

### In Summary

Invasive species are a pressing environmental and economic threat. The best way to limit impacts of nonnative species is to prevent them from invading and becoming established in a new area. If this fails, eradication may still be possible, but generally only if the species is identified and treated quickly. Once established, efforts to restrict spread to uninfested areas can limit further damage. Controlling population sizes in heavily invaded areas can also reduce deleterious effects, but is unlikely to lead to eradication. Last, maintaining healthy natural communities, either by limiting human disturbance, or restoring of previously impacted areas, can limit opportunities for exotics to take hold.



Purple loosestrife (*Lythrum salicaria* L.) was introduced as an ornamental plant. It has invaded wetlands in nearly all contiguous US states, replacing diverse native vegetation with dense monocultures. It also impacts the wildlife that depend on native wetland habitat.

Photo courtesy of USDA

### Where Can I Get More Information?

Ecological Society of America, 1707 H St, N.W., Suite 400, Washington, DC 20006. 202-833-8773. esahq@esa.org. <http://www.esa.org>. *Issues in Ecology* #5: "Biotic Invasions: Causes, Epidemiology, Global Consequences and Control," available online at: <http://www.esa.org/science/Issues/FileEnglish/issue5.pdf>

Aquatic Nuisance Species Task Force: <http://www.anstaskforce.gov/>

Federal Interagency Committee for the Management of Noxious and Exotic Weeds: <http://ficomnew.fws.gov/>

Global Invasive Species Programme: <http://www.gisp.org/>

Invasive Species Specialist Group of the World Conservation Union: <http://www.issg.org/>

National Biological Information Infrastructure, Invasive Species Information Node: <http://invasivespecies.nbi.gov/>

National Invasive Species Council: <http://www.invasivespecies.gov/>  
Management Plan, 2001: Meeting the Invasive Species Challenge, available online at: <http://www.invasivespecies.gov/council/mp.pdf>

USGS Biological Resources Division  
Invasive Species Program: <http://biology.usgs.gov/invasive/>  
Nonindigenous Aquatic Species Program: [http://cars.er.usgs.gov/Nonindigenous\\_Species/nonindigenous\\_species.html/](http://cars.er.usgs.gov/Nonindigenous_Species/nonindigenous_species.html/)

Office of Technology Assessment Report: Harmful Non-Indigenous Species in the United States: [http://www.wss.princeton.edu/~ota/ns20/year\\_f.html](http://www.wss.princeton.edu/~ota/ns20/year_f.html)

## INVASION!

West Nile virus, killer algae, sudden oak death. No, they're not Hollywood's latest thriller, but invasive species, which pose a genuine threat to our environment and economy. Expansion of global trade, and increases in human mobility have resulted in unprecedented invasion by nonnative species. These biological invasions produce severe, often irreversible impacts on agriculture, recreation, and natural resources. Invasive species impact biodiversity, habitat quality, and ecosystem functioning. They are the second-most important threat to native species, behind habitat destruction, having contributed to the decline of 42% of U.S. endangered and threatened species. Introduced species also present an ever-increasing threat to agricultural productivity and human health. In the United States, the economic costs of nonnative species invasion exceed \$137 billion each year, more than the combined total of all other natural disasters.



courtesy of USGS  
Fire Ant (*Solenopsis invicta*)



The Ecological Society of America

### What are Invasive Species?

Nonindigenous species are those that evolved elsewhere and have been purposely or accidentally relocated. While species can colonize new regions on their own (e.g. migrating wildlife, plants and animals rafting on debris), humans have dramatically increased the magnitude and scale of exotic species' movements. Approximately 50,000 nonindigenous species have been introduced into the United States alone. Not all introduced species become invasive. Some introduced species appear to be relatively benign, but others are strong competitors or voracious predators with devastating effects. Invasive species are the subset of introduced species that persist, proliferate, and cause economic or environmental harm, or harm to human health.

### How Did They Get Here?

Some nonnative species have been deliberately imported, while others arrived in the U.S. accidentally. Examples of nonindigenous species intentionally released into natural areas include nonnative plants, such as kudzu, that were introduced to control soil erosion; European birds, which were introduced to make colonists feel more at home; and game fishes stocked for sport fisheries. Other imported species were intended only for agricultural, horticultural, or aquarium use, but subsequently moved into natural landscapes, some with significant ecological or economic impacts. Crops and trees have escaped plantations and become pests; nonnative ornamental plants used in landscaping often disperse into surrounding wild lands; and aquatic species reach new environments when unwanted pets or bait fish are set free in natural waterways.

### Aquatic Hitchhikers

When ships unload their cargo, they often fill their ballast tanks with water to provide balance for their return journey. In addition to water, many aquatic organisms are sucked into these tanks and given transport. A ship will then empty its ballast tank (and various aquatic stowaways) at the next port where it takes on cargo. It is estimated that more than 10,000 marine species each day may travel around the globe in the ballast water of cargo ships. Many invasive species have been introduced into new areas in this manner, including the zebra mussel (*Dreissena polymorpha*), pictured here. One control mechanism is to exchange ballast water on the high seas between ports to remove invasive species before they reach the destination port. Other methods being explored include using filtration, U.V. irradiation or ozone to sterilize ballast water prior to discharge.



courtesy USGS

Frequently, intentional introduction of one species leads to unintentional introduction of associated species. Examples include pathogens that reside in the soils of potted horticultural imports; weed seeds that contaminate crop seeds; or pathogens that spread from aquacultural production facilities to native populations. Transport vessels may act as vectors for other species. Forest pests can travel world-wide in wood packing material used in shipping. Boats and airplanes have unwittingly provided transportation to remote islands for a host of vertebrate invaders, including rats and brown tree snakes. Even hikers can contribute to invasive spread, by carrying seeds embedded in muddy boots from one locale to another.

