Are Invasive Species Really So Bad?

New research reveals nature is far more resilient than we thought

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THE TRUTH ABOUT INVASIVE SPECIES

How to stop worrying and learn to love ecological intruders

BY ALAN BURDICK

I have seen the future, and it lives in Miami.

The suburbs of Miami, to be exact: in the ever-expanding netherworld between the potted plants and subtropical nightlife of South Beach to the east and the tropical plants and deep-rooted wildlife of Everglades National Park to the west.

The future lives in Homestead. So does Todd Hardwick, owner and primary employee of Pesky Critters Nuisance Wildlife Control. Noisome possums and trash-can raccoons are his standard fare, and the money is in alligators, which crawl out of the swamps and into backyards, the two environments being ever more synonymous. But the real
Kudzu, a plant from Asia, is despised in southeastern states for its aggressive growth. But like many nonnative species, it was once beloved. American gardeners of the late 1800s embraced its fragrant blossoms. In the 1920s it was promoted for its potential as livestock forage, and in the 1930s the Soil Conservation Service planted it widely for erosion control. The Department of Agriculture declared it a weed in 1972.

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**Pueraria montana**
fun, and Hardwick's specialty, is catching exotic species. Miami is the through point of the nation's imported animal and plant trade, and virtually everyone in South Florida, including Hardwick, has a neighbor with a backyard menagerie of lucrative critters on hold for resale. With so many unofficial zoos so close together and so little expertise at maintaining them, animals are constantly escaping into the streets and flower beds, and when someone spots, say, a pesky cougar on the lawn, Hardwick gets the call.

Hardwick has caught mountain lions, ostriches, rheas, emus, macaque monkeys—even once, a bison on the freeway. Mostly the animals are lone escapees, but a number of species—especially reptiles—have gone loose often enough that they've formed free-roaming populations that reproduce amid the imported mango groves and ornamental hedgerows. The naturalized aliens include Cuban tree frogs, various South American anoles, and South Asian pythons and boa constrictors. Hardwick's business card shows a photograph of an Indonesian python he once extracted from a burrow beneath someone's home; it was 22 feet long.

In short, if all the biogeographic barriers in the world were suddenly eliminated—all the impassable gulfs, oceans, and mountain ranges that have historically kept the planet's local native species from moving around and mixing together—the jumbled result would look something like Homestead. Minus the lions and pythons, it's the sort of neighborhood into which we're all slowly moving—or is slowly moving into ours. Colonies of stinging South American fire ants have settled in Texas; the zebra mussel, a pistachio-size mollusk from Europe, carpets the bottom of the Great Lakes. Feral pigs, native to Eurasia and North Africa, now root in the lawns of San Jose, California. Giant Asian carp, introduced in the 1970s to control aquatic weeds, leap unsolicited into fishing boats along the Mississippi River. Escaped pets, sport fish and garden plants run amok, insects that come hidden in the foliage of imported plants, pests that are introduced to control other pests—the invaders are legion, from anywhere, going everywhere.

Nature appears to be entering a new era—the Homocene, one scientist calls it—wherein the greatest threat to biological diversity is no longer just bulldozers or pesticides but, in a sense, nature itself. The renowned Harvard biologist Edward O. Wilson has claimed that the introduction of alien species is second only to habitat destruction as the leading cause of extinctions worldwide. A recent NASA report, heralding a novel effort to monitor the progress of alien species via satellite, placed the economic cost of alien species between $100 billion and $200 billion. "Nonindigenous invasive species may pose the single most formidable threat of natural disaster of the 21st century," the report's authors warn. "The threat of invasive species is perhaps our most urgent economic and conservation challenge." Purple loosestrife, that showy Eurasian flower you may have seen advancing along roadsides? Its floral path leads straight to hell.

Or not. Like the outwardly pastoral streets of Homestead, nothing is quite what meets the eye when it comes to alien species. For the past 50 years ecologists have devoted close study to movements of exotic species, in an effort to better understand why they go where they do and the impact they have when they arrive. The results of this unintended natural experiment turn out to be surprising, even to scientists. Nature, it seems, is far more resilient and is run by ecological rules that are far less orderly than expected. Alien species do pose a threat. But their real crime isn't against nature; it's against us and our self-serving ideas of what nature is supposed to be.

