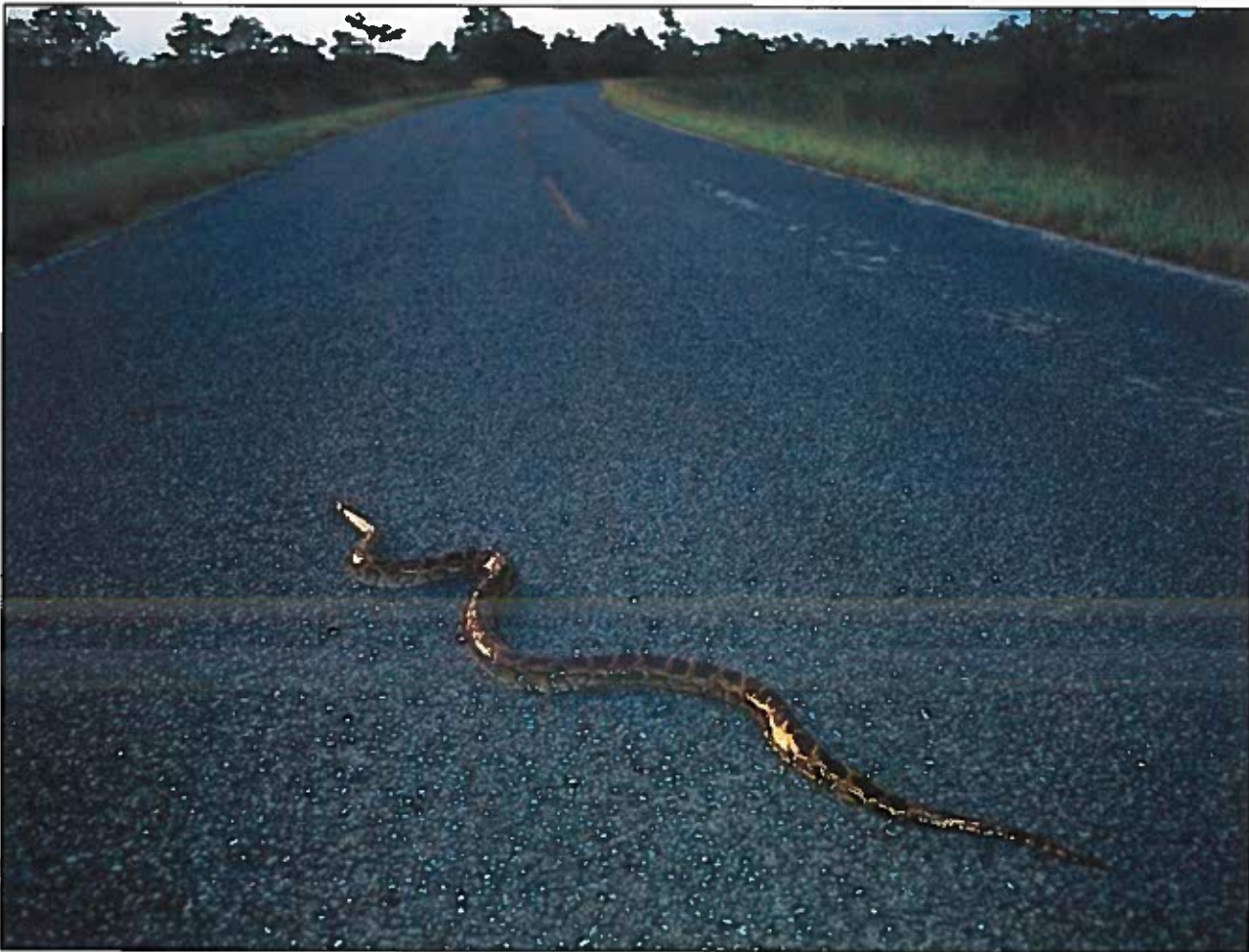


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Attack of the Alien Invaders



The Burmese python doesn't appear in any field guide of the endemic reptiles of North America. But anyone in Florida who wants to see one of these Southeast Asian snakes in the wild need only drive the Everglades National Park road on a summer's eve. Captive pythons frequently escape or are released by their owners. In the wild, they can

quickly dwarf the local wildlife, reaching 20 feet (6 meters) in length and growing as thick as a telephone pole.

