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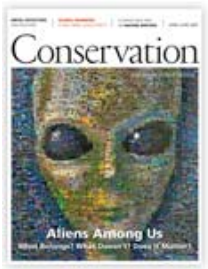

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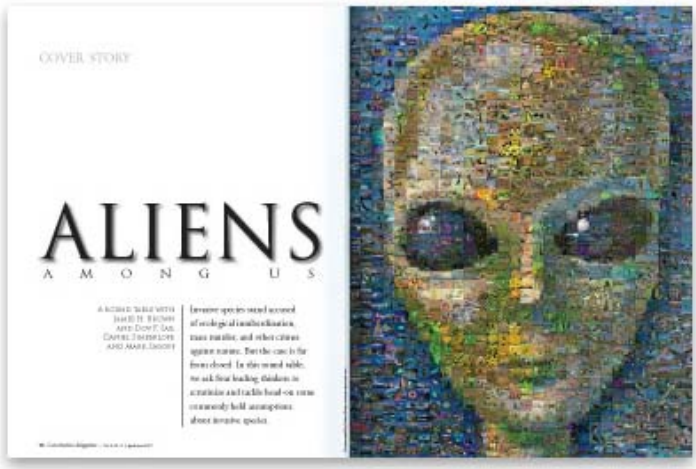
Aliens Among Us



Invasive species stand accused of ecological insubordination, mass murder, and other crimes against nature. But the case is far from closed. In this round table, we ask four leading thinkers to scrutinize and tackle head-on some commonly held assumptions about invasive species.

A round table with James H. Brown and Dov F. Sax, Daniel Simberloff, and Mark Sagoff
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James H. Brown is Distinguished Professor of Biology at the University of New Mexico, Albuquerque. On a practical level, Brown is known for his long-term experimental studies looking at microscale ecological relationships in the Chihuahuan Desert. On a theoretical level, he is challenging some of the underpinnings of conservation on island-like habitats. In 2001, he was awarded the Ecological Society of America's Eugene P. Odum Award for his work in education. His coauthor and former graduate student, Dov F. Sax, is an assistant professor at the University of Georgia's Institute for Ecology. Sax's current research focuses on how exotic species change patterns of biodiversity at different scales.

Do Biological Invasions Decrease Biodiversity?

By James H. Brown and Dov F. Sax

Yes, and no The fact is, we don't know nearly as much about invading species as we need to—despite decades of research by ecologists, paleobiologists, and biogeographers.

We can't predict when invading foreign species will replace native animals and plants, nor can we predict when or by how much invading species will disrupt the structure and function of ecosystems. We don't know how serious the threats of alien invaders are to our native flora and fauna; these are scientific questions. And, as is often the case in science, the answer is less clear than reports in the popular press about the devastating impacts of gypsy moths, zebra mussels, and purple loosestrife might imply.

We do know that, as the human population grows and spreads, native plants and animals become extinct; humans are introducing species into new areas, both intentionally and unintentionally. And we know that global biodiversity is decreasing as a result of human-assisted invasions. But on a local level, things look quite different.

At small scales, the extinction of native species has typically been more than offset by the colonization of invading species. Already- abundant and widespread species have expand-ed their ranges, more than compensating in local species richness for the restricted endemic forms that have disappeared.

This does not mean that exotic species have not caused extinctions. It simply means that, on average, there is locally fewer than one extinction of a native species for every successful colonization of an alien species. This will come as a surprise to many who believe that biodiversity is decreasing everywhere on earth.

But it is true, for continents as well as islands. North America presently has more terrestrial bird and mammal species than when the first Europeans arrived five centuries ago. Although the passenger pigeon, heath hen, and Carolina parakeet are extinct and the California condor, red wolf, and black-footed ferret are essentially gone from the wild, these losses are more than offset by the colonization of house sparrows, European tree sparrows, rock doves, ringed doves, monk parakeets, ring-necked pheasants, chukar partridges, house mice, Norway rats, European hares, wild boars, feral horses, oryx, and many other species. Out of a total flora of approximately 6,000 vascular plant species, California has more than 1,000 naturalized exotics (1); yet fewer than 30 natives are known to have become extinct (2).

