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## Friendly Invaders

By [CARL ZIMMER](#)

New Zealand is home to 2,065 native plants found nowhere else on Earth. They range from magnificent towering kauri trees to tiny flowers that form tightly packed mounds called vegetable sheep.

When Europeans began arriving in New Zealand, they brought with them alien plants — crops, garden plants and stowaway weeds. Today, 22,000 non-native plants grow in New Zealand. Most of them can survive only with the loving care of gardeners and farmers. But 2,069 have become naturalized: they have spread out across the islands on their own. There are more naturalized invasive plant species in New Zealand than native species.

It sounds like the makings of an ecological disaster: an epidemic of invasive species that wipes out the delicate native species in its path. But in a paper published in August in [The Proceedings of the National Academy of Sciences](#), Dov Sax, an ecologist at [Brown University](#), and Steven D. Gaines, a marine biologist at the University of California, Santa Barbara, point out that the invasion has not led to a mass extinction of native plants. The number of documented extinctions of native New Zealand plant species is a grand total of three.

Exotic species receive lots of attention and create lots of worry. Some scientists consider biological invasions among the top two or three forces driving species into extinction. But Dr. Sax, Dr. Gaines and several other researchers argue that attitudes about exotic species are too simplistic. While some invasions are indeed devastating, they often do not set off extinctions. They can even spur the evolution of new diversity.

“I hate the ‘exotics are evil’ bit, because it’s so unscientific,” Dr. Sax said.

Dr. Sax and his colleagues are at odds with many other experts on invasive species. Their critics argue that the speed with which species are being moved around the planet, combined with other kinds of stress on the environment, is having a major impact.

There is little doubt that some invasive species have driven native species extinct. But Dr. Sax argues that they are far more likely to be predators than competitors.

In their new paper, Dr. Sax and Dr. Gaines analyze all of the documented extinctions of vertebrates that have been linked to invasive species. Four-fifths of those extinctions were because of introduced predators like foxes, cats and rats. The Nile perch was introduced into Lake Victoria in 1954 for food. It then began wiping out native fish by eating them.

“If you can eat something, you can eat it everywhere it lives,” Dr. Sax said.

But Dr. Sax and Dr. Gaines argue that competition from exotic species shows little sign of causing extinctions. This finding is at odds with traditional concepts of ecology, Dr. Sax said. Ecosystems have often been seen as having a certain number of niches that species can occupy. Once an ecosystem's niches are full, new species can take them over only if old species become extinct.

But as real ecosystems take on exotic species, they do not show any sign of being saturated, Dr. Sax said. In their paper, Dr. Sax and Dr. Gaines analyze the rise of exotic species on six islands and island chains. Invasive plants have become naturalized at a steady pace over the last two centuries, with no sign of slowing down. In fact, the total diversity of these islands has doubled.

Fish also show this pattern, said James Brown of the [University of New Mexico](#). He said that whenever he visits a river where exotic fish have been introduced, "I ask, 'Have you seen any extinctions of the natives?'" "The first response you get is, 'Not yet,' as if the extinction of the natives is an inevitable consequence. There's this article of faith that the net effect is negative."

Dr. Brown does not think that faith is warranted. In Hawaii, for example, 40 new species of freshwater fish have become established, and the 5 native species are still present. Dr. Brown and his colleagues acknowledge that invasive species can push native species out of much of their original habitat. But they argue that native species are not becoming extinct, because they compete better than the invasive species in certain refuges.

These scientists also point out that exotics can actually spur the evolution of new diversity. A North American plant called saltmarsh cordgrass was introduced into England in the 19th century, where it interbred with the native small cordgrass. Their hybrid offspring could not reproduce with either original species, producing a new species called common cordgrass.

Long before humans moved plants around, many plants hybridized into new species by this process. "Something like a third of the plant species you see around you formed that way," Dr. Sax said.

Biological invasions also set off bursts of natural selection. House sparrows, for example, have moved to North America from Europe and have spread across the whole continent. "Natural selection will start to change them," Dr. Sax said. "If you give that process enough time, they will become new species."

"The natives themselves are also likely to adapt," Dr. Sax added. Some of the fastest rates of evolution ever documented have taken place in native species adapting to exotics. Some populations of soapberry bugs in Florida, for example, have shifted from feeding on a native plant, the balloon vine, to the goldenrain tree, introduced from Asia by landscapers in the 1950s. In five decades, the smaller goldenrain seeds have driven the evolution of smaller mouthparts in the bugs, along with a host of other changes.