Photograph by Melissa Farlow

By Susan McGrath

Republished from the pages of *National Geographic* magazine

All over the world, animals and plants that evolved somewhere else are turning up where they're not wanted.

In the hour of long shadows and cooling tarmac, the snakes of the Everglades slip out in search of supper. Cruise control set at 25, my cherry red sports car slips out after them, prowling ceaselessly back and forth, back and forth, on the two-lane river of tar that runs through the park.

At 8:23 a short, fat snake appears, immobile, in my lane. I leap out to examine the stubby little creature and—*Tsssss!*—it flicks its head straight back and snaps its jaws open, presenting a sinister flower of petal pink flesh. Yikes. A cottonmouth. I hop back in the car. At 8:28 a dark, sinuous snake, slim as a bootlace—too slim to be what I'm looking for. At 9:03 another little fatty, worth a closer look. Nope. A pygmy rattlesnake, maybe.

Then a dry spell. At 10:00, headlights appear behind me. I watch them coming on fast in the rearview mirror and when my gaze returns to the road ahead, there's my snake—a roadblock of a snake, as thick as a thigh and as long as the lane is wide—and I'm almost on top of it. I mash the brake pedal and fling out an arm to warn the driver behind me. The vehicle swerves around me. An instant before contact, the driver sees the snake, lurches onto the shoulder, lurches back onto the road, and speeds away. The glossy argyle of bronze and charcoal lies unscathed.

Python molurus bivittatus, the Burmese python, is a species you won't find in any field guide of the endemic reptiles of North America; it's a native of Southeast Asia. But anyone in Florida who wants to see one in the wild can try the Everglades National Park road on a summer's eve. It's a bizarre sight: The guy in my headlights is already bigger than any other snake in North America, yet it's a mere pipsqueak by its own standards. It may live 25 years and reach 20 feet (6.1 meters) in length. It can achieve the girth of a telephone pole; it can dine on full-grown deer.

Skip Snow, a park biologist, has examined scores of Burmese pythons found in the Everglades in the past few years, hatchling, juvenile, and adult. "There's little doubt they've become established and are breeding here," he told me, though you could see he still has trouble believing it himself.

If Snow were here tonight, he'd pin this ten-footer (three-meter snake) with a snake stick, wrestle it into a rubber tub, and run it back to the lab where he'd euthanize and autopsy it. But Snow is busy elsewhere, and yours truly is cowering in the sports car, fighting an absurd urge to lock the doors. The animal lies still just long enough for me to get a good look, then glides heavily into the scrub.

Back at Flamingo Lodge, I blurt my news to the night manager.

"So you saw a ten-foot (three-meter) python," he drawls. "That's nothing."

Some call it the "blender effect," others "a giant biology experiment with no one in charge." What it boils down to is this: All over the world, in nearly every region and kind of ecosystem, animals and plants that evolved somewhere else are turning up where they're not wanted—having been transported by us, inadvertently or intentionally. Burmese pythons are imported to Florida from Asia for the pet trade and end up being dumped in the Everglades by people who find that they don't make such great pets after all. Pythons are generalists—long-lived, not too fussy about what they eat—so they survive, find one another, and breed.

Likewise, Western species pop up in the East. The red-eared slider turtle, native to the Mississippi Basin, has been shipped all over the world as a pet and for food. The turtle is spreading across Asia and southern Europe, devouring native frogs, mollusks, and even birds.

Some alien species are beneficial. Most agricultural plants and animals in North America are aliens, for instance—native to Europe, South America, or elsewhere. Japanese oysters and clams are mainstays of the shellfish industry worldwide. But some transplants have an outsize effect on the ecosystems into which we deliver them. Ecologists call these "invasive species."

