EarthTrends: Featured Topic

Title: **Bioinvasions: Stemming the Tide of Exotic Species**
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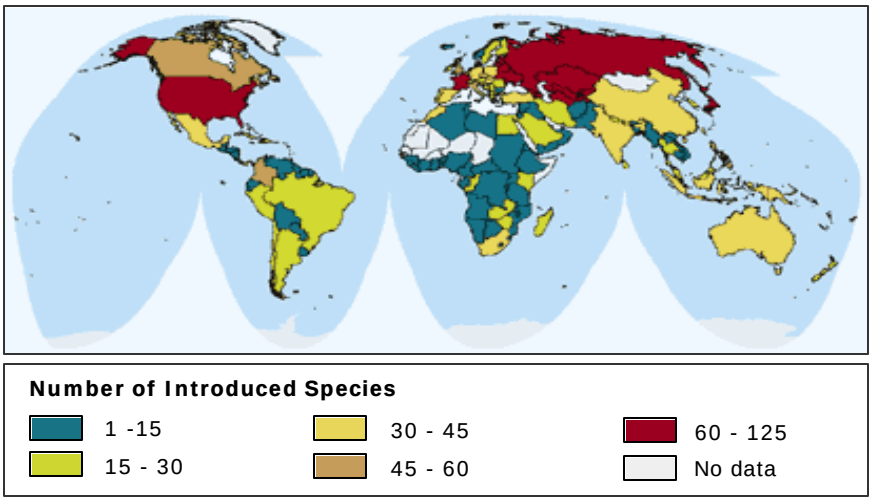
Ever since humans began traveling over land and sea, assorted livestock, crops, pets, pests, and weeds have tagged along. Nearly every region of the globe has benefited economically from introduced species. Yet new arrivals that become invasive have also created major problems for agriculture and other human enterprises and disrupted distinct communities of native plants and animals.

Today, almost 20 percent of the world's endangered vertebrate species are threatened in some way by exotic invaders, including 13 percent of vulnerable mainland vertebrates and 31 percent of those on islands (MacDonald et al. 1989:232-233). Nonnative fish introductions are common in most parts of the world, too, with serious consequences for freshwater and coastal ecosystems. A survey of 31 fish introductions in Europe, North America, Australia, and New Zealand found that in 77 percent of the cases, native fish populations were reduced or eliminated following the introduction of nonnative fish (Ross 1991:363). Worldwide, two-thirds of freshwater species introduced into the tropics and more than 50 percent of those introduced to temperate regions have become established (Welcomme 1988:29) (see Figure 1). Invasives similarly crowd out native plant species in grasslands. In the U.S. and Canadian Great Plains, at least 11 percent of plant species are nonnative, and more than 20 percent are nonnative in the California Central Valley Grasslands and the Florida Everglades (White et al. 2000:47).

Introduction of Nonnative Species Is a Global Phenomenon

Figure 1: Number of Species Introductions into Inland Waters by Country



Source: Revenga et al. 2000

In fact, invasions of natural ecosystems by nonnative species now rank second to habitat loss as the major threat to biodiversity (Wilson 1992:253; Wilcove et al. 1998:607; ISSG 2001). The sparse data available suggest that the pace of invasions is accelerating in parallel with the growth of global trade. In the San Francisco Bay area, for instance, the rate of successful aquatic invasions has climbed from an average of one species every 55 weeks between 1851 and 1960, to one every 14 weeks from 1961 to 1995 (Cohen and Carlton 1998:556). Marine ecosystems in the Mediterranean now contain 480 invasive species, the Baltic 89, and Australian waters 124 (Burke et al. 2000:50). Some ecologists predict that as the number of potential invaders increases and the supply of undisturbed natural areas

declines, biological pollution by alien invaders may become the leading factor of ecological disintegration (Crooks and Soulé 1996:39).

The Convention on Biological Diversity adopted at the 1992 United Nations environmental summit in Rio de Janeiro recognized this threat. The treaty calls on participating nations "as far as possible and as appropriate [to] prevent the introduction of, [to] control, or [to] eradicate those alien species that threaten ecosystems, habitats or species" (Carlton 1996:100). Participating nations are exploring how to implement this enormous task.