### Why Are Invasive Species A Problem?

Invasive species may negatively impact native species in any number of ways, including eating them, competing with them, interbreeding with them, or introducing pathogens and parasites that sicken or kill them. Invasive species affect nearly all habitats on Earth, ranging from wilderness areas, to croplands, rangelands, and forests, as well as freshwater and marine ecosystems. Invasive species can be thought of as biological pollutants, with potentially severe impacts on the ecosystems they inhabit. Like other pollutants, they may change the species composition of the environments they inhabit or impact the normal functioning of the ecosystem by altering fire regimes, hydrology, nutrient cycling and productivity. Unlike most other pollutants, the effects of biological invaders are likely to increase through time as existing populations expand, even if new introductions are halted.

### What Threats Do Invasive Species Impose?

- Invasive species threaten native species. Exotics have contributed to the decline of 35-46% of imperiled species in the United States.
- In agricultural landscapes, invasive plants, herbivores and parasites outcompete crops for soil and water resources, reduce crop and forage quality, and poison some livestock species. Invasive species on US agricultural and rangelands cost over \$54 billion annually.
- Introduced organisms degrade resources, such as national forests (see box at left). Current estimates of annual losses and damages from forest pests and pathogens in the U.S. reach \$4.2 billion.



courtesy FWS

The Asian long-horned beetle (*Anoplophora glabripennis*) arrived in the US in 1996. This insect infests hardwood trees, and could cause more destruction than Dutch elm disease, chestnut blight, and gypsy moths combined.

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- Recreational and commercial fisheries are also vulnerable to the threat of invasions. European green crabs negatively impact oyster, clam and crab fisheries on the Pacific coast.
- Aquatic invasive species, such as the zebra mussel, clog lakes and waterways and adversely affect public water supplies, nuclear power plants, irrigation, water treatment systems, recreational activities, and shipping.
- Invasive pathogens may also directly affect human health. West Nile virus arrived in the United States as recently as 1999. In 2003, 4200 people were infected, resulting in 284 deaths.
- Hybridization with exotics can alter the genetic makeup of native species. Cultivation of genetically modified organisms provides a special case of such risk. When GMOs interbreed with wild relatives, their

DNA becomes part of the gene pool of natural populations. Long-term consequences are not known.

### What Can Be Done?

**Prevention** is the single best way to limit impacts of nonnative species. Methods include decontamination of freight, packaging material and transportation equipment that could contain unknown biotic hitchhikers, and restricting deliberate imports of potentially harmful species. Unfortunately, it is difficult to forecast which species will become a problem. However, new protocols for invasive risk assessment that consider species' life history, habitat preferences, and history of invasive behavior have improved our predictive capacity. Once potentially invasive species are identified, it is critical to halt their intentional or unintentional spread.

**Eradication** may be feasible early in an invasion or in a restricted area. Early detection and rapid response is an efficient tactic for local eradication of new invaders. Regular monitoring programs to identify new exotics soon after they invade, in conjunction with any of the control methods listed below, are critical components of this strategy. Systematic early detection and rapid programs exist for agricultural pests, but similar programs on natural areas have been slow to develop, and underfunded.

**Containment** (preventing further transport of existing exotics within the US) is an important tool to reduce the impact of existing invaders. Strategies for containment generally combine tools used in prevention and eradication.

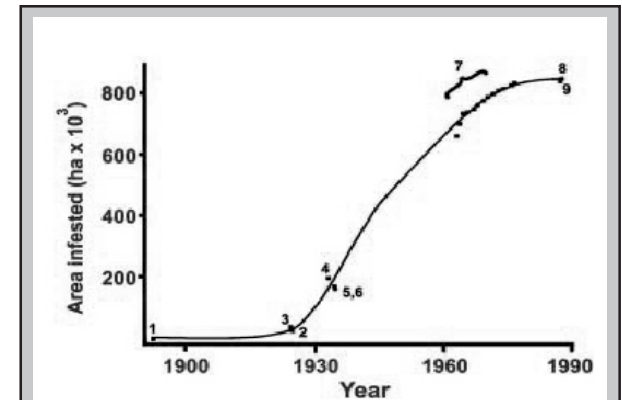
**Control** methods can include any of the following:

- Chemical control* (using pesticides, herbicides, or fungicides) can be effectively used to kill invasive species, but it can be problematic due to impacts on non-target organisms, including humans. Prolonged use of chemical control is expensive, and may be ineffective when target organisms evolve resistance to certain chemicals.

- Mechanical control* (physically removing the invasive species or changing habitat conditions) is often successful, but can be expensive and labor intensive. Modifying habitat conditions, through alteration of fire or flooding regimes, is a mechanical control option when removal of individuals is infeasible.

- Biological control* (introducing a natural enemy – predator or parasite – generally from the invader's native range) is often the only alternative for controlling an invasive species that has established dense populations over large areas. It can be an environmentally sound way to control invasive species with minimal expense, but some control agents do not survive and others attack non-target organisms.

**Restoration** of native communities is an important step to minimize the chances an area will be reinvaded. Many control techniques inherently create disturbance, which may increase the vulnerability of an area to subsequent invaders.



Moran and Zimmerman 1991

The spread of invasive species typically follows a pattern similar to the one shown above, for the colonization of jointed prickly pear (*Opuntia aurantiaca*). Intervention to control invasives is generally much easier during the early stages of invasion than after the species has spread over large areas.