It's too soon to know how invasive the Burmese python will prove, but consider the case of the brown tree snake, a native of New Guinea and Australia. A few of them stowed away aboard military equipment after World War II and disembarked on the island of Guam. There they found no brown tree snake enemies and no brown tree snake rivals and tens of thousands of birds that had never known a terrestrial predator. In this land of milk and honey the snakes have multiplied exponentially, reaching densities of up to 13,000 a square mile (2.6 square kilometers). Their venomous bites account for a disquieting number of emergency room visits; their climbing habits have caused more than 2,000 electrical outages; and 8 of Guam's 11 native forest bird species have been wiped out.

North America got its wake-up call with the arrival of the zebra mussel, a thumbnail-size mollusk native to the Black Sea that showed up in Lake St. Clair, Ontario, in 1988. Zebra mussels like to attach themselves to a hard surface, and they don't mind a crowd. They'll clump on rock, they'll clump in pipe, and they'll clump mussel-next-to-mussel-atop-mussel in astonishing congregations of as many as 70,000 individuals a square foot (0.1 square meters). Within two years zebra mussels tiled the shallows of the Great Lakes. Intake pipes from utilities and factories became choked with mussels. Lights dimmed. Ships' rudders jammed. Businesses closed. Eradication proved impossible, and today the U.S. and Canada lose about 140 million dollars a year to the mussels.

Aggressive plants may be the most destructive of all invasive species. Mile-a-minute weed, *Mikania micrantha*, a perennial vine from Central and South America, was planted in India to camouflage airfields during World War II. Today it camouflages large swaths of southern Asia, overrunning forests and crops and smothering life under a green blanket.

"Before humans started moving around, the rate of species movement was a geologic rate," says Jim Carlton, an invasives expert who is the director of the Maritime Studies Program of Williams College and Mystic Seaport in Mystic, Connecticut. "Now we're moving species faster and farther than they ever would or could have moved in nature."

That movement comes with a shocking price tag. The state of Florida spends 50 million dollars every year controlling invasive plants. New York, New Jersey, Illinois, and the federal government have spent 175 million dollars battling the tree-killing Asian long-horned beetle. The 2001 hoof-and-mouth disease outbreak in England cost businesses there nearly four billion dollars. In all, experts estimate, invasives cost the U.S. alone more than 140 billion dollars yearly.

The less quantifiable effects are no less terrible. The ecologist E. O. Wilson ranks invasive species second only to habitat destruction in the magnitude of the threat they pose. In removing natural barriers to species movements, Wilson says, we're changing the very nature of wild places, replacing unique animal and plant communities with a generic, impoverished hodgepodge world of hardy generalists: a world not of Sumatran rhinos, golden turtles, Blackburnian warblers, and giant saguaro but merely one of cats, rats, crows, and West Nile virus.

Picture a starlit Maui evening. Balmy air, greengold pools of light among the bromeliads and ferns. An invisible frog chorus provides live music—*co-KEE!* Human soloists contribute a reedy counterpoint—*GOT-one!*

Mele Hong shines her light at the base of a leaf to reveal a plump, orangey brown frog no bigger than a bottle cap. He inflates his throat and shrieks *co-KEE* at 90 decibels—as loud as a lawn mower. She grabs the little guy, and into the freezer-bound Ziploc bag he goes.

Fong, then the Maui Invasive Species Committee outreach specialist, and Fern Duvall, a state wildlife biologist, are showing a neighborhood group how to find a Caribbean tree frog called, not surprisingly, a coqui. By removing the frogs in mildly infested areas, people can help keep them from spreading—and keep their own gardens frog free. It's too late for that here: This garden backs onto a highly infested wooded ravine. Duvall estimates that there may be 10,000 little frogs within earshot tonight. Breeding males start calling in the evening and can call all night—all year long.

Few things have gotten the Hawaiian public's attention like this "quarter-size frog with the million-dollar voice," as *Hawaii Business* magazine dubbed it. Entering the Pacific on nursery plants from Puerto Rico, the newcomer occupies pockets of Hawaii in numbers so biblical that the Big Island has declared a state of emergency to qualify for federal funds to eradicate it.