In Australia, the introduction of cane toads in the 1930s has also spurred evolution in native animals. "Now that you have cane toads in Australia, there's a strong advantage for snakes that can eat them," said Mark Vellend, of the University of British Columbia. Cane toads are protected by powerful toxins in their skin that can kill predators that try to eat them. But in parts of the country where the toads now live, black snakes are resistant to the toxins in their skin. In the parts where the toad has yet to reach, the snakes are still vulnerable.

Dr. Brown argues that huge negative effects of invasions are not documented in the fossil record, either. “You see over and over and over again that this is never the case,” he said. Species have invaded new habitats when passageways between oceans have opened up or when continents have collided.

“The overall pattern almost always is that there’s some net increase in diversity,” Dr. Brown said. “That seems to be because these communities of species don’t completely fill all the niches. The exotics can fit in there.”

In a recent paper in the journal *Science*, Peter Roopnarine of the California Academy of Sciences and Geerat Vermeij of the University of California, Davis, looked at the history of invasions among species of mollusks, a group that includes mussels, clams and whelks. About 3.5 million years ago, the mollusks of the North Pacific staged a major invasion of the North Atlantic. Before then, the Arctic Ocean had created a barrier, because the mussels could not survive in the dark, nutrient-poor water under the ice.

A period of [global warming](#) made the Arctic less forbidding. Yet the migration did not lead to a significant drop in the diversity of the Atlantic native mussels. Instead, the Atlantic’s diversity rose. Along with the extra exotic species, new species may have arisen through hybridization.

The Arctic Ocean is now warming again, this time because of human activity. Computer projections indicate it will become ice-free at least part of the year by 2050. Dr. Roopnarine and Dr. Vermeij predicted that today’s mollusks would make the same transoceanic journey they did 3.5 million years ago. They also expect the invasion to increase, rather than decrease, diversity.

But critics, including Anthony Ricciardi of [McGill University](#) in Montreal, argue that today’s biological invasions are fundamentally different from those of the past.

“What’s happening now is a major form of global change,” Dr. Ricciardi said. “Invasions and extinctions have always been around, but under human influence species are being transported faster than ever before and to remote areas they could never reach. You couldn’t get 35 European mammals in New Zealand by natural mechanisms. They couldn’t jump from one end of the world to another by themselves.”

It is estimated that humans move 7,000 species a day. In the process, species are being thrown together in combinations that have never been seen before. “We’re seeing the assembly of new food webs,” said Phil Cassey of the University of Birmingham in England. Those new combinations may allow biological invasions to drive species extinct in unexpected ways.

[Botulism](#), for example, is killing tens of thousands of birds around the Great Lakes. Studies indicate that two invasive species triggered the outbreak. The quagga mussel, introduced from Ukraine, filters the water for food, making it clearer. The sunlight that penetrates the lakes allows algae to bloom, and dead algae trigger an explosion of oxygen-consuming bacteria. As the oxygen level drops, the botulism-causing bacteria can multiply. The quagga mussels take up the bacteria, and they in turn are eaten by another invasive species: a fish known as the round goby. When birds eat round gobies, they become infected and die.

“If you pour on more species, you don’t just increase the probability that one is going to arrive that’s going to have a high impact,” Dr. Ricciardi said. “You also get the possibility of some species that triggers a change

in the rules of existence.”

Dr. Ricciardi argues that biological invasions are different today for another reason: they are occurring as humans are putting other kinds of stress on ecosystems. “Invasions will interact with climate change and habitat loss,” he said. “. We’re going to see some unanticipated synergies.”

Both sides agree, however, that decisions about invasive species should be based on more than just a tally of positive and negative effects on diversity. Invasive weeds can make it harder to raise crops and graze livestock, for example. The Asian long-horned beetle is infesting forests across the United States and is expected to harm millions of acres of hardwood trees. Zebra mussels have clogged water supply systems in the Midwestern United States. Exotic species can also harm humans’ health. “[West Nile virus](#), [influenza](#) — these things are invasions,” Dr. Ricciardi said.

On the other hand, some invasive species are quite important. In the United States, many crops are pollinated by honeybees originally introduced from Europe.

“It’s not that this is all good or all bad, and I’m not sure science should be the arbiter,” Dr. Brown said. “Placing values on these things is the job of society as a whole.”

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