
For example, if we focus only on avoiding extinctions, then we could end up with a zoolike wor
where all species are carefully tended by man but are separated from the ecosystems in which the
once lived, died, and evolved. Similarly, a conservation program that focused only on wh
ecosystems can do for humans would have no time for ecosystems or species that don't contribute
human well-being in an obvious way.

Layering goals and managing landscapes with an eye to the future, rather than the past, is th
cutting edge of conservation, but some ecologists, conservationists, and citizen environmentalists ju
aren't there yet. Among some conservationists, reverence for particular historic ecosystems ca

approach the religious.

One May evening at a Hilo restaurant, over a glass of wine, I talked to Giardina, my guide to th Laupahoehoe Natural Area Reserve, about his professional quest to eliminate introduced strawber guava from the island. Giardina believes that historical ecosystems are superior to the new mixes species emerging in the human-dominated present. And it both shocks him that other people do n share this view, and occasionally unsettles him that he, a scientist, believes it so implicitly.

"Are we so religious about this biodiversity ethic that we need to be called out on it?" he wonde "I mean, one plant is photosynthesizing as well as another, right? The chloroplast in one plant is th same as the chloroplast in any plant. The rest is just window dressing—a series of tubes to get wat or nutrients to that chloroplast. Who cares if it is a chloroplast in ʻōhiʻa or guava? If you really d down to why we should care, you end up with nothing. You are running on faith that we should care."

This faith that native ecosystems are better than changed ecosystems is so pervasive in fields lik ecology that it has become an unquestioned assumption. One often finds it built into experiment which sometimes automatically classify any human change to nature as "degradation." Until recentl it lurked behind conservation organizations' mission statements, which exalted the untouched plac above all others. And it still saturates nature writing and nature documentaries, where the wild always better than the tame. But it wasn't always so. The cult of pristine wilderness is a cultur construction, and a relatively new one. It was born, like so many new creeds, in America.

# 2 | The Yellowstone Model

I drove into the little hamlet of Mammoth Hot Springs one October to attend a scientific conferen on the future of Yellowstone National Park. Mammoth is entirely inside the park and features a hote staff housing, a couple of private houses, and lots of parking. In the fall it also features rutting elk. A I pulled into a parking spot, I saw two big bulls, their heads lowered and antlers entangled, push eac other in slow circles. All around them stood tourists, photographing and filming, some as close as dozen feet away. In the truck next to me, a man watched the spectacle through his windshield as h polished off a Dairy Queen blizzard. Welcome to Yellowstone, the wildest place in the lower forty eight.

Yellowstone National Park covers 3,472 square miles in Wyoming. Its unique features ar geothermal—hot molten rock rises very close to the surface here, providing the heat and pressu behind geysers, hot springs, fumaroles, and bubbling mudpots. Otherwise Yellowstone is a hig plateau, much of it covered in subalpine forest dominated by lodgepole pine. Bears, bison (also know as buffalo), elk, wolves, pronghorn (also known as antelope), and bighorn sheep live here in gre numbers. The sky is big, the canyons are deep, the quiet is startling, and the valley bottoms, in the fa are covered with buttery gold grasses and red-stemmed stunted willows.

Many call Yellowstone the “mother park.” In the story of its creation one can read the story of th rise of a certain set of ideas about nature in America—ideas that excluded humans and that presage the conservation movement’s persistent focus on wilderness. While European conservationis focused on sustainable human use and avoiding extinctions, America perfected and exported th “Yellowstone Model,” based on setting aside pristine wilderness areas and banning all human us therein, apart from tourism.

Much of Yellowstone spent millennia buried under a shifting landscape of ice, until about 13,50 years ago.[1] Initially, the surroundings would have been more like arctic tundra than the pine forest th makes up much of the park today. But well before the vegetation took on its modern look, th ancestors of modern Indians arrived. Archaeologists have found their spear points and other artifac dating back to 10,000 to 11,000 years ago, some made of obsidian from the park’s famed blac Obsidian Cliff.[2]

Euro-American mountain men, trappers, and hunters first visited Yellowstone in the early 1800 but official parties didn’t systematically explore the area until the 1860s.[3] This long delay may hav saved the park, for by 1860 a shift had taken place in American attitudes toward wilderness.