Having a thousand car alarms shrilling in your garden all night, every night, is understandably unfortunate, and failure to disclose that coqui frogs are on your property when you sell it can get you sued in Hawaii. But these are the least of Hawaii's coqui worries. A deafening, all-night chorus could hurt tourism, pillar of the economy. It's already dampened the 80-million-dollar nursery export business. And Fern Duvall points out that the frogs will eat a billion insects, robbing native birds of food.

Fong and Duvall are dismayed by the strength of tonight's chorus, but "there's an educational opportunity here," Fong says. Maybe the spotlight on the frogs will illuminate the broader problem of invasives, helping Fong and others make headway against the species that have them lying awake at night. *Miconia*, for instance.

"In the Kurt Vonnegut book *Cat's Cradle*, there's this material called Ice-9 that binds water permanently and destroys the world," Art Medeiros, a U.S. Geological Survey botanist, says. "Miconia is like Ice-9."

A tree with leaves the size of a small child, *Miconia calvescens* evolved in heavily canopied forests in South America. There it hangs back until a tree falls and creates a light gap, which it races to fill. Pacific Island forests, in contrast, have airy, discontinuous canopies. Without canopy-forest competitors, miconia fills all the light gaps, creating canopies as continuous as awnings, under which few animals or other plants can live.

"It's like a biological desert under there; completely silent," Medeiros says. *Miconia* has already invaded the island of Tahiti and replaced two-thirds of its native forest. The government there has given up trying to control miconia, but that's not the end of the story. Even if they accept the eradication of their native fauna and flora, the Tahitians still need soil and watershed protection. *Miconia* is extremely shallow rooted. When all the trees are miconia, there's little to anchor the forest and soil on slopes. Landslides are stripping the island of both.

This "green cancer" also infests tens of thousands of acres on Maui, where the soil is loaded with miconia seeds. Maui County deploys a 13-person team intent on destroying plants before they can set more seed. It's not enough.

"Right now, there's a window of opportunity with miconia and other weeds—a chance we can keep them under control. But at the rate we're working," Medeiros says, "things don't look good for Hawaii's plants and animals."

Miconia reached Tahiti and Hawaii as an ornamental tree, a precursor to the multibillion-dollar global

business in exotic pet, aquarium, and nursery plant species that is responsible for an extraordinary shuffling of wildlife around the planet. Much of that trade passes through Miami, a scant 75 miles (120.7 kilometers) from where Skip Snow chases pythons. Tom Jackson, a NOAA biologist, gave me a tour. First stop, Snakes at Sunset. Here, two kids have their noses glued to a tank in which three black-and-yellow Nile monitor lizards scamper about.

"They'll be seven feet (2.1 meters) long before you know it, and they have nasty temperaments," Jackson says. "Kids, don't buy these." He looks sternly at their mother.

Mother probably doesn't know it, but not far away an ecologist named Todd Campbell is trying to eradicate a large population of these carnivorous lizards in the bedroom community of Cape Coral. Campbell's not as worried about the bedrooms as he is about two national wildlife refuges within swimming distance of town.

(Two wildlife species you won't find for sale in pet stores these days are Gambian rats and prairie dogs, thanks to a nightmarish scenario that played out in 2003. Prairie dogs at Phil's Pocket Pets, in Villa Park, Illinois, had been previously housed next to Gambian rats shipped from Africa. The rats were infected with a dangerous smallpox relative called monkeypox, which skipped to the prairie dogs and thence to their new owners. Fortunately no one died, but more than 70 people in six states were sickened before the Centers for Disease Control and Prevention traced the source.)

Next stop on Jackson's tour of Miami is Exotic Aquariums, boasting aisles of glittering exotic fishes, many of which—including the poison-spined lionfish—you can now find in U.S. waters.

More damaging than any fish, says Jackson, is the aquarium strain of a tropical seaweed, *Caulerpa taxifolia*. In 1984 a sprig of *Caulerpa* was dumped into the sea from Monaco's oceanographic museum. When it was discovered, three years later, the *Caulerpa* colony wasn't much bigger than a bath mat. But "France and Monaco argued about how it got there," says Dan Simberloff, director of the University of Tennessee's Institute for Biological Invasions. "Then they argued over which agency was responsible for it. Then they argued over whether it would become problematic. When they finally got around to dealing with it, it was too late. Today, *Caulerpa* carpets 30,000 acres (121.4 square kilometers) of the Mediterranean. If they'd just jumped in when they found it and pulled every scrap, they could have nailed it."