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Alan Burdick is a senior editor at Discover. This article is drawn in part from Out of Eden: An Odyssey of Ecological Invasion, to be published this month by Farrar, Straus and Giroux. Copyright 2005 by Alan Burdick.
“he should include in his thoughts some definite idea of the animal’s place in the community to which it belongs, just as if he had said, ‘There goes the vicar.’” The secret ingredient determining the composition of any given ecosystem—who’s in, who’s out—is competition. Every species, native or alien, must vie for limited niche space, like a game of musical chairs or like mailmen battling over access to a handful of mail slots.

For Elton and many subsequent ecologists, this explained why places like Hawaii were unusually vulnerable to the incursion of alien species. Small ecosystems are simpler—with fewer species, and thus more available niches—and so are more open to new species. Also, the native residents of these small ecosystems—surrounded by fewer species than their counterparts in large continental ecosystems—are evolutionarily less fit to compete against invaders. “The balance of relatively simple communities of plants and animals is more easily upset than that of richer ones,” he wrote, “and more vulnerable to invasions.” For confirmation, look no further than the average vacant lot or agricultural plot: low in diversity and highly invaded.

Elton was among the first natural scientists to articulate a link between biological diversity—the number and variety of native species in an ecosystem—and ecological health. Greater diversity conveys a degree of “biotic resistance,” he argued, which helps preserve the integrity of an ecosystem over time. A natural, undisturbed ecosystem could be thought of as an immunologic system; invasion, its disease. A recent issue of National Geographic described ecological invasion as a “green cancer.”

The disease metaphor is compelling. There’s just one problem: Fifty years of research by invasion biologists around the world has failed to confirm it.

When an alien species enters a new ecosystem, it can alter the environment in a number of ways: by eating native species (in its 50 years on Guam, the Australian brown tree snake has eliminated 9 of 13 native bird species); by spreading disease among them (introduced birds in Hawaii thrive in part because they are far less susceptible to the avian malaria parasite, also an introduced species, than native birds are); or by altering the environment in such a way that favors themselves (like melaleuca, an Australian tree that is spreading through the Everglades in part by changing the frequency and intensity of fires).

What invading species mostly don’t do, it turns out, is out-compete native species. Take the case of the American gray squirrel, which was introduced in England in 1876. Dubbed “tree rat” by its detractors, the invader has made a pest of itself in its new land, where it is in the habit of eating flower bulbs and birds’ eggs and stripping the bark from young birch trees. In addition, the spread of the gray squirrel has coincided with declining numbers of the Eurasian red squirrel, a native beloved by Brits despite the fact that it is only slightly less destructive than the gray squirrel.

Over the years, the gray squirrel has become an almost iconic example of an invading species outcompeting a native one. But even with fewer than 30,000 red squirrels remaining in England today, there is little hard proof that competition explains the gray squirrel’s success or the red squirrel’s decline. Scientists have found that the gray is more efficient at foraging in the woods and in backyards. On the other hand, even before the gray’s arrival, red squirrel populations in Britain had a periodic tendency to die out. (They were reintroduced to Scotland and Ireland several times during the 19th century.)

In addition, it is now known that two-thirds of gray squirrels are silent carriers of a viral skin disease fatal to red squirrels. Domination comes easier to those who can spread a pox. But is that competition?

By and large, superior competitive ability isn’t what enables alien species to invade. Likewise, small ecosystems can’t be said to be competitively weaker than big ones. Small ecosystems are more vulnerable to extinctions; their member species are fewer in number and have limited refuge, and so are at statistically greater risk of being eliminated by a single event, whether a hurricane or the introduction of a predatory snake. But biological diversity per se—the number of species in an ecosystem—provides no shield against invasions. In a 1999 issue of the journal *Biological Invasions*, Daniel Simberloff, a prominent ecologist at the Institute for Biological Invasions at the University of Tennessee at Knoxville, writes simply, “It seems clear to me that there is no prima facie case for the biotic resistance paradigm.”

Indeed, one of the big surprises to invasion biologists is the
large number of alien species that any given ecosystem can harbor. South Florida, perhaps the most conspicuously invaded region on the U.S. mainland, is home to at least 300 introduced plant species—about 18 percent of the plant total. In San Francisco Bay, marine ecologists Jim Carlton of the Maritime Studies Program of Williams College and Mystic Seaport and Andrew Cohen of the San Francisco Estuary Institute have discovered more than 250 nonindigenous species. In the classic view of ecosystems, outlined by Elton and later Robert MacArthur and E. O. Wilson in their theory of island biogeography, ecosystems run on a knife’s edge: They are tightly structured, without much room for new competitors.