Wilderness has been seen throughout Western history as a source both of inexhaustible resource and of real peril, a domain of mushrooms and monsters, timber and timber wolves. Many Europea

colonizers preferred towns and fields, where things were altogether safer, and they thought it progre
when the land claimed for civilization expanded and savage nature shrunk.

It wasn't until societies attained a little safety, prosperity, and leisure that nature in its wilde
aspect began to seem rather romantic. Eighteenth- and nineteenth-century British Romantics such
William Wordsworth and Percy Shelley took issue with older ideas that nature was inevitably desola
and terrible, that it was a soulless clockwork machine, or that it existed just as a heap of raw materia
from which man could build civilization. On the contrary, they cried, nature was the stuff of life, th
warp and weft of the great unity of which everything was a part. It could, in places, be sublime, eg
shaking. Venturing out into the wild, to some place awe-inspiring, ideally with lots of vertical drops
gloomy forests, Romantics compared their own puniness to the overwhelming forces of nature, a
experienced a mix of pleasure and horror.[4]

It took some time for the colonists and pioneers of America to come around to the idea of th
sublime. While Romantic Europeans were swooning over the beauty of craggy mountains, the glory
solitude, and the handwriting of God in Nature, life was harder in the New World. Land was still bein
"conquered" for civilization, and bears, wolves, and cougars threatened human lives. In the words
wilderness historian Roderick Nash, "The pioneer, in short, lived too close to wilderness for i
appreciation."[5]

By the nineteenth century, some few American men—mostly in the East, where the wilderness ha
been sufficiently beaten back—began to sing the praises of rugged nature. But these early America
nature-lovers did not make a very firm distinction between wilderness and the pastoral in their gener
celebration of all things natural. In 1836 Ralph Waldo Emerson wrote *Nature*, about the transcende
possibilities of "essences unchanged by man; space, the air, the river, the leaf." He enjoyed "perfe
exhilaration" whilst "crossing a bare common, in snow puddles at twilight, under a clouded sky."[6] A
a "common" is a bit of land held in common for everyone in town to graze their livestock, it is hard
what we would call wilderness.

At just about the same time, in the late 1830s, a trapper from Maine, Osborne Russell, uses th
vocabulary of the Romantics to describe the Lamar Valley, now inside Yellowstone National Park, a
a place "where happiness and contentment seemed to reign in wild romantic splendor surrounded b
majestic battlements which seemed to support the heavens and shut out all hostile intruders."[7]

Emerson's protégé and tenant was Henry David Thoreau, still considered by America
conservationists as a sort of Abraham of their creed. Emerson owned Walden Pond, to which Thorea
famously retreated in 1845 to be absolutely alone and free. The pond, which has come, for many, to b
an icon of nature, was not very deep in the woods or really very wild. It was a mere mile and a half
so from Concord Village in Massachusetts, and Irish railroad workers lived in shanties as close as ha
a mile to Thoreau's cabin, thanks to a railroad line from Boston to Fitchburg that ran right by th
pond.[8] Thoreau apparently walked along the line to get to town "every day or two."[9] He wrote, "Th
men on the freight trains, who go over the whole length of the road, bow to me as to an o
acquaintance, they pass me so often, and apparently they take me for an employee."[10]

But this proximity to civilization didn't spoil Thoreau's sense of being out on his own. Th important thing was that his cabin was far enough removed from town for him to escape the commo mode of life, which he saw as a recipe for the bleak "lives of quiet desperation" that most men lead.[1

Thoreau did not describe Walden Pond as "wilderness," but he did discuss wilderness in a 186 essay, "Walking," in which he made a distinction between cities and wilderness and associate wilderness with the qualities of being uncivilized, publicly owned, and generally speaking, due west far north of Concord. Indeed, he may have preferred to contemplate some truly wild places in sma doses. A trip to the Maine woods terrified him in the accepted manner of Romantic encounters wi the sublime. On top of Mount Katahdin, he felt his surroundings to be "savage and dreary," "a place heathenism and superstitious rites—to be inhabited by men nearer of kin to the rocks and wild anima than we."[12] Such intense experiences were good for the soul but not for everyday wear.

Thus Thoreau, who is often seen as a great defender of wilderness—among his most frequent quoted lines is "in wildness is the preservation of the world," which is often misquoted as " *wilderness* is the preservation of the world"—actually preferred a middle ground between the tru wild and the truly civilized.