A Biological Conveyor Belt

Burgeoning world trade has a particularly great potential to increase bioinvasions by opening unintentional but major dispersal opportunities. Food- and water-borne disease organisms, agricultural pests and weeds, and other nuisance species hitchhike to new lands aboard ships, airplanes, and trucks, stowed in shipping containers and packing materials or riding on nursery stock, unprocessed logs, fruits, vegetables, and seeds (McNeely 1996:53). On any given day, for instance, about 3,000 aquatic species are moving around the globe in the ballast tanks of ships, a biotic conveyer belt that has already altered the ecological makeup of much of the world's fresh and coastal waters (Carlton 1996:100).

Deliberate introductions of exotic plants and animals for commercial and agricultural purposes also can pose risks. The bulk of the diet of most of the world's population comes from crop and livestock species that originated elsewhere (McNeely 1996:53), and land managers, agricultural scientists, and other sectors of society have clear economic incentives to continue importing exotic species for food, timber, horticultural, and other uses. These intentional imports do not always prove benign. The golden apple snail, which was introduced into Asia from South America in 1980 to be cultivated as a high-protein food source, has dispersed into the region's rice paddies, where it feeds voraciously on rice seedlings, causing significant crop damage (Naylor 1996:443).

Of course, not all newly arriving species become problems; about 10 percent of introduced species become established in nonnative environments, and about 10 percent of those become pests (Knowler and Barbier 2000:70 citing Williamson 1996). But those nonnative species that do become problems cause economic as well as biological damage. Estimates of economic losses, not including damage to native species or to ecological services, range up to several billion dollars per year in the United States alone (U.S. OTA 1993:5). One recent attempt to quantify the economic damages and control costs of invasive species in five countries—the United States, South Africa, the United Kingdom, Brazil, and India—came to $336 billion a year (Pimental et al. 2000:14). (See Figure 2 for examples of the impacts of invasive species.)

Erecting Barriers Against Invasions

What can be done to stem the tide of bioinvasions? For one, before intentionally introducing an exotic, it would be helpful to thoroughly analyze potential risks and trade-offs of the introduction. However, biologists cannot predict with certainty the invasive potential of any given plant, animal, or microbe (Mooney and Drake 1989:499-500). For this reason, a few nations--such as New Zealand, where 47 percent of the flora is already exotic (Heywood 1989:40)--have adopted the precautionary principle, banning importation of all exotic species except for a few clean-list species that are known to be benign. In contrast, most nations, if they have any import restrictions at all, use a dirty-list concept, only denying import of known problem pests or weeds (Bean 1996:204-210).

In the case of unintentional invasions, the first line of defense is a system of quarantines and regulations

Losses Due to Invasive Species

Figure 2: Comprehensive data on nonnative species and their effects on biodiversity are not available at a global or regional level, but there are many well-documented cases of individual species invasions—and the high costs incurred.

Ecosystem	Typical Sources of Invasives	Examples of Invasives' Impacts
Agroecosystems	Intentional introductions for crops, livestock, and horticulture; accidental transport of pests and diseases.	- Agricultural losses from bioinvasions worldwide range from $55 to $248 billion a year (Bright 1999:51). - The Asian gypsy moth and nun moth are projected to cost $35-58 billion in tree losses in the United States over 50 years (U.S. OTA 1993:118). - Up to 46 percent of the endangered plants and animals in the United States have been negatively impacted by invasive species (Wilcove et al. 1998).
Coastal	Through ballast water; intentional introductions for aquaculture, fish stocking, and ornamental uses; species migrations via artificial canals.	- Leidy's comb jelly, native to the western Atlantic, invaded and led to the collapse of the anchovy fishing industry in the Black Sea (Bright 1998:157).
Forests	Exotic tree species spread from forest plantations; horticultural introductions; transport of insect pests via traded forest products and other goods.	- South Africa will need to spend about $900 million in the next 20 years to control invasive trees and plants that consume about 3.3 billion m^3 of water annually (WRI 2000:196, 202). - In the eastern United States, native fir and hemlock forests are threatened by several species of adelgid, a tiny aphid-like insect (Stein and Flack 1996).
Freshwater	Fish, higher plants, invertebrates, and microscopic plants are accidentally introduced through shipping, commerce, and aquaculture, and intentionally for fishing.	- Canada and the United States have spent $8 million since 1991 to control sea lampreys, which have invaded the Great Lakes, plus $12 million attempting to restore lake trout, one of the freshwater fish the sea lamprey eats (Fuller et al. 1999:19-21). Similarly, controlling the zebra mussel (a native of European rivers) in the Great Lakes cost $300-400 million in 1989-1995 (Revenga et al. 2000:56). - Water hyacinth, native to the Amazon, has spread through rivers and lakes on every continent except Europe. It clogs waterways and infrastructure, reduces light and oxygen in freshwater systems, and causes changes in water chemistry and species assemblages (Hill et al. 1997).
Grasslands	Intentional introductions for game hunting, improved rangeland productivity, and agriculture.	- In Australia, a grass native to the Caribbean called *Parthenium* invades pasture as well as cropland and causes allergic reactions in livestock and humans (Ricciari et al. 2000:239). - In Canada, crested wheatgrass, native to Asia, (*Agropyron cristatum*), displaces native species and, in turn, reduces nutrient content and organic matter in soil (Christian and Wilson 1999).

