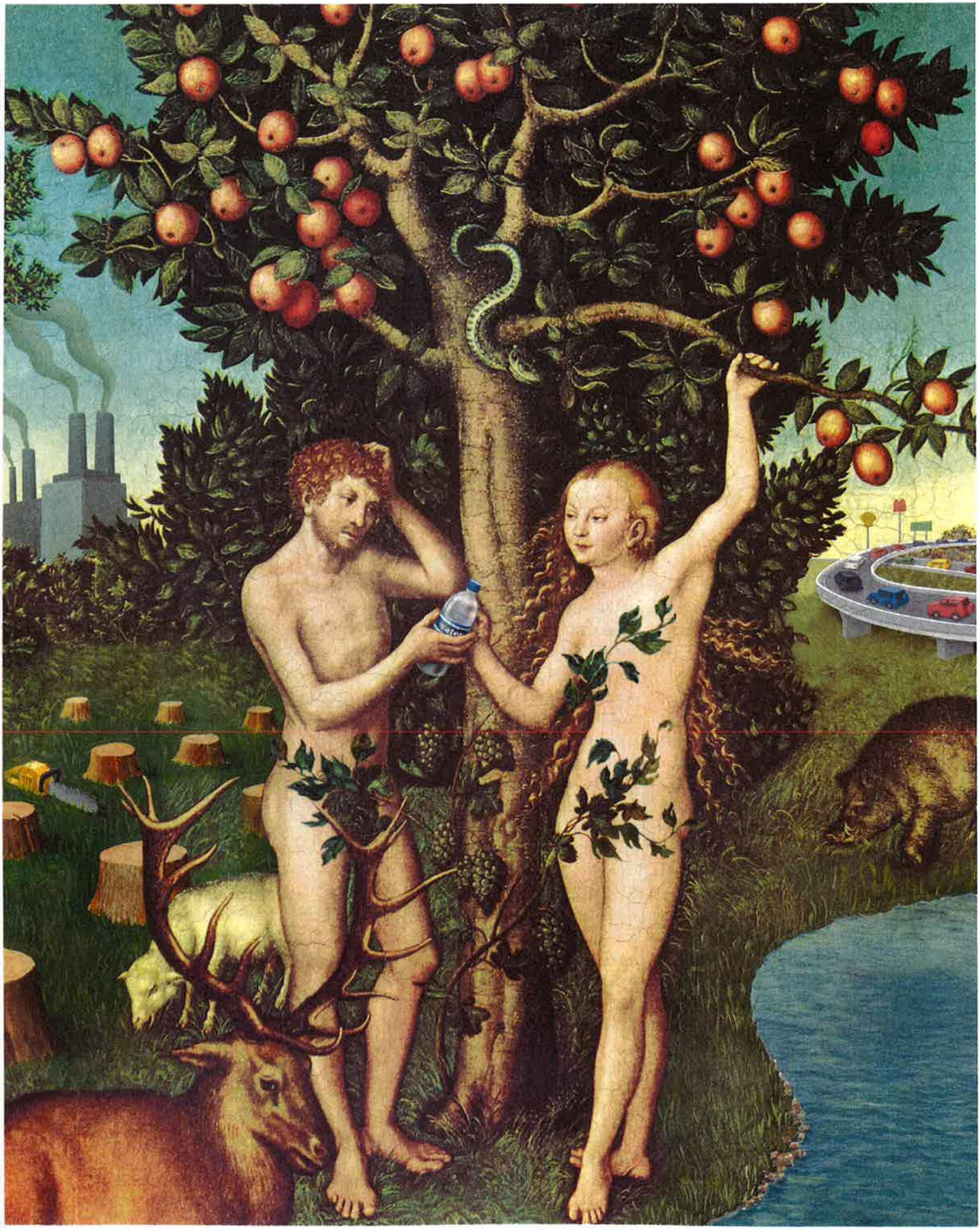

THE NEW NORMAL

As though working through the five stages of grief, more and more ecologists are reluctantly accepting that we live in a human-dominated world. And some are discovering that patchwork ecosystems might even rival their pristine counterparts.

BY EMMA MARRIS

Joe Mascaro, a PhD student in a T-shirt and floral-print shorts, is soaking up the diversity of the Hawaiian jungle. Above, a green canopy blocks out most of the sky. Aerial roots wend their way down past tropical trunks, tree ferns, and moss-covered prop roots to an understory of ferns and seedlings. The jungle is lush, humid, and thick with mosquitoes. It is also as cosmopolitan as London's Heathrow airport.