The reason we now often read Thoreau as a champion of wilderness may have much to do with th influence of one of his biggest fans, parks advocate John Muir. Muir was a Scottish-born explore reverent Christian, ecstatic naturalist, and energetic nature preservationist active from the 1860s un his death in 1914. In forest "temples" in the Sierra Nevadas in California, he saw "sparks of the Divi soul" in every rock and leaf.[13] Throughout his career he whipped up American enthusiasm abo nature in magazine articles and other writings and advocated for national parks. He saw himself as John the Baptist figure, trying to bring civilized humans to God through the glory of His mountai and forests.[14] He even looked the part. His friend, magazine editor Robert Underwood Johnso recalled that "he looked like John the Baptist as portrayed in bronze by Donatello and others of th Renaissance sculptors—spare of frame, hardy, keen of eye and visage, and on the march eager movement."[15]

Muir was a great admirer of Thoreau but altogether more picky when it came to nature. On wilderness would really send Muir into ecstasies. According to historian Roderick Nash, "Much as h admired Thoreau's philosophy, Muir could not suppress a chuckle at a man who could 'see forests orchards and patches of huckleberry brush' or whose outpost at Walden was a 'mere saunter' fro Concord."[16]

But what did "wilderness" consist of for Muir? It must not be changed radically to suit ma —"ploughed or pastured," "hacked and trampled."[17] Most economic uses of the land would therefo be ruled out. Muir also mentions the availability of solitude as one necessary component.

But although Muir, like Thoreau, has often been cast as an early champion of reverence for pristi wilderness, his writing reflects a more open mind toward people than many remember. For exampl he does say that any man can live in harmony with nature, build houses, raise crops there, even do little low-key mining, as long as they are not "mere destroyers … tree-killers, wool and mutton me

spreading death and confusion."[18] So while he sees "white gold-hunters" as "spoiling" the Black Hil
of South Dakota, he classes the "free trappers of the early romantic Rocky Mountain times" with t
"picturesque cavalcade of Sioux savages" as the rightful inhabitants of the place.[19]

Muir's ideas about wilderness as sacred space are his chief legacy, however, and he undoubted
helped create an American conservation movement that often focused on protecting pristi
wilderness rather than on achieving coexistence between humans and other species. He was certain
more interested in nature for nature's sake than many of the men who set up the first parks. Mu
fought for California's Yosemite because he was inspired by its untouched beauty,[20] whi
Yellowstone was made a public park in 1872 with the encouragement of the Northern Pacific Railroa
mostly to prevent the geysers and springs from becoming private, for-profit tourist attractions.

Yellowstone's plants and animals were hardly considered when it was made a park, and initiall
hunting went on in the area as usual. In the 1880s George Bird Grinnell, editor of *Forest and Strean*
visited the park and began to write about the toll hunting was taking on the wildlife, and in 188
hunting of traditional game species was banned in the park.[21] The nascent wildlife-conservatio
movement that Grinnell spoke for was a product of what historian Nash calls the "wilderness cult,"
national fad for all things wild that emerged in the 1890s, just as urbanizing, industrializi
Americans settled down to enough safety, prosperity, and leisure to enjoy the wilderness.[22] Wilderne
historian William Cronon suggests that this movement was an eighteenth-century version
primitivism—"the belief that the best antidote to the ills of an overly refined and civilized mode
world was a return to a simpler, more primitive living."[23] To my mind, the wilderness cult can also b
seen as the Americanization of an essentially European Romanticism, with less swooning and mo
shooting; less poetry and more adventure stories.

In 1893 the influential American historian Frederick Jackson Turner famously declared the frontie
closed. In his speech to the American Historical Association, he posited that the frontier had create
much that was good in the American character: independence, toughness, democracy itself.
Americans believed him and mourned the death of the Wild West by going camping, starting Bo
Scout troops, and reading Jack London stories about hardscrabble life in Alaska. "The wilderness cu
comprised a broad spectrum from those who sallied forth to those who read animal stories to the
kids," says Arizona State University historian and ecologist Matthew Chew. "The former were les
numerous than the latter."