“What invasions have shown is that there are plenty of unused resources,” says Ted Grosholz, a marine biologist at the University of California at Davis who for years has monitored the incursion of the European green crab into the bay. “Ecosystems can absorb a lot of new species. I mean, holy cow, look at San Francisco Bay! Who would have thought an ecosystem had that much unused niche space?”

**Invasions Unfold Invisibly.** The average person will take alarm at a lion in the street—a large novelty and a personal hazard—but pay less heed to the progress of Asian crabgrass and Cuban tree frogs in the backyard (“Honey, is that a toad?”). Most alien species blend seamlessly into the ecosystems they enter. Like wallflowers, they slip in quietly, hang around the margins, and keep to themselves.

Which isn’t to say that a wallflower will necessarily remain a wallflower. The Brazilian pepper tree, introduced into South Florida a century ago, began to spread widely only in the 1950s; it now fills significant portions of the Everglades, in part by exuding a poisonous sap and clearing space for itself. And once an alien species becomes widespread, it is extremely difficult to eliminate.

Still, most invasions do no harm. Even prevalent ones can have surprisingly little impact on their new environments. A review of the history of purple loosestrife by zoologists Heather Hager and Karen McCoy, formerly at the University of Guelph in Ontario, concluded that despite belief to the contrary, there is little or no evidence to suggest that the incursion of the plant has serious ecological consequences. “The direct scientific rationale used to advocate purple loosestrife control does not exist,” they write, adding that “aesthetic reasons remain the justification for its control.”

Marine environments turn out to be particularly absorbent to—and forgiving of—alien species. Although exotic crabs, sea worms, sponges, clams, and diseases have been introduced around the world for hundreds of years on or in ships (and by many other means), marine biologists have documented not a single example of an invading marine species driving a native marine species extinct, whether by predation, competition, or disease. “The key question is, what is the impact?” says Grosholz. “What effect does it have? Does it matter? Extinction may not be the only issue. That’s the main difference between marine and terrestrial ecosystems. With the Australian brown tree snake in Guam you can point to species and say, ‘Look, those things are gone,’ With marine species it’s not so easy. You can get qualitative shifts in communities if a species falls below a certain population threshold. I’m more concerned about those kinds of changes.”

Invasion is not a zero-sum game, with invaders replacing natives at a one-to-one (or a one-to-two, or more) ratio. Rather, and with critical exceptions, it is a sum-sum game, in which ecosystems can accept more and more species. Indeed, in both marine and terrestrial ecosystems, the big surprise is that the incursion of alien species can actually increase, rather than decrease, biodiversity at a local level. This makes sense: If you add many new species and subtract no or only a few native ones, the overall species count goes up.

To put it differently, invasions don’t cause ecosystems to collapse. That’s what Florida illustrates so vividly. If anything, there’s more nature running around there than ever before. In small ecosystems like the Everglades or the Hawaiian Islands, where native species are already imperiled by disappearing habitat, invading species may be the final straw. Invasions may radically alter the components of an ecosystem, perhaps to a point at which the ecosystem becomes less valuable, engaging, or useful to humans. But unlike, say, the clear-cutting of a forest or the poisoning of a lake, invasions don’t make ecosystems shrink or disappear.

“With invasions in a place like San Francisco Bay, you’ve got more species than you had before,” says Carlton. “If you’ve added 250 new species since 1850 with no species known to have gone extinct, why don’t we consider that good? I think that’s a very good question.”

One answer, ecologists say, is that there are at least two kinds
of diversity to keep in mind: alpha diversity, the number of species in any given location, and beta diversity, the relative diversity between any two locations. If a New York snail invades San Francisco Bay and a San Francisco snail invades New York Harbor, the alpha diversity in both locations has increased, but the beta diversity has decreased, because the two environments now share two species. Each place is that much less unique. Moving species around the world may increase local diversity, but it doesn’t increase the overall number of species on the planet; that number only goes down.