The asymmetry holds even on islands and insular habitats. Within the last few centuries following European colonization, relatively few insular endemic plant species have become extinct, whereas invading species have approximately doubled the size of island floras—from 2,000 to 4,000 on New Zealand; 1,300 to 2,300 on Hawaii; 221 to 421 on Lord Howe Island, Australia; 50 to 111 on Easter Island; and 44 to 80 on Pitcairn Island (3).

How can this be? The biota of every place on earth is poised on a continually shifting balance of filling and emptying. The effects of immigration and speciation increase diversity, and the effects of emigration and extinction decrease diversity. But how full is it? There are two extreme views. Some ecologists and biogeographers have suggested that the biota is so saturated with plant and animal species that adding immigrating aliens causes the extinction of an equal number of native species—much like a game of musical chairs, where every player has to compete for a space in order to remain in the game. Other researchers contend that most places on earth are far from saturated and hence the world is able to absorb colonizing aliens without losing as many natives. Our research supports the latter view in some, but not all, local areas.

Foreign invaders often evoke strong emotional responses, even from normally objective scientists. We are not suggesting that naturalized species are desirable, nor are we arguing against efforts to prevent immigration or to eradicate foreign species. But we are calling for more rigorous scientific evidence to support claims that invading alien species cause major decreases in local biodiversity and damage to wild ecosystems; currently, there is little objective evidence to support sweeping claims of wholesale death and destruction. We also believe that we should try to learn as much from alien species as possible. They provide a rich set of unintentional and uncontrolled yet highly replicated experiments—ones that may ultimately help us to better understand complex patterns of biodiversity.

From current scientific research we can draw six conclusions:

1. Many places have experienced extinctions of native fish, plants, and birds.
2. Alien species have undoubtedly contributed to the extinction of some of these species. The ultimate cause of extinction is often ambiguous, however, because other human

activities have had substantial environmental impacts.
3. Despite the extinction of some native species, the total number of species usually increased or remained the same in local areas.
4. Although we often accuse invading species of damaging the structure and function of ecosystems, there is usually little hard scientific evidence of such negative impacts.
5. The fact that islands show such different capacities to absorb immigrating birds and plants suggests that there is no single definitive explanation as to how alien species impact *local* biodiversity.
6. The net effect, however, is still a loss of *global* biodiversity. Many of the invading alien species are common and widely distributed. By contrast, many of the native species that have gone extinct were endemics and have thus been lost forever.

Literature cited:

1. Rejmanek, M. and J.M. Randall. 1994. Invasive alien plants in California: 1993 summary and comparison with other areas in North America. *Madroño* 41:161-177.
2. Tibor, D.P. 2001. *California Native Plant Society's Inventory of Rare and Endangered Plants of California*, 6th edition. California Native Plant Society, Sacramento, California.
3. Sax, D.F., S.D. Gaines and J.H. Brown. 2002. Species invasions exceed extinctions on islands worldwide: a comparative study

Daniel Simberloff is the director of the Institute for Biological Invasions at the University of Tennessee, Knoxville. He works on many introduced species, from the small Indian mongoose on islands worldwide to northern hemisphere pines in Patagonia. His interest in invaders began when he used them to test ecological theories. After seeing first-hand their myriad impacts on natural environments, his interest took a turn toward conservation. He spends much of his time convincing the public and policymakers that impacts of biological invasions, although one of the great global changes, can be prevented, eradicated, or managed. Simberloff started his studies in ecology as a student of E.O. Wilson.

Photo courtesy of University of Tennessee

Given the stakes, our *modus operandi* in dealing with invasive species should be "guilty until proven innocent"

By Daniel Simberloff

Warranted Critics have argued that the war against invasive species is more about aesthetics than science. Some have even gone so far as to accuse conservationists of xenophobia or even racism. I believe such arguments are a red herring.

True, most introduced species—by some rough estimates, 90 percent—do not cause substantial ecological or economic impacts. But 10 percent of a large number is still a large number. The U.S. alone has 6,000 introduced species (excluding microbes) that are thriving without human assistance.