Americans found wilderness salubrious. Writing in 1901, Muir said that wildness was a necessi
for "tired, nerve-shaken, over-civilized people" suffering from "the vice of over-industry and th
deadly apathy of luxury."[25] And a version of this idea—wilderness as tonic for the "neurasthenia" an
garden-variety "overstrain" of fast-paced city life—is still with us. Wilderness was considered such
tonic that it was actually prescribed by some doctors. Among them was Silas Weir Mitchell, the nerv
doctor who famously prescribed a disastrous "rest cure" for the writer Charlotte Perkins Gilman. Sh
turned her ordeal into a short story, "The Yellow Wallpaper," about how easy it is to go around th
bend when there's nothing to occupy your mind. Mitchell took a different and possibly mo

successful tack with his male nerve patients. To them he offered a “west cure” in which patients we instructed to head west, engage in a “sturdy contest with Nature,” and write about it.[26] Among h patients so prescribed was Owen Wister, whose 1902 novel *The Virginian* about his experiences o west started the American fad for cowboys. Wister blanched at the idea of building an elevator at th Grand Canyon of the Yellowstone as a “vulgarization” of “a supreme piece of wild natural beauty.”[27]

Wilderness cultist supremo Teddy Roosevelt famously advocated a “strenuous life” for America men, filled with hunting, fishing, physical hardship, and derring-do. *The Virginian* was dedicated him. Roosevelt believed that the proper stage for the strenuous life was the wilderness, where gam and fish are there for the taking. Roosevelt, of course, also found the wilderness beautiful, but for hi its key role was as a kind of many-faceted opponent against which to test oneself. The difficult fa was that triumphing against this opponent often meant diminishing it by, for example, making road ribbons of civilization cutting through the wilderness, or by hunting or trapping and removi specimens of its wild animal life. The near-extinction of the American bison was a case in point. “H is a truly noble beast, and his loss from our prairies and forests is as keenly regretted by the lover nature and of wild life as by the hunter,” Roosevelt wrote in 1897.[28]

The solution was parks. Parks would become a source of game, which would overflow onto lan where they could be hunted. Roosevelt described Yellowstone as “a natural breeding-ground an nursery for those stately and beautiful haunters of the wilds which have now vanished from so ma of the great forests, the vast lonely plains, and the high mountain ranges where they once abounded.”

And parks became a place where Americans could get a look at the vanished frontier. They cou see the West, even after it was won. Or as Grinnell put it in 1882, Yellowstone could be like a “rock around which the “tide” of immigrants heading west to farm would break, “leaving it undefiled by th unsightly traces of civilization” for “generations yet unborn.”[30]

Grinnell’s idea about the value of Yellowstone’s pristineness was echoed eighty years later. In th early 1960s, a committee of scientists led by A. Starker Leopold, son of the famous conservationi Aldo Leopold, met to consider some of the vexing management problems at the United State national parks. The report they produced, known as the Leopold Report, may be among the mo frequently quoted documents in American conservation history. Here is their view on what the goal wildlife management in the parks should be: “As a primary goal, we would recommend that the biot associations within each park be maintained, or where necessary recreated, as nearly as possible in th condition that prevailed when the area was first visited by the white man. A national park shou represent a vignette of primitive America.”[31]

The influence of this report has been enormous. Over time, according to Yellowstone historian Pa Schullery, it has developed an “almost scriptural aura.”[32] It neatly encapsulates a long and widely he opinion in American conservation that natural areas *should* look like they did before Europea showed up, that this is their correct state, the holy baseline. Ever since, managers at Yellowstone hav obsessed over the state of the area in 1872, when it was made a park. They have pored throug historical accounts to determine how many elk were there, and whether they wintered in the par

They have used old photos to determine the density of aspen. The National Park Service still aims protecting parks' "natural condition," which it defined in 2006 as "the condition of resources th would occur in the absence of human dominance over the landscape."[33]

This high opinion of pristine wilderness and low opinion of human changes to the landscape hav always coexisted in America with a more pragmatic school of thought, which seeks to combine huma use and nature preservation. And the pragmatists have arguably been the victors in real terms. A ma of U.S. national parks, which instantiate the pristine wilderness idea, shows a white continent flecke with green here and there. A map of lands managed for resource use by the Forest Service, the Burea of Land Management, and other agencies looks like the West has been tie-dyed. The Park Servic manages just 84 million acres out of 650 million acres of federally owned land.

