# Invasive species and their effects on native species

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Many thousands of species, including animals, plants, fungi, bacteria, and viruses, have been transported to areas outside their native ranges and have successfully established new populations there. If one of these introduced species then causes significant negative ecological, economic, or human health impacts, it is categorized as an invasive species. The movement of species around the globe is not a new phenomenon, but human intervention has drastically increased the rate of movement, the distances that organisms can travel, and the types of species that are now transported around the globe. Invasive species are accidentally or intentionally introduced to new areas via many routes, including the horticultural trade, agriculture, aquaculture, agroforestry, the game animal trade, the pet trade, ship ballast, fishing bait, transport of untreated wood, and mud stuck to boots or tires. They also can be introduced as food items. The economic cost of invasive species is considerable. For example, the impact of introduced agricultural pests and weedy species on cropland, pastures, and forests costs billions of dollars annually in the United States. Invasive trees in South Africa have been calculated to reduce current river flow rates by up to 22%; controlling their spread will cost many millions of dollars, but allowing them to spread further would be costlier still, given their threat to critical water supplies. Invasive species also increase public health risks. In the Northeast United States, areas with invasive Japanese barberry bushes (Berberis thunbergii) had nine times more blacklegged ticks (Ixodes scapularis, the species responsible for transmitting Lyme disease to humans) than areas without Japanese barberry.

Invasives also affect many native species through predation, disease, herbivory, competition for resources, and hybridization, resulting in genetic swamping of the native species. Entire ecosystems are affected by invasives that alter fire regimes, cause nitrogen enrichment, and remove native foundation species. The following case studies demonstrate both the diversity of invasive species and the range of effects that they can have on native species and ecosystems.

## Predators

Cats and snakes are two important predator invasives.

*Cats.* Invasive cats (*Felis catus*) are responsible for 26% of all predator-related island bird extinctions worldwide and have been described as being by far the most dangerous of any introduced carnivore (**Fig. 1**). Cats are particularly damaging predators as they continue to hunt even when fed regularly by humans. Because cats are good at controlling rats aboard ships, they have traveled around the world; some have escaped to create feral populations, whereas others have been intentionally introduced to control mice and rats in new colonies. In

**Fig. 1** **Cats are one of the most effective introduced predators, preying on birds and other small animals. (*Photograph courtesy of Keri Van Camp*)**

addition to killing unwanted introduced rodents, they also kill great numbers of other native small mammals, birds, reptiles, and amphibians. Feral cats in the United States kill an estimated 240 million birds per year, and that estimate doubles with the inclusion of cats that are pets. Invasive predators on oceanic islands often severely affect native prey species, many of which are endemic species that occur nowhere else on Earth. For example, the cat of a lighthouse keeper was solely responsible for the extinction of the Stephens Island wren (*Xenicus lyalli*), the only flightless songbird in the world, in 1894, with 12 additional native bird species being extirpated from this island by cats within a few years. Feral cat populations have been controlled successfully with the introduction of feline-specific viruses or toxins, followed by hunting and trapping once the population size is reduced. For example, the removal of cats from Long Cay Island in the British West Indies resulted in the recovery of the highly endangered iguana *Cyclura carinata*.

However, the consequences of removing invasive species such as cats can be much more complex than anticipated. Cats were introduced on Macquarie Island, Australia, in 1818. Initially, the cats had little effect on the Macquarie Island parakeet. Then, rabbits were introduced to the island in 1879. With this year-round food supply, the cat population grew rapidly, ultimately hunting the parakeet to extinction. By the 1960s, it became clear that the rabbits were destroying the maritime tall grassland and megaforb associations, and thus the *Myxoma* virus was introduced as a biocontrol for the rabbit population. Rabbit populations became much lower by the 1970s, and the cats switched to eating seabirds. A cat eradication effort began in 1985 to protect the seabirds, with the final cats being removed from the island in 2001. At this point, the remaining rabbits (that is, those that survived the virus and the cats) began to reproduce rapidly, and once again they began to devastate the unique plant communities on the island, transforming them into bare ground or grazed lawns. Clearly, the best solution is to prevent invasions from occurring in the first place.