The larger cost of invasions is hard to discern. Most of us live small, local lives and are grateful for whatever manages to grow on our windowsills; we live in alpha-diversity worlds. In contrast, beta diversity is visible only on a grand scale and requires effort to see and take in. Its appreciation is a luxury, although perhaps no less valuable for being one.

A head count of species—native or introduced—in one place or another is one way to measure the impact of biological invasion, but it may not be the most telling. “We should focus on ecosystem management, not just species management,” says Grosholtz. “Extinction is a warning sign, but equally important are fundamental changes in ecosystem structure. Where do we draw the line? Maybe we have to say, ‘We care about this line, and we don’t care below that one.’”

Since Elton’s time, ecologists have struggled to account for the distribution and spread of alien species. They now realize that the key factor is opportunity. The more frequently and persistently a foreign plant or animal is exposed to a new environment, the better its odds of invading. Ecologists call this propagule pressure. It amounts to a kind of Noodle Theory: Throw enough different kinds of noodles at a wall long enough and eventually one will stick, no matter whether the noodle is buckwheat or soba or the wall is cement or wood paneled.

Consider the English house sparrow, which is now ubiquitous in the United States. The initial attempt to introduce eight pairs of the birds in Central Park in 1851 did not succeed. In 1852 the sparrow’s supporters made a second attempt to introduce the bird, and this time the bird caught on—almost certainly because this time 50 pairs were released, followed by other releases elsewhere in the country. An argument is sometimes made that sparrows and similar species make good invaders because they are “opportunists” and well adapted to human surroundings. In fact, as Mark Williamson, an ecologist at the University of York, notes in Biological Invasions, the presence of an exotic species merely reflects the effort we’ve put into establishing its company.

Or consider the average weed-infested plot: a roadside, a vacant lot, an acre of agricultural land. Elton argued that these environments are weedy because they have been disturbed by humans: By reducing them to simple ecosystems with fewer species, we have rendered them less resistant to invasion. But the real dynamic is perhaps less complicated. By definition, disturbed environments see more human traffic, and where humans go, invading species—weeds, seeds, snakes, mice—tend to follow. The invaders succeed not because the ecosystem is somehow weakened but simply because more invaders manage to reach it. “It only reflects the fact that species are more likely both to be transported from disturbed areas and to arrive in them, because of human activities,” Williamson writes.

The consensus today among invasion scientists is that, given the right opportunity, any native species can become an invader in some environment in the world, and any native ecosystem can be invaded by something. Last December, in a paper in Proceedings of the National Academy of Sciences, ecologists Brad Taylor of the University of Wyoming and Rebecca Irwin of Dartmouth College examined the distribution of several hundred exotic plant species that have become established in the United States to try to detect a pattern to their establishment. They found that the strongest predictor for why aliens are where they are is real estate activity: The higher the economic activity of the land—the more intensively used by us—the more likely alien species will be found there. Where we go, invaders follow.

I t may seem that how we talk about nature is irrelevant to how we deal with it, a mere semantic gloss. But where alien species are concerned, semantics is everything.

In the early days of invasion biology, notes Macalester College biologist Mark Davis, most researchers used neutral terms like “introduced,” “nonnative,” and “founding populations” to describe the phenomenon. Charles Elton was largely alone, though not for long, in his use of the flashier terminology: “alien,” “ex-
otic," "invader." While emphasizing the threat, the heavy use of this language implied that the otherness of an invading species is somehow ingrained in its biological being. In fact, an invader is simply a species that comes from somewhere else; its definition is purely geographic. It took invasion biologists 50 years to grasp the truth: Alien species are alien in name only.

Jim Carlton has tried to expunge the word "invasive" from his vocabulary altogether. "Where's the science in it? How is it quantified? I try not to use the term in my writing. I use 'introduced,' as in not native. What its ecological impacts are, that's another issue. The scale of environmental impacts is a continuum. I don't see a line; I see the line for human purposes. With a lot of invasions, it's not ecology, it's 'Who cares?' "

Alien species do not come from Mars; they are not "other." They are very much of us, by us; we are the main agent of their spread. Some organisms, like the brown tree snake, are accidental travelers, incidental to our own movements around the world. But many more—the ornamental plants, the pet boa constrictors now free-ranging in Homestead—come expressly at our invitation. We like aliens. We may not like what they do when they escape our immediate control. But if we want to keep them from spreading, we must first acknowledge their tremendous appeal, which is what draws them into our company in the first place.