This forest on the Big Island features mango trees from India (*Mangifera indica*); *Cecropia obtusifolia*, a tree with huge, star-shaped leaves from Mexico, Central America, and Colombia; rose apples (*Syzygium jambos*) from southeast Asia; tasty strawberry guava (*Psidium cattleianum*) from the threatened Atlantic coast of Brazil; and a smattering of Queensland maples (*Flindersia brayleyana*) from Australia. It also has candlenuts (*Aleurites moluccana*), a species that humans have moved around so much that its origins have become obscure. There is at least some native Hawaiian representation in the form of hala, or screwpine (*Pandanus tectorius*), which is pictured on the crest of Punahou School, where U.S. President Barack Obama studied. There are no Hawaiian birds here, though. Mascaro sees plenty of feral pigs, descendants of those brought by settlers from other parts of Polynesia or from farther afield. The soil is black and rich. Mascaro likes it here.

Most ecologists and conservationists would describe this forest in scientific jargon as "degraded," "heavily invaded," or perhaps "anthropogenic." Less formally, they might term it a "trash ecosystem." After all, what is it but a bunch of weeds—dominated by aggressive invaders, almost all of them introduced by humans? It might as well be a city dump.

A few ecologists, however, are taking a second look at such places, trying to see them

Illustration by Darryl Brown, courtesy of George Fox University

without the common assumption that pristine ecosystems are good and anything else is bad. The nonjudgmental term for such a place is "novel ecosystem"—one that has been heavily influenced by humans but is not under human management. A working tree plantation doesn't qualify; one abandoned decades ago would. A forest dominated by nonnative species, like Mascaro's mango forest, counts—even if humans never cut it down, burned it, or even visited it.

No one is sure how much of Earth is covered by novel ecosystems, but Erle Ellis, a map specialist at the University of Maryland, has taken a stab at quantifying it. Defining novel ecosystems as "lands without agricultural or urban use embedded within agricultural and urban regions," Ellis estimates that at least 35 percent of the globe is covered with them. Their share of the planet will probably expand, and many ecologists think that these novel ecosystems are worthy of study and, in some cases, protection.

For one thing, some novel ecosystems seem to provide a habitat for native species—sometimes crucial habitat, if all that the species originally had is gone. They also often do a good job of providing ecosystem services—those things nature does that benefit humanity, such as filtering water in wetlands, controlling erosion on hillsides, sequestering carbon from the atmosphere, and building soil. Provision of ecosystem services is a popular argument for preserving intact ecosystems, but many preservation advocates blanch a little when it comes to making the same case for these "weedy" areas.

Mascaro actually prefers novel ecosystems to some native ones that are so vulnerable to damage by humans that they require intense management to maintain their "pristine" state. He sees the latter as museum-piece parks. "Do we value the fact that nature contains a list of things that were there 1,000 years ago, or do we value it because it has its own processes that are not under human control?" Mascaro asks. For him, the value is in the processes.

Watching such processes unfold has scientific merit to many researchers. Novel ecosystems are often ideal natural experiments for studying things such as community assembly—how species find their way to a place and which species become permanent residents—and evolution of species in response to one another. In essence, it takes a dynamic ecosystem to study ecosystem dynamics, and these novel ecosystems are the planet's fastest movers. Mascaro bets that all the rules of thumb and general relationships developed over the years by ecologists working in "intact" or "historical" ecosystems will probably also apply in these new assemblages, but no one knows for sure—because no one has studied them much.

There are some questions about the ways in which things might be different in novel ecosystems. Will landscape types remain the same, with forests replacing forests and grasslands replacing grasslands? Will novel ecosystems evolve faster? Will they be dominated by one species, as many who study invasive species fear? Will species composition oscillate wildly for decades or even longer? "We can't know except to observe it," says Mascaro.

One of the first researchers to see the importance of the scrubby parts of Earth was Ariel Lugo, a forest-service ecologist in Puerto Rico. In 1979, Lugo was managing researchers who were measuring the ground covered by trees within pine plantations not being actively managed. His technicians came back to headquarters sweaty and discouraged. "They said that they couldn't measure the trees without clearing all the new undergrowth," says Lugo. "They said it was impenetrable. I thought they were wimps."

The idea that ecosystems dominated by pine, an invasive species, were so thick that his workers couldn't even walk through them contradicted a central assumption of ecology: that native forests will be the most lush. Millennia of co-evolution should have created an ecosystem in which almost every niche is filled, converting the available energy into trees and other species in the most efficient way. Conservationists also generally assume that native ecosystems contribute best to ecosystem services.