Then again, through the Wilderness Act of 1964, the wilderness purists were able to layer the ideas on top of those public use lands. The act takes a pristineness approach, saying, "A wilderness, contrast with those areas where man and his own works dominate the landscape, is hereby recognize as an area where the earth and its community of life are untrammeled by man, where man himself is visitor who does not remain."[34] Any federal land can be designated wilderness, and once it is, th agencies running it must preserve its wilderness character. One of its key provisos bans permane roads. One hundred and nine million acres have so far been designated wilderness in the United State Sixty six million acres of that are not already parks.

Acreage aside, the pristine wilderness idea has been incredibly influential, and not just in Americ It underpins the Yellowstone Model of nature preservation. The formation of Yellowstone—c perhaps, the ban on hunting in Yellowstone—was a breakthrough in conservation. Never before had society voluntarily restrained itself from using natural resources in deference to "higher" uses nature, such as pure enjoyment. Since Yellowstone's creation parks and nature reserves have been se up around the world. By one count, about 13 percent of the Earth's land (and a paltry 1 percent of i oceans) are protected areas, and it is undoubtedly the richer for it.

Americans and Europeans from the very beginning of the "wilderness cult" days made it the business to push for nature preservation in other countries, on the Yellowstone Model.[35] Countri with lots of land inhabited by few people—or by people with few rights—began their own nation parks. From the 1870s to the 1890s, Australia, Canada, New Zealand, and several African countrie opened parks.[36] With their own wilderness increasingly used up, westerners formed organizations lik the International Union to Preserve Nature (now the International Union for Conservation of Nature IUCN) and the World Wildlife Fund, in 1948 and 1961 respectively. These organizations continued t fight for new parks and other protected areas throughout the world. Soon the focus on protected are got scientific support. In the late 1970s and early 1980s conservation biology was born as a scientif discipline. Two of its founders, Michael Soulé and Bruce Wilcox, wrote in the field's first textboo that "protected areas" are "the most valuable weapon in our conservation arsenal."[37]

But protected areas are not without their problems. Most early parks were chosen both for the perceived lack of value as working landscapes and for the value they could deliver to tourists seekin

scenic beauty and the sublime. Early parks are all craggy, bedecked with grandiose vistas and ta
waterfalls. Preserving something less sexy, like a swamp, just because it was a rare ecosystem, wou
have to wait until the 1940s.[38] Existing protected areas are disproportionately steep, rocky, barren, ar
covered in ice—useless for economic gain, and unrepresentative of the full spectrum of ecosystems o
the planet.

Parks located on more fertile, flat, and workable land have another problem: people often we
already living there when the protected area was created. And because the Yellowstone Model requir
"untouched" nature, the people were often kicked out. Both Yosemite and Yellowstone were populate
before they were parks. Yosemite Valley was the on-and-off home of the Miwok Indians, a group o
whom were expelled to make way for gold miners in 1851 by the "Mariposa battalion" under th
authority of the Mariposa County sheriff. But they didn't stay out.[39] Later Muir himself called for th
expulsion of all Indians from Yosemite National Park.[40] A few lived in the park in the early decades o
the twentieth century, on display, in an "Indian village." The last family left in 1969.[41] In Yellowston
an initial agreement to let Indians stay was called off in 1877, and the area's residents were forcib
removed.[42]

According to journalist Mark Dowie, about half of the Earth's protected areas were "eith
occupied or regularly used by indigenous peoples." Millions of people have been moved in the la
century to protect nature, but the irony is that they were doing the least harm—after all, that is wh
their land had sufficient nature to interest conservationists in the first place.[43] Today's conservatio
organizations are increasingly realizing that a protected area doesn't have to be depopulated to wor
But Dowie believes that new "conservation refugees" continue to be created."[44] The "no peop
allowed" baggage of the Yellowstone Model is hard to shed.

Depending on the goal at hand, protected areas can indeed be the most valuable weapon in o
arsenal. But even good weapons can misfire, causing collateral damage and casualties by friendly fir
And we mustn't believe that protected areas are the *only* weapon in our arsenal.

The mother park is also a good place to examine the tenacious idea of the "balance of nature." Whe
conservationists guess what a park would look like in the absence of human domination, they assum
that it would not have changed much on its own. Historical baselines are useful only for stab
ecosystems. In the second half of this chapter, I'll explain how ecologists first embraced, the
discarded this idea of a static or stable nature. Yellowstone, as it happens, is a great example of
place that has no stable state we can hang our hat on. It has always been in flux.