The frightening economic numbers only obscure our cozy, complicated relationship to aliens. Consider again the claim that alien species cause $100 billion to $200 billion in economic damage. A portion of that damage is straightforward. Cleanup and control of the zebra mussel, which clogs reservoirs and water-intake pipes along the Great Lakes, costs $5 billion annually. But how about the Russian wheat aphid, one of numerous nonindigenous insect pests that cause $13.5 billion in damage to U.S. crops—which themselves are made up almost entirely of introduced species? Or the introduced insects, diseases, and weeds that cause $3 billion in damage and control costs to lawns, gardens, and golf courses—which again are almost wholly composed of exotic, hybridized species? Yes, the damage is real, and the culprits are nonnative—but the blanket use of the term "aliens" here is slightly disingenuous.

For the most part, the alien offenders are all too familiar. Although the bird-eating brown tree snake causes some $5 million annually in damage and control costs, the largest "alien" threat to the nation's birds comes from pet cats and feral house cats, which together inflict an estimated $14 billion in damage. (The cats would do better by us if they caught the nation's 250 million introduced rats, which cost $19 billion in losses to farms, industries, and homes.) A recent analysis by ecologists Jessica Gurevitch and Dianna Padilla of the State University of New York at Stony Brook revealed that true alien species—creatures like the brown tree snake—threaten only 6 percent of imperiled wildlife with extinction. The far greater portion is imperiled by grazing and trampling from our old, alien friends: cattle, goats, and feral pigs. Yes, alien species are second to habitat destruction as a threat to biodiversity, but they are a far second indeed.

All numbers aside, our concern about alien species is really an attempt to articulate the plight of the natives: the rare flower pollinized only by one species of bird, or the albino cricket endemic to one cave in Hawaii. Alas, such organisms may have no value—not to world economies, not even to the ecosystems they inhabit, which will hardly pause when these members are gone. Like works of art, they are priceless: novel efflorescences, compelling to us—and worth saving—perhaps only because they came into being without us, though they now require all our artfulness to survive.

With habitat destruction, the stakes are clear, the threats stark. We face a choice between, say, a grove of redwood trees and a parking lot, between an alluvial pond and a suburban swimming pool. We choose between nature's life and nature's death.

By contrast, the issue of alien species presents a spectrum of illustrative grays. A few species do cause costly problems and have caused tragic extinctions. But those are the rare cases. By and large, most species have no visible impact. They blend in. They live happily among us—on our lawns, under our homes—and we, it seems, live happily among them. What alien species reveal in a place like Homestead is that nature and humans, long considered incompatible, can get along quite well together. The issue they present is not whether we will be surrounded by nature but rather: What kind of nature do we want around us?

In seeking an answer, it would be ideal if we could appeal to some outside judge, size up the costs with some external, scientific yardstick. What would nature do? But this hope can't guide us. Fifty years of invasion biology has failed to identify a clear ecological difference between an ecosystem rich in native species and one chock-full of aliens. Invasions don't weaken ecosystems—they simply transform them into different ecosystems, filled with different organisms of greater or lesser value to us.

It is tempting to think of alien species as a plague upon us, as a sort of biological pollution that muddies our natural world. But that approach only muddies our thinking. "The concept of 'biological pollution' is a tough sell," says Jim Carlton. "Biological pollution means, I don't know, a badly polluted river or something. The oyster industry of the Pacific Northwest is based on exotic species and supplies many of the oyster houses of Chesapeake Bay. Nobody in that industry thinks the oyster is really a polluting organism. Has it had an ecological impact in the Pacific Northwest? I suppose so. But it's a multimillion-dollar industry. It employs a lot of people."

The point is not that all invasions, or even any invasions, are desirable. Rather, the point is that the only reliable measure for the value of native species is our desire. Whether invasions are good or bad is a question to ask ourselves, not our scientists. It's also an opportunity to contemplate what we want from nature and to start taking responsibility for it.
Bos taurus

Cattle are aliens too—and are among the most destructive friends we tend. The grazing and trampling of livestock threaten more than three and a half times as many native plant species globally as are threatened by nondomesticated aliens. And livestock threaten almost as many native animal species as alien predators do.