Their impacts are staggering. Many Garry oak woodlands and meadows in the U.S. Pacific Northwest are now seas of Scotch broom. Oaks have largely replaced the American chestnut, a tree that once occupied over 100 million hectares of eastern North America. Dead man's fingers, a Pacific alga, carpets much of the nearshore seafloor of the southern Gulf of Maine and the Nova Scotia coast where kelp forests once stood. And massive monocultures of the Pacific "killer alga" smother sea-grass meadows off the coasts of Spain, France, Italy, and Croatia. And all of these changes have occurred within the past two centuries.

And then there are species such as the American chestnut. Although it is not threatened, it is difficult to find one in nature nowadays. For ten moths whose host plant was the chestnut, it is now too late—they are extinct.

Birds are taking a big hit, too. Ornithologists estimate that 1,186 (12 percent) of the world's bird species are threatened with imminent extinction. For 510 of these, the threat is wholly or partly from introduced species (predators, competitors, and herbivores).

Some observers question whether we should pin the blame on invasive species, noting that the prosecution's evidence is often anecdotal, speculative, and based on limited observation. Yet they fail to mention that the same could be said about the evidence for every other claimed cause of extinction—habitat destruction, pollution, disease, and so on. The last individuals of a species almost always disappear while no one is watching. The occasional reappearance of a species long thought extinct—for example, the ivory-billed woodpecker—makes biologists loath to declare a species extinct for decades beyond its last unequivocal sighting. Because no clear boundaries delimit community types, we cannot simply say a type of community has disappeared. Nevertheless, I need only look around to see that the oak-chestnut-hard pine forests of eastern North America no longer exist in the absence of chestnut.

What's worse, many introduced species now recognized as invasive horrors were innocuous in their new homes for decades before they abruptly spread. For instance, Brazilian pepper was introduced to Florida a century before it exploded across the southern part of the state.

Unfortunately, we're not good at prediction. If we knew which invasions would be harmful and which inconsequential, it would be straightforward to exclude only the bad actors among planned introductions. However, invasion biology is a new field that coalesced as a distinct discipline only in the 1980s. We have made great progress, but our predictive tools still carry wide confidence limits, and after-the-fact eradication is still extremely difficult. For at least the next few decades, we will have to assume that most established introductions are irrevocable.

Given these facts, I believe our *modus operandi* in dealing with deliberate introductions must be "guilty until proven innocent"—even though it contradicts the basic tenet of U.S. jurisprudence.

In other words, our blacklists should be supplemented by whitelists. In the U.S. and almost all other nations, we currently use blacklists. The relatively few species that have made it to the blacklist are the known troublemakers—every other species can be admitted. The whitelist flips that system on its head. We would vet every species, no matter how apparently unthreatening.

We'd have to be frank about our limitations and grant that some species denied white- list status would have proven innocuous if introduced, and a certain number granted such status and introduced will prove to be harmful mistakes. But surely it is our obligation to act on our knowledge about invasions rather than acquiesce to a policy of admitting almost everything and then studying the consequences later?

Just as with global climate change, it would be cheaper and easier in the short term to say that we lack proof and should delay regulation. As in other scientific matters with public-policy ramifications, policymakers and political pundits all too often cite the small minority to suggest that substantial controversy swirls around the importance of introduced species. It does not.

Mark Sagoff directs the Institute for Philosophy and Public Policy at the University of Maryland. He has published widely in law, philosophy, and environmental issues. His work has appeared in *Orion* and *Atlantic Monthly*. His most recent book is *Price, Principle, and the Environment* (Cambridge University Press, 2004). In 1991, Sagoff was named a Pew Scholar in Conservation and the

Environment, and in 1998 he was awarded a fellowship at the Woodrow Wilson International Center for Scholars. He believes that ecology is a historical, not a theoretical, science.

Are nonnative species harmful?

By Mark Sagoff

That depends on your perspective That nonnative species harm the natural environment is a dictum so often repeated that one may assume it rests on evidence. It does not.

Biologists often use pejorative terms such as "pollute," "meltdown," "harm," "destroy," "disrupt," and "degrade" when speaking about nonnative species. These words, along with metaphors borrowed from war and from cancer pack political punch. Insofar as they convey aesthetic, moral, or spiritual judgments, they have a place in political debates and policy discussions. What troubles me as a philosopher is that these value-laden terms and their under-lying concepts pervade the scientific literature of conservation biology and invasion ecology. These concepts are not defined; general-izations based on them are not tested. Indeed, if you try to prove that invasive species harm natural environments, you'll find your-self in a scientific maze of dead ends and circular logic.