Despite the calamity in the Mediterranean, the U.S. didn't prohibit the sale of *Caulerpa* until 1999. The next year, *Caulerpa* was found growing in the water northwest of San Diego. Authorities acted with impressive speed, isolating and poisoning the *Caulerpa* patches in a four-million-dollar strike that appears to have been successful.

Tour over for the day, Jackson drives me back to his bungalow to pick up my car. On his doorstep we find a plastic tub with a frog inside and a note on the lid: "Tom, I found this in my pool. Any idea what

species?" Jackson can't say offhand. The amphibian's not from Florida, but it could be from almost anywhere else in the world.

Restricting the entry into the United States of alien species such as *Caulerpa* and zebra mussels, already known to be invasive elsewhere, would be almost automatic, one would think. The reality is more complex—and far more difficult. In most countries, unless a species is on a short blacklist of noxious weeds or injurious wildlife, or restricted under the Convention on International Trade in Endangered Species, you're free to import it. (Australia and New Zealand have abandoned this presumption of innocence in favor of a more effective "clean list" of approved species; species not on the list are denied entry.)

Further hampering prevention efforts in the U.S. is a lack of coordination between government agencies, and the fact that agencies have multiple, sometimes conflicting mandates. The U.S. Department of Agriculture keeps the noxious-weed list, but focuses primarily on protecting agriculture and the nursery trade, not wilderness. Thus it took the USDA five years to list melaleuca, the highly invasive Australian paperbark tree that had converted 500,000 acres (2,023.4 square kilometers) of native Florida wetlands to forest.

The U.S. Fish and Wildlife Service regulates the trade in wild animals, but it's also charged with promoting industries like aquaculture that are often responsible for introducing invasives. When three species of Asian carp escaped from catfish farms into the Mississippi River, Illinois petitioned the wildlife service to add Asian carp to the injurious wildlife list; aquaculturists lobbied against the listing. Three years later a decision is still pending. In the meantime, the U.S. and state governments are resorting to a nine-million-dollar electric barrier to keep Asian carp out of the Great Lakes. State departments of fish and game, for their part, are charged with protecting the environment from invasives, but they often manage alien game species such as feral pigs and exotic deer for hunters.

Some experts believe the answer is a well-funded national center for invasive species based on the Centers for Disease Control and Prevention model. Though Congress took a first step in 1999, establishing the National Invasive Species Council, it has remained underfunded.

"As a society we've adopted an exclusively reactive mode," says David Lodge, an ecologist at the University of Notre Dame. "Invasives aren't like other forms of pollution. They don't stop spreading when you stop releasing them. They grow, and they grow in an accelerating manner. Doing nothing to prevent them is a particularly damaging policy."

At Pier 39 in San Francisco Bay, a Mad Hatter's tea party of marine biologists has made itself at home on a dock. Several huddle around an orange washtub using tweezers to sort through a malodorous slurry; others scrutinize bewildering aggregations of glop and argue Latin nomenclature; one scowls at a fastidiously coiled rope. For their purposes, "the more derelict the dock the better," says Andy Cohen.

Anything left dangling overboard accumulates the shaggy coat of marine organisms known as fouling.

Cohen, a marine biologist at the San Francisco Estuary Institute, organized this weeklong outing—a rapid-assessment survey in which biologists collect organisms at 15 sites around the bay to see what's shown up since last time they looked.

"You never know what you're going to find," Cohen says. "It's like a story unfolding before your eyes."

The San Francisco Bay and San Joaquin Delta constitute the biggest estuary system on the west coast of the Americas. One of the world's busiest international ports, it harbors a million wintering shorebirds, supplies drinking water to two-thirds of Californians, and nurses the young of many marine creatures. Cohen believes it also qualifies as the most invaded aquatic ecosystem in the world. In some parts of the bay, 90 percent of species are alien.