Although people didn't think in terms of ecosystems in 1882, park historian Paul Schullery believ
that when George Bird Grinnell wrote about the park as a rock above the tide of immigration, h
expected Yellowstone to persist, unchanging forever: "It seems pretty likely to me that, within th
reasonable natural variations as he surely understood them (harsh winters, and so on), he w
imagining that some ongoing and relatively stable Yellowstone landscape would result from ju

setting it aside and keeping it undeveloped."

That would have been the general view in the nineteenth century. "I think the implication is cle among those people that it was possible to set it aside and keep it as something that would just go and on," says Schullery—though he adds, like a true historian, that it is foolish to mal generalizations about what "everybody" in the nineteenth century thought based on the writte documents they left behind.

The idea of nature as unchanging or fluctuating only modestly around a stable equilibrium, ofte called the "balance of nature" view, goes back a long way, at least to the ancient Greeks.[45] Th American proto-conservationist George Perkins Marsh summed up his generation's view in 1864 b writing that "without man, lower animal and spontaneous vegetable life would have been constant type, distribution, and proportion, and the physical geography of the earth would have remaine undisturbed for indefinite periods, and been subject to revolution only from possible, unknow cosmical causes, or from geological action."[46]

At the end of the nineteenth century, early ecologists such as Eugenius Warming gave the "balanc of nature" scientific credence. Warming and others looked into the question of "succession"—th changes in a particular landscape over time, leading to a final and stable endpoint. A fire might wip out a forest, and a completely new set of plants might grow up from the ashes. But early ecologis noted that those plants would slowly be replaced by another suite of species, and those by still anothe until eventually the original species that characterized the forest returned and took their rightful plac

Most influential among these early ecologists was Nebraska native Frederic Clements, active fro the turn of the century through the 1930s. Clements saw newly available land as being colonized by random, unstable suite of plants that would, over time, gravitate toward a predictable cast characters, determined by climate. This grouping of species, the "climax," would go on foreve barring disturbance such as fire, windstorm, plow, flood, or ax.[47] Clements believed that climax would stay the same forever because they are perfectly balanced—in a state of stable equilibrium, which any deviations from the mean tend to decrease over time, like a swing slowing down to har still after a child has hopped off it.

With the help of animal ecologist Victor Shelford, Clements extended his succession arguments t all organisms in nature. So the animals, as well as the plants, were included in the climax communit which inexorably sprang up in any given climate.[48] Clements believed that every place on Earth ha one single correct climax community, which he considered to be a kind of "organism." All th activities of plants and animals within this organism would eventually cancel each other out; if acor were plentiful, squirrel populations would increase and eat them, then decrease as the food supply ra out. Oaks and squirrels would always ultimately return to an equilibrium state. Clements believed th no internal force could push the community to a new state.

Ecologist Henry Gleason at the University of Michigan, a contemporary of Clements, disagree with this idea. Gleason believed plant communities were assembled mostly by chance, based on wh got there first and what was able to hold on in the face of competition by other species. B

Clements's idea of climax vegetation lodged itself firmly in the heads of many ecologists for years f
come.

While some ecologists, including Marston Bates, tried to move away from Clementsian ideas in t
1950s, other ecologists hewed to the idea of stable equilibriums, especially the growing "systen
ecology" group that studied energy and nutrient flows through ecosystems in the 1960s and 1970
Such ecologists could model a lake, a forest, or even the whole Earth as a kind of large machine wi
inputs and outputs.[49] At the end of the year, they believed, most of these systems balanced out. Th
sun went up, photosynthesis occurred, nitrogen and other nutrients moved around, decomposers brol
things down, big guys ate little guys, and the sun went down, with the ecosystem pretty much t
same.[50]

This notion of stability persisted through the decades, even as ecologists learned more about ho
ecosystems responded to what they called *disturbance*. Many plants, it emerged, could not on
tolerate disturbance but actually thrived on it. In some species, seeds can't germinate until they hav
been through a fire. In forests, light-hungry species depend on tree-falls that open up the canopy
make their move. But instead of upending the status quo, this expanding understanding th
disturbance was not the enemy of nature was neatly folded into the overall stability theory. By the la
1970s, American ecologists were talking about the importance of patchiness in an ecosystem,[51] an
describing a forest composed of patches of different ages as a "shifting mosaic."[52] But this shiftin
mosaic was, so to speak, the texture of the overall steady state.[53] The forest as a whole was sti
considered to be constant. The numbers and total mass of each species of plant or animal in any give
ecosystem were believed to be stable over time, fluctuating only modestly. And unless disturbanc
was severe, ecosystems could "heal" themselves, returning to their original composition.[54]