Those who call for additional resources to fight nonnative species typically point to examples such as the zebra mussel, purple loosestrife, and honeysuckle, which they say have had costly and disruptive effects. Examples can shore up nearly any thesis; that is why examples are not arguments. Rather than draw general conclusions from preselected and biased examples, as the literature often does, we should look to scientific studies that consider a sample of species or sites selected at random.

Ecologists have not shown that nonnative species, once established, behave differently than native ones. For example, the striped bass introduced from the Chesapeake is the most abundant game fish in the Sacramento-San Joaquin estuary. Is there anything about the striped bass that suggests its provenance; is there anything about it that indicates how long it has been there? Can one tell from inspecting these creatures or these systems whether the striper went east or west?

To tell whether a species is native or alien, ecologists rely on historical and paleoecological evidence. No study demonstrates that alien and native species or "heirloom" and "invaded" ecosystems are distinguishable in the way they look or behave. In other words, if on the basis of historical evidence one group of ecologists lists those species established at a site that are native and those that are alien, a second group of ecologists having no knowledge of the historical facts could not tell which list was which simply by observing the interaction of the creatures living in the system.

Moreover, for even the most villainous suspects, there are two sides to the story. Eutrophication has plagued the Great Lakes for decades. But by filtering phytoplankton and other suspended material from the water column, the nonnative zebra mussel has helped clean up Lake Erie and other parts of the Great Lakes, the Hudson River, and many more aquatic environments. These mussels are much more efficient at filtration than their native counterparts. Many birds feed on them, and the mussels' excrement provides habitat for a food chain anchoring a great diversity of species. Biologists credit the zebra mussel with restoring native grasses and fishes. Were it native, the zebra mussel would be hailed as a savior, not reviled as a scourge.

Commentators often refer to the costs of controlling a species as a measure of the harm it does. Control costs may be used as a measure of harm when people spend their own money. However, the connection between benefits and costs when a governmental agency spends other people's money is less apparent. Government agencies may seek huge budgets for invasive species programs and may then cite these as "control costs" to justify the expense. The U.S. Forest Service spent billions to fight forest fires, to the detriment of

the health of forests. Experience has shown that the costs of government programs are not reliable measures of their benefits.

Estimates of the economic costs of an invasive species such as the zebra mussel—it clogs water intake valves and filtration plants—differ wildly. A 1993 U.S. Congressional Office of Technology Assessment report pegged damage and control costs at about US$300,000 per year (1), whereas in 2005 biologist David Pimentel referred to an updated estimate of US$1 billion per year (2). Municipalities and industries have had to retrofit facilities to make them mussel-compatible. It has been a costly one-time endeavor. But it may be a bargain in view of what might have been spent to save affected aquatic ecosystems from eutrophication over time.

Throughout history, anti-immigration activists have supported their xenophobia with examples of individual immigrants who depend on welfare or commit crimes. Ecologists who seek public funds to exclude or eradicate nonnative species attribute to them the same disreputable qualities that xenophobes have associated with immigrants—for example, uncontrolled fecundity and aggressive behavior.

The pejorative stereotyping of newcomers may be no more appropriate in the ecological than in the social context. The zebra mussel has spread widely, but this suggests only that it found a niche to occupy, not that it "harmed" the environment in a scientifically definable and testable way. Ecologists worry that "weedy" species will spread around the world; but what is wrong with that, as long as the immigrants generally add to local species richness or diversity? One might give aesthetic, moral, and spiritual reasons for keeping species close to where Noah dropped them off. From a scientific perspective, however, what defines "weediness?" Are certain species "weeds" because they succeed globally, as do Starbucks and Taco Bell?

Literature cited:

1. Office of Technology Assessment. 1993. Harmful Non-Indigenous Species in the United States. Washington D.C., U.S. Congress Office of Technology Assessment.
2. Pimentel, D., R. Zuniga and D. Morrison. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. *Ecological Economics* 52(3): 273-288.

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