Lugo went to see for himself. Sure enough, the pine plantations were bursting with vigor, far more so than nearby native-only forests of

the same age. Lugo did a systematic study of the pine plantations and some mahogany ones, finding that the plantation understories were nearly as species-rich, had greater above-ground biomass (the sheer weight of all the living things), and used nutrients more efficiently than the native forest understories. He submitted his results to *Ecological Monographs*. (1) Reviewers were horrified. In the end, it took almost a decade to get the paper past peer review.

Since then, Lugo has found many novel ecosystems in Puerto Rico and elsewhere that are much more diverse than native forests but largely ignored by ecologists. "That diversity doesn't count because they are the wrong species," says Lugo, shaking his head. He's found alien trees that, by creating a shaded canopy on parched, degraded pasture, make possible the establishment of native trees that could never cope with such an environment on their own. As a result, he now finds it difficult to despise invasive trees (as he thinks his colleagues do), and he even embraces the change. "My parents and their parents saw one Puerto Rico," he says, "and I am going to see another Puerto Rico, and my children will see another."

To think there is some kind of Garden-of-Eden, pristine ecosystem is just going to get us nowhere.

Lugo wasn't the only researcher thinking along these lines, but it was not until 2006 that the new approach gained a manifesto—and a name. Lugo and 17 other researchers published a paper, "Novel ecosystems: theoretical and management aspects of the new ecological world order," suggesting that such systems merited scientific attention. (2) To demonstrate the depth of resistance to the idea, the published paper quoted referees' comments on the submitted manuscript. "One reviewer commented that the examples are ecological disasters, where biodiversity has been decimated and ecosystem functions are in tatters, and that 'it is hard to make lemonade out of these lemons.'" But Lugo and his colleagues saw it in a different light: "We are heading toward a situation where there are more lemons than lemonade," they wrote, "and we need to recognize this and determine what to do with the lemons."

Lemons can have their own value, says restoration ecologist Richard Hobbs, lead author of the paper and now at the University of Western Australia in Crawley. Some novel ecosystems, he says, are "alternative stable states," relatively entrenched ecosystems that would be very difficult to drag back to historical conditions.

Around the time the paper came out, Mascaro became interested in Lugo's work and set out to see whether his results could be replicated on the windward side of Hawaii's Big Island. Were the many novel ecosystems on the island nurturing any native species? Were they providing ecosystem services? He studied 46 forests growing on lava flows of varying ages at various altitudes and dominated by a variety of species, including albizia (*Falcataria moluccana*), a fast-growing tree from southeast Asia, and Australian ironwood (*Casuarina equisetifolia*). He found that, on average, the forests had as many species as native forests. But by and large, they weren't incubating natives as they seemed to in Puerto Rico. (3)

Part of the reason for the difference may lie in the uniqueness of Hawaiian flora, which evolved in isolation for up to 30 million years. (4) Not many plants got to Hawaii in the first place, so competition and predation pressures weren't very fierce. Without having to worry about being eaten by anything larger than an insect, raspberries and roses lost their thorns and mints lost their minty defense chemicals. When people introduced plants from other parts of the world along with their attendant herbivores, Hawaiian plants couldn't compete.

But Mascaro's results didn't put him off the novel-ecosystem concept. For one, he found that in many measures of forest productivity, such as nutrient cycling and biomass, novel forests matched or outproduced the native forests. They might not be natural in the eyes of purists, but they are behaving exactly as they should. "These ecosystems, like it or not, are going to be driving most of the natural processes on Earth," he said at the 2008 Ecological Society of America meeting in Milwaukee, Wisconsin.

It's a message that Peter Kareiva, chief scientist at The Nature Conservancy in Seattle, Washington, wants to see move from the academic world to the world of conservation management. "You hear conservationists talk about what they want to save, what they want to stop," he says. "They should talk about what they want the world to look like in 50 years." Studies of novel ecosystems could help conservationists "face the facts and be strategic," Kareiva says, rather than try to beat back the unceasing tide of change.

Kareiva is a great fan of the ecosystem-services argument for preserving nature. But he admits that the problem of what to do when novel ecosystems provide better services than the native ones is "a question we don't talk about that much." Nevertheless, he is willing to imagine a world in which, for example, exotic strains of the reed *Phragmites* are allowed to thrive in U.S. wetlands because they provide a great habitat for birds—rather than be torn out in an expensive and potentially fruitless attempt to return native vegetation to dominance.

Ecosystem-service arguments are powerful enough to get some ecologists to abandon, or at least put aside, their deep distrust of novel ecosystems. Like many of his peers, Shahid Naeem, an ecologist at Columbia University in New York, says he "would love to get rid of every invasive species on the planet and put all the native species back in their place." Yet he's willing to see what can be made of novel ecosystems because he feels an imperative to improve conditions for the billions of humans on Earth.