Generations of field ecologists tried to make their observations fit this model, but the real wor
was stubbornly unpredictable. One of the quantitative ecological models that predict stab
equilibriums in nature is the Lotka-Volterra equations, named after two ecologists. These equation
predict that predator and prey populations will oscillate in an elegant symmetry: the moose will boom
providing more food for the wolves, who will then boom and eat most of the moose; with the moo
all eaten, the wolves will starve, and once wolf numbers are down, the moose will boom again. Moo
and wolf will dance this way together forever, or so the equations say. The problem, writes ecologi
Daniel Botkin, is that so many contingencies are left out of this model. These mathematical moo
and wolves are all identical. There is no infancy or old age, no disease, no parasites, no pac
hierarchy, no vegetation scarcity, no cruel winters, no refuges from wolves, and no other prey beside
moose.[55] Botkin, as an eager young ecologist, tried his best to squish data on moose and wolves that l
and others gathered on Isle Royale in Lake Superior into Lotka-Volterra oscillations. It would not fi
For Botkin, the implication is that these predictable cycles are, in real life out in nature, swamped b
sheer randomness (in ecological jargon, *stochasticity*).

Botkin wasn't the only one to fail to extract the expected curves from nature. Mathematic
biologists have found that chaos, rather than equilibrium, is more common in the simple food wel

they study. The authors of one such study wrote that in their Baltic Sea plankton communit maintained in a lab for over eight years, "predictability was limited to a time horizon of 15–30 day only slightly longer than the local weather forecast."[56]

Botkin's experience on Isle Royale disagreed with the pervasive background assumption th ecosystems were fundamentally stable. In his 1990 book *Discordant Harmonies*, he characterized th assumption as "dominant in textbooks on ecology and the popular environmental literature," "th foundation of the twentieth-century scientific theory about populations and ecosystems," and "th basis of most national laws and international agreements that control the use of wild lands and wi creatures."[57]

While Botkin's book was well read among ecologists, he feels that the assumption of stability still with us and is as tenacious as ever. "The balance of nature idea is so deeply ingrained that it still dominant," he says. "If you ask an ecologist if nature never changes, he will almost always sa no. But if you ask that same ecologist to design a policy, it is almost always a balance of natu policy."

As Botkin suggests, these days most professional ecologists do not believe in Clementsia succession. They admit that systems in true long-lasting equilibrium are the exception. Disturbanc are so common in some systems that no stable endpoint is ever reached. Even in sleepy places whe disturbances like fires, mudslides or volcanoes are rare, ecosystems barely have a chance to sett down into a serious self-perpetuating groove before the climate changes.

Feng Sheng Hu, a paleoecologist at the University of Illinois in Urbana, likes to quote the Gree philosopher Heraclitus, to his students: "the only constant in nature is change itself." As an exampl he cites the magnificent old-growth forests of the Pacific Northwest. To the untrained eye, the seve hundred-year-old Douglas-fir trees that dominate the scene look not only finished, somehow, b timeless, as if they had been sitting there, knee deep in the hummus of their ancestors, for millions years. But from a forest paleoecologist's perspective, they are *only* seven hundred years old. "Th species in fact has the ability to live 1,000 or 1,200 years," Hu says. "But you don't see many of the that old. So what happened?"

The biggest driver of change in these forests, within the past couple of million years or so, has bee what some researchers call *secular climate change*—climate changes that were not humanity's fau Seven hundred years ago marked the end of the Medieval Warm Period, a dry and warm climat episode that would likely have seen frequent fires. The cooler, wetter climate that came afterwa allowed the "old growth" forests we see today to begin to develop. And that first generation Douglas-firs is still growing up, with a good five hundred years left to go—barring any ne disturbances. Here the climate changes faster than the life span of a single generation of trees.

"The point," says Hu, "is that there really isn't one unique state of natural conditions for any give landscape. What is more realistic is to set a range of natural conditions."

I asked Hu if he could identify a "quiet moment" where planet Earth's ecosystems stayed put lon enough to be considered in some kind of stable equilibrium, something we could use as a baseline. H