



# RAGAMUFFIN EARTH

A small group of ecologists is looking beyond the pristine to study the scrubby, feral and unintended. **Emma Marris** learns to appreciate 'novel ecosystems'.

Joe Mascaro, a PhD student in a T-shirt and floral print shorts, is soaking in 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 understorey 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 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 US 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, and almost all 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 without the common assumption that pristine ecosystems are 'good' and anything else is 'bad'. The non-judgemental term is 'novel ecosystem'. A novel ecosystem is 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 non-native species counts, like Mascaro's mango forest, 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. To help with this article, *Nature* asked Erle Ellis at the University of Maryland, Baltimore County, who produces maps of ways that humans use Earth, to take 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% of the globe is covered with them (see map, overleaf). 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



ILLUSTRATIONS BY JANUSZ KAPUSTA

job of providing 'ecosystem services', those things that 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 of its 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 in 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.

### Havens of biodiversity?

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 that were 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 went against a central assumption of ecology: that native forests will be the lushest. 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 vigour, 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, and found that the plantation understoreys 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 understoreys. He submitted his results to the journal *Ecological Monographs*<sup>1</sup>. 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 that are 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 pastureland, 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 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."

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 called "Novel ecosystems: theoretical and management aspects of the new ecological world order"<sup>2</sup> suggesting that such systems were

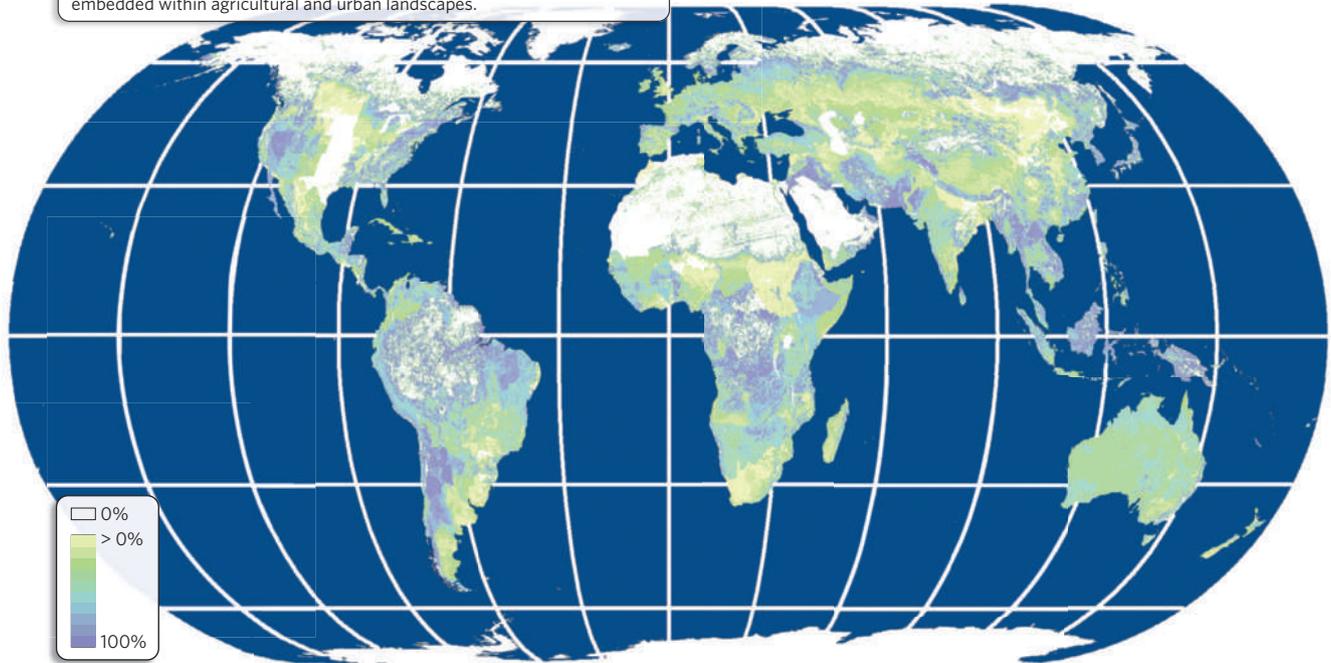


Joe Mascaro investigates biodiversity on Hawaii's Big Island.

E. MARRIS

## GLOBAL COVERAGE

The amount of land taken up by novel ecosystems, defined as unused lands embedded within agricultural and urban landscapes.



E. ELLIS

worth scientific attention. 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 towards 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 if his results could be replicated on the windward side of Hawaii's Big Island. Were the many novel ecosystems on the islands 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<sup>3</sup>.

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<sup>4</sup>. 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 defence chemicals. When people introduced plants from other parts of the world, along with their attendant herbivores, Hawaiian plants couldn't compete.

### Futuristic perspective

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 out-produced 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 to "face the facts and be strategic", Kareiva says, rather than trying 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 US 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 to one side, their deep distrust of novel ecosystems. Like many of his peers, Shahid Naem, 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 as 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

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— Joe Mascaro

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 that take 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, would put albizia forests in 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 and that "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 towards the 'ōhi'a — growing sideways to escape the shade of the next row in, 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."

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 only on 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 were 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.

### A question of values

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, they 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 samey and artificial, "sort of like eating at McDonalds".

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 metres 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." ■

Emma Marris writes for *Nature* from Columbia, Missouri.

1. Lugo, A. *Ecol. Monogr.* **62**, 2–41 (1992).
2. Hobbs, R. J. et al. *Global Ecol. Biogeogr.* **15**, 1–7 (2006).
3. Mascaro, J., Becklund, K. K., Hughes, R. F. & Schnitzer, S. A. *Forest Ecol. Manage.* **256**, 593–606 (2008).
4. Ziegler, A. *Hawaiian Natural History, Ecology and Evolution* 157 (University of Hawaii Press, 2002).

See Editorial, page 435.

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