*Brown tree snakes and Burmese pythons.* The brown tree snake (*Boiga irregularis*) was accidentally introduced to Guam after World War II, probably in the undercarriage of military aircraft. By the 1970s, the population size of the brown tree snake had reached a density of 100 per hectare (1 ha = 2.47 acres), as they had ample food supplies, no known diseases or parasites, and very few predators on Guam. The brown tree snake has devastated the native fauna on the island. Of the 18 native bird species, 12 went extinct and five others declined more than 90%. Of the three native bat species, two have gone extinct, whereas the third, the Mariana fruit bat (*Pteropus mariannus*), is now endangered. These species did not coevolve with predators such as the brown tree snake and thus had few defenses against such an efficient nocturnal, arboreal predator. The losses of these bird and bat species have cascading effects across the entire island because they played important roles in pollinating flowers, dispersing seeds, and controlling insect populations. Many other invasive species, including introduced rats, pigs, deer, birds, and skinks, have become established on Guam as well, further affecting the native ecosystems. Old-growth forests on the island are no longer regenerating and the fate of other native species is unclear. In addition to the effects of the brown tree snakes on native species, direct economic costs are estimated to run as high as $12 million (U.S. dollars) per year, primarily as a result of power outages when the snakes crawl into and short out the electrical transmission system. Brown tree snakes are continuing to disperse around the globe as stowaways on airplanes, with some traveling as far away as Spain. Interdiction has proven difficult. Barriers have been erected, traps around ports and airports in Guam catch hundreds of snakes per year, and detector dogs are used on Guam and at destination ports. This vigilance will need to be maintained indefinitely if brown tree snakes are to be kept in check.

Invasions of nonnative snake species continue to occur around the globe. Burmese pythons (*Python molurus bivittatus*) are a recent invader in Florida (**Fig. 2**). They prey on many species, including endangered species such as the wood stork and Key Largo woodrat, as well as species such as white ibis, limpkins, and round-tailed muskrats that are of conservation concern. Burmese pythons now occupy thousands of square kilometers in southern Florida. In fact, although cold temperatures will eventually limit their spread northward, it is unclear

**Fig. 2** **Invasive reptiles such as the Burmese python (*Python molurus bivittatus*) are often introduced via the pet trade. (*Photograph courtesy of Everglades National Park, Florida; National Park Service*)**

whether measures will be able to prevent their spread to other suitable habitats nearby, such as the Florida Keys.

## Disease and insect pests

Fungi and insects are notable invasives, often decimating native species.

*Chestnut blight.* Chestnut blight (*Cryphonectria parasitica*) is an invasive fungus from Asia that first arrived in North America on infected Japanese chestnut trees in the late 1800s. It was first detected on American chestnut trees (*Castanea dentata*) in 1904 at the New York Zoological Park in the Bronx. As the trees lacked any resistance or tolerance to the disease, it rapidly spread throughout the deciduous forests of the eastern United States. The fungus spores invade chestnut trees through any small break in the bark and then the fungal mycelium grows throughout the vascular tissue of the tree, killing the tissue and stopping the transport of water and nutrients. Billions of American chestnut trees were lost from the forests of the eastern United States and were replaced by other hardwood species, primarily oak trees. The chestnut was once a dominant forest species, amounting to 25% of the trees in some areas. These trees produced huge quantities of nuts every year, and therefore the loss of the chestnut had a very negative impact on other species that depended on those nuts for food, including bears, deer, elk, squirrels, raccoons, and turkeys, as well as the people who harvested the nuts. Chestnut trees now exist only as small understory tree sprouts that grow from the old stumps. These sprouts eventually succumb again to the blight, and new sprouts emerge. Reproduction by seed is absent. At some point, these old stumps will lose their vigor and the sprouts will die out. There are several organizations that are

working to develop blight-resistant strains of the American chestnut, but it seems highly unlikely that it will ever be able to return as a dominant tree species in the forests of the eastern United States.

*Emerald ash borer.* The emerald ash borer (*Agrilus planipennis*) is an invasive insect recently introduced from Asia that is decimating the native ash tree species in North America. It was first discovered in 2002, but had probably been introduced about a decade or more earlier from Asia into the Detroit area in untreated ash wood used in crates or packing materials. It is now found from Wisconsin to New York and as far south as Tennessee. Larvae feed on the cambium layer under the bark, and their feeding galleries disrupt the flow of water and nutrients in the tree. They remain in the bark and wood as larvae and pupae; then, when the adults emerge, they may disperse up to 0.8 km (0.5 mi) away. It also spreads by the shipping of infected nursery trees and the transport of firewood. Efforts are being made to identify early infestations to limit its spread (**Fig. 3**), but tens of millions of trees have already been killed. It is estimated that the emerald ash borer may result in the loss of all 18 native ash species in North America. Researchers are searching for natural enemies against the borer in its native range to use as biocontrol agents, as well as looking for trees that demonstrate genetic resistance to the borer. As with the American chestnut, the loss of North American ash trees is likely to have a cascade effect on other native species throughout the northern deciduous forests of the United States.