designed to limit the free flow of species through trade, transport, aquaculture, agriculture, forestry, game farming, horticulture, the pet trade, recreation, tourism, and travel (Berntsen 1996:8). To that end, there is interest in clarifying the World Trade Organization's (WTO) "phytosanitary standards" to ensure that trade regulators have greater discretion to take precautionary measures against potential invasives. The WTO could also classify and regulate "high risk" pathways, products, and other factors in the transport of invasive species (Sizer et al. 1999:19). However, the creation of such new barriers and rules is difficult in light of potential conflicts with treaties such as the General Agreement on Tariffs and Trade that promote fewer, rather than more stringent, restrictions on international trade (U.S. OTA 1993:288-290).

Nevertheless, some steps are under way. The 156-nation International Maritime Organization (IMO) is trying to develop an international legal regime to control ballast water discharge, which is the source of many invasives in coastal estuaries. To help

developing countries control the introduction of invasives through ballast water, the IMO, the Global Environmental Facility and the United Nations Development Programme have committed $10 million in technical assistance and pilot projects (IMO 2001). In the interim, several countries, including Canada, the United States, Chile, Israel, Australia, and New Zealand, have acted individually to protect their waters from invasions through national and local legislation that imposes mandatory or voluntary ballast water controls. Some ports, like Buenos Aires in Argentina, Scapa Flow in Scotland, and Vancouver in Canada have done the same (IMO 2001).

Some countries are raising the profile of the battle against invasives. For example, in 1999, President Clinton created a United States interagency Invasive Species Council charged with improving education, research, and action against invasives (Clinton 1999; Reichard and White 2001:107).

There are also signs that individuals are beginning to understand the importance of their role in curbing invasive introductions, given that many invaders reach new territory via people who import seeds for their gardens, shop at nurseries, or transport plants in their luggage. In a recent survey of 157 people, mostly United States citizens interested in horticulture, 83 percent expressed a desire to avoid buying invasive plants (Reichard and White 2001:108). In Florida and Minnesota and in Australia, groups are working with the nursery industry to identify species that are potential invaders and could be taken off the market voluntarily or tagged with a warning. A popular mail order nursery in Washington State has already voluntarily withdrawn some known invasive species from its sales catalogue (Reichard and White 2001:106). South Africa, similarly, is targeting plant nurseries for tighter regulations on the sales of invasive plants (WRI 2000:202).

Once invasives are established, eradication is difficult and costly. As of 1999, South Africa was spending about $35 million a year on efforts to control invasions of woody tree species which, unlike native species, consume large quantities of the country's water. In South Africa, employees of the national Working for Water Programme physically cut down the problem species (WRI 2000:196, 198). However, South Africa, like many other countries, also uses biological controls against invasives; since the 1800s, countries have tried intentionally introducing the exotic enemies of invasive pests and weeds to attempt to suppress them or control their range. But these biological controls are not always effective. Only about 10-15 percent of the natural enemies of arthropod pests that are introduced succeed at controlling their target. About 30-40 percent of biological controls against weeds are successful (Hill and Greathead 2000:208).

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