At the disappointingly shipshape Coast Guard dock, four or five seamen wince as Jim Carlton of Williams College claws up a handful of silty invertebrates fouling the bottom of a float.

"Where do the exotic ones come from?" a seaman asks.

"This sea squirt is from New England. This little mussel is from Japan," says Carlton, sorting through his haul with a mucky finger.

"Do you have anything from here?"

Carlton smiles ruefully. "Not in this pile, no."

They stare for a moment. Then, "How do they get here?"

"Oh, fouling is responsible for quite a few," Carlton says, "especially from the gold rush, when so many old, heavily fouled wooden ships sailed in and were abandoned here. The oyster trade. Fish bait. Ballast water brought the rest."

Big cargo ships often carry 20 million gallons (75.7 millions liters) of ballast water. They pump it into and out of one or more tanks to keep the ship stable. They take on ballast water in one harbor, dump it out in another; take on water in Boston, dump it out in Odessa. The ships draw in not only water, but whatever's in it. Sampling has turned up as many as 300 species on a single ship, from schools of 12-inch (30.5-centimeter) fish to the microscopic dinoflagellates that cause red tides.

More than 45,000 cargo ships move 10 to 12 billion tons (9.1 to 10.9 billion metric tons) of water from port to port around the world every year. In them, Carlton estimates, "5,000 or more species could easily

be in motion on any given day." Ballast water delivered the comb jelly to the Black Sea and the zebra mussel to the Great Lakes. It reportedly dumped an Asian strain of cholera bacteria in Peru, triggering a 1991 epidemic that killed 10,000 people.

Slowly—"far too slowly," Andy Cohen says—New Zealand, the U.S., Norway, and a few other countries are adopting regulations that require ships to exchange their ballast water while out at sea, so coastal species from one port won't get dumped out in another. But the regulations have loopholes big enough to steer a tanker through. Better than ballast exchange, Cohen says, is ballast water treatment. Washington State, which now relies on ballast exchange, will require ships to have installed on-ship treatment systems by 2007. In the meantime an ever changing biological soup of species is ballasted, deballasted, and reballasted every day in every major port in the world.

"I like to use the quote credited to Winston Churchill," Linda Drees, a National Park Service invasive species expert, tells me. "You can always count on the Americans to do the right thing after they've exhausted all the other possibilities."

Exhibit A: North Dakota's nemesis, a yellow-topped, tap-rooted Asian perennial called leafy spurge. It hit the Great Plains in 1909 and found there broken, overgrazed ground and nary an animal, vegetable, or mineral that could stop it. It galloped away across the prairies, spreading by root and spreading by seed, eventually infesting 1.2 million acres (4,856 square kilometers) in North Dakota alone.

"Cattle hate spurge," explains Chuck Weiser, a Ward County, North Dakota, weed board member. "It has an acrid sap that burns their mouths." One stem in a square foot (0.1 meter) of pasture reduces grazing in that spot by 50 percent; two stems reduce it by 90 percent. Three stems and "cattle won't even walk in it."

Today spurge costs the Dakotas, Montana, and Wyoming an estimated 144 million dollars a year in lost revenues and direct expenses. Alberta, Manitoba, and Saskatchewan are similarly afflicted. North Dakota declared spurge a noxious weed in 1935, requiring ranchers to control it. But "herbicides won't eradicate it," Weiser says. "And you can't pull it up. The root can grow 20 feet (6.1 meters) deep."

By the early 1980s the situation in North Dakota was so desperate that local, state, and federal agencies, universities, and landowners came together. They committed to tackling spurge with a model that has produced results elsewhere: develop a strategy, coordinate with other agencies, devote adequate resources, and never let up. Florida used this model, finally, to control the melaleuca tree. New Zealand has used it to eradicate rats on some Pacific Islands. Australia used it to eliminate kochia weed from 8,000 acres (32.4 square kilometers).

In North Dakota, counties started sharing ranchers' herbicide costs. The state studied what grazing sheep could accomplish (spurge tastes just fine to them) and imported thousands of sheep from drought-riven Texas, shepherds and all, and parceled them out to ranchers.