The idea that novel ecosystems provide welcome diversity has also gained traction. Thinking on invasive species has mellowed significantly since the field was first established in the 1950s. Newer work by the likes of Mark Davis at Macalester College in Saint Paul, Minnesota, and Dov Sax at Brown University in Providence, Rhode Island, has shown that the vast majority of species that humans move around can slot into new ecosystems without driving anything else extinct—and that the common vision of invasive plants forming dense monocultural stands taking over everything else in their path is actually the exception. Yet the newcomers in novel systems can still be a genuine worry.

Peter Vitousek, an expert on Hawaiian biodiversity at Stanford University in California, puts albizia forests into the category of dangerous invaders because they wipe out stands of the native 'ōhi'a tree (*Metrosideros polymorpha*). He acknowledges the services that novel ecosystems provide, noting, "They may even support native biological diversity in some important circumstances." But, he adds, "As with many good ideas, [tolerance of novel ecosystems] can be taken to an extreme at which it is no longer useful. I think most of the albizia-dominated stands of Hawaii represent that extreme." His point is well illustrated where one of Mascaro's albizia forests abuts a native 'ōhi'a forest. The albizia trees on the boundary actually lean out toward the 'ōhi'a—growing sideways to escape the shade of the adjacent row, encroaching on the natives' sunlight, and looking poised to usurp them. It is a menacing spectacle and an apt symbol for their tireless expansion.

Mascaro grants the point. "I can understand where a manager wants to bulldoze an albizia forest if they are worried that it is going to exterminate an ecosystem type that is the last on Earth," he says. "If we want to debate whether to use or conserve novel ecosystems, we will always have to deal with the risk they pose to other systems. But at the moment, we're scarcely debating it at all."

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Novel ecosystems are likely to cause at least some extinctions. For example, species that have evolved dependent relationships with other species are less likely to do well in a world in which the pot is stirred and everything is redistributed. Hawaiian honeycreepers, beautiful birds that often feed on only one type of flower, are not doing well; several are already extinct. So for those who care about slowing or stopping the rate of such extinctions, novel ecosystems are a net negative.

James Gibbs, an ecologist at the State University of New York in Syracuse, subscribes to

this view. "I think celebrating [novel ecosystems] as equivalent or improved is not appropriate." As an example, he points to Clear Lake in Northern California, where the number of fish species has risen from 12 to 25 since 1800. Sounds like a success story. But, says Gibbs, species that had been found only in that lake were replaced with fish that are common elsewhere — so there was a net loss in biodiversity. A similar caveat may hold for the genetic diversity hidden within a species. Forests dominated by the offspring of a handful of exotic colonizers could be less genetically diverse than forests that have sat there for thousands of years.

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In the end, the question of novel ecosystems, like so many questions in ecology and conservation, boils down to what should be valued most in nature. For people who value processes, such as Mascaro, novel ecosystems are great hubs of active evolution. For those who value ecosystem services, any novel ecosystem could be better or worse than what came before, depending on how it operates. For those who care about global extinctions or about preserving historical ecosystems, novel ecosystems are bad news. Gibbs says he values the exquisite complexity of ecosystems that have evolved together over thousands or millions of years. "Why are we worried about the extinction of languages, the roots of music, all these weird cuisines?" he asks. "There is something about diversity and our need to steward it. It is the subtlety and the nuance and complexity that makes life interesting." Novel ecosystems seem, to him, to lack this value, to be artificial, "sort of like eating at McDonald's."

To Kareiva, though, that attitude is "one of the reasons the conservation movement is failing. To think there is some kind of Garden-of-Eden, pristine ecosystem . . . There is none! That view is just going to get us nowhere."

Indeed, the Garden-of-Eden view, in which ecosystems are static, is no longer widely held. This means that novel ecosystems, far from being a new phenomenon, simply represent the latest changes on a dynamic Earth. Gradual climatic changes and sheer randomness mean that some species wander around continents over vast timescales, fleeing glaciers, splitting up, and reforming. This is why Davis and some others do not like the "novel" label. "Ecosystems are always new, from one year to the next," says Davis. "Ecosystems are always encountering new species—it might be not from another country but from 100 meters upstream. Much more accurate would be to refer to these as 'rapidly changing' ecosystems—but I guess that is not catchy enough."

Standing in his Hawaiian forest, Mascaro is all too aware of change—and it is something he values, even if humans did have a hand in the process. He never swore allegiance to preserving ecosystems as they were before humans arrived, as many conservationists of an older generation did. "People come up to me and say, 'It sounds like you've given up,'" says Mascaro. "I want to say, 'I never took up arms, my man.' This isn't about conceding defeat; it is about a new approach." ❧

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