## Ecosystem transformers

Ecosystems can be dramatically changed by invasive species.

*Cheatgrass.* Cheatgrass (*Bromus tectorum*) has invaded arid regions worldwide after accidental introductions as a seed contaminant in cereal crops. Between 1890 and 1935, cheatgrass transformed the Intermountain West region of the United States (that is, the area between the Rocky Mountains to the east and the Pacific mountain ranges to the west) into a virtual monoculture. It is now the dominant plant across at least 200,000 $km^2$ (77,220 $mi^2$). Cheatgrass is an annual that dies in the summer, creating a blanket of highly combustible fuel across the landscape. The resulting fires cover hundreds of thousands of hectares, moving quickly across the landscape and totally consuming all aboveground plant material. The loss of vegetation during the fires leaves the soil vulnerable to erosion, which then creates sedimentation problems in the surrounding creeks and rivers. Previously, these areas had a fire frequency range of 60–100 years, but now the fire frequency is 3–5 years. This increase in fire frequency has led to the complete loss of the shrub community. The loss of these shrubs affects the endangered sage grouse (*Centrocercus urophasianus*), as well as many other native animals and plants.

*Earthworms.* Earthworms have not inhabited many northern regions for 10,000 years, since the Pleistocene glaciation eliminated the previous earthworm fauna. Over the past few hundred years, the use of soil as ballast, the relocation of landfill, the nursery trade, reforestation projects, and the release of unused bait have resulted in the introduction of well over 100 different earthworm species. When earthworms invade, the leaf litter layer vanishes as the surface organic matter is mixed into the underlying mineral soil. The loss of the litter layer shifts the food web relationships of litter-dwelling and litter-feeding organisms, altering their abundance and

**Fig. 3** **Sticky trap boxes, usually purple in color (such as the one shown here), are hung in ash trees to track the spread of the emerald ash borer and assist in control efforts. (*Photograph courtesy of Keri Van Camp*)**

composition. Declines in native ferns, woodland flowers, and tree species such as sugar maple have been linked to the presence of invasive earthworms, whereas the growth of invasive plants such as European barberry (*Berberis vulgaris*), stiltgrass (*Microstegium vimineum*), and garlic mustard (*Alliaria petiolata*) is facilitated. In addition to redistributing soil organic matter, earthworms also alter soil porosity and soil structure, increase the rate of nutrient cycling, create higher levels of nitrogen in the soil, raise the soil pH, and increase the rate of litter decomposition. These transformations, coupled with excessive deer herbivory and pressure from invasive plants, are having a profound influence on the regeneration of deciduous forests in the eastern United States.

## Future conservation

As seen in these examples, invasive species can have devastating effects on native species and ecosystems. The challenge is to decide how to respond to these invasions. Some conservationists see the task of removing invaders as a very expensive and nearly impossible goal, and feel that we should accept that they are here to stay. Preserving native biodiversity within these novel ecosystems is seen as a more realistic and reachable goal than trying to restore the original ecosystem. These conservationists also see great value in preserving ecosystem function, regardless of the species composition. Others vehemently disagree and point to the numerous examples of successful eradication and control. They argue that the threat to global biodiversity is too great to not continue the fight against invasives. Conservationists on both sides of this issue agree that the best solution is to prevent further invasions and, whenever possible, eradicate invasives in areas before they become fully established.

*See also:* BIODIVERSITY; BIOGEOGRAPHY; ECOLOGICAL COMMUNITIES; ECOLOGICAL COMPETITION; ECOLOGY; ECOSYSTEM; ENDANGERED SPECIES; EXTINCTION (BIOLOGY); INVASION ECOLOGY; POPULATION ECOLOGY; POPULATION VIABILITY; PREDATOR-PREY INTERACTIONS; RESTORATION ECOLOGY.

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## Keywords

Invasive species; extinction; eradication and biocontrol; ecosystem transformations; loss of biodiversity

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## Additional Readings

Emerald Ash Borer

National Invasive Species Council

National Invasive Species Information Center