Federal agencies in the U.S. and Canada ramped up efforts to find an insect or pathogen that could control spurge. In 1988 they hit pay dirt. *Aphthona* flea beetles, when released in great numbers, "will knock a hole in spurge," Weiser says. "The larvae eat their way into the root system and weaken the plant." Fungi and bacteria finish the job.

Biocontrol is an ancient idea—the Chinese used predacious ants to keep herbivorous insects from grain stores thousands of years ago, and a desire for rodent control undoubtedly prompted domestication of the cat—but it's one with a rather mixed record. A moth aptly named *Cactoblastis cactorum* tamed 16 million acres (32,375 square kilometers) of prickly pear cactus infesting the Australian outback. But a weevil introduced to subdue invasive musk thistle in the U.S. is clobbering native thistles. Research and testing of biocontrol agents are extremely expensive. And even effective biocontrols rarely accomplish the job on their own.

The flea beetles used to combat spurge, for example, are no magic bullet. They don't work in sandy soil, they don't perform in cool weather, and they can take years—as many as ten—to reduce really bad infestations. The best approach, experts say, is integrated pest management (IPM), combining, in this case, sheep and bugs and herbicides where needed. In North Dakota, research is showing that IPM has an added advantage: grazing two or more species, sheep and cattle, for instance, and managing the amount of time each spends on a given patch of land, increases the biodiversity of the grasses and improves soil, strengthening the land's ability to resist invaders.

It's too soon to declare victory, but for the first time in almost a century, spurge in North Dakota is on the wane.

Integrated pest management is a good approach to controlling established invaders, Jim Carlton says. But better yet is "integrated vector management—preventing invasives by managing every footstep of the pathway that brings a species from Brazil to France or from Hong Kong to San Diego. People always ask me, 'Hasn't everything that *can* be introduced already *been* introduced?'" Carlton says. "Well, there's a European fouling invertebrate called a sea squirt, *Asiddiella aspersa*, that's probably been on the hull of thousands of European ships over 500 years of shipping. But it only showed up for the first time in a New England bay in the 1980s. Based on that time line, I'd say no: Everything that can invade has not invaded, and we can't afford to let it."

It will take worldwide political action to tackle the problem of invasives, Lodge and others believe. They suggest that the new, more stringent security measures being instituted in the U.S. to prevent terrorist activity offer an opportunity. Invasive species control measures could be piggybacked onto them.

Military experts might welcome such collaboration. A 2004 article in *Parameters*, the U.S. Army War College quarterly, warns that terrorists could use invasives as weapons to "disrupt and demoralize the U.S. government and its citizens over time."

Individual action is needed too. "Roll up your sleeves and get out there," urges Dan Simberloff of Tennessee University. Many people have. Perhaps you've hiked past them in parks, or seen them by the side of the road, wrestling honey-suckle or Himalayan blackberry. What may look like a hopeless battle

and a lousy way to spend a Sunday yields results. Volunteers battle Scotch broom in Washington's Olympic Peninsula region most every Tuesday, rain or shine; there's still Scotch broom, but no longer so much of it as to bar the flight of prairie butterflies. In the Waikamoi Preserve on Maui, Nature Conservancy volunteers have weeded kahili ginger from the forest floor one Saturday a month, every month, for 14 years. As a result of their work, rare native ferns and mosses are still luxuriant on the ground there. In the grandest weed-pulling project of all, South Africa employs more than 20,000 people felling and uprooting water-hogging invasive trees. It's a program that has restored water to streambeds—and self-respect to impoverished, long-out-of-work citizens, many of them women.

It's been 15 years now since the U.S. entered the period Jim Carlton likes to call A.Z.M.—after zebra mussels. At a shocking cost to economies and to nature, we've learned what damage invasives can do. Some of it is permanent. No amount of ballast water exchange is going to eradicate zebra mussels from the Great Lakes. No fumigating of shipping pallets will reinstate the American chestnut, king of North America's eastern forests, felled by an invasive fungus. Many ecosystems are simply changed beyond recognition; for them, there's no going back.

But what we still have is infinitely precious. To sit by and watch it destroyed would be worse than foolish; future generations will call it unforgivable.

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