A Special Issue on Global Movement of Invasive Plants and Fungi

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The global movement of plants and fungi has been an integral part of human activity for many centuries: Plants have been transported as food and used for medicinal and ornamental purposes, and fungi associated with such plants have traveled with them. When plants and fungi are introduced into areas far from their native habitat, they usually die out unnoticed once they are no longer in use. In some cases, however, a species encounters few of the factors that limit spread in its natural habitat, or it may invade a new niche in which it can thrive and even become dominant. The result is an invasive species that can be extremely damaging.

An invasive species is defined as "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health" (OTA 1993). In the early part of the 20th century, it became obvious that some restrictions on the introduction of nonindigenous organisms were necessary to avert damage from invasive species, and thus safeguarding regulations were implemented. Despite these efforts, the number of introductions and the amount of damage resulting from invasive plants and fungi continue to increase. The impact of the repeated introduction of invasive species may be so devastating, in fact, that—as in Hawaii, for example—invasive species cause more loss of biological diversity than does human activity (Vitousek et al. 1987).

The introduction of plants has often been intentional, but the impact of an invasive weed may go well beyond the intended effect of the introduction. Consider, for example, kudzu (*Pueraria lobata*) in the United States. Originally introduced from Japan as a soil stabilizer and ground cover, kudzu now overruns thousands of acres of fields and forests every year. Another example is the nonindigenous plant *Melaleuca quinquenervia*, which was introduced as an ornamental curiosity and is now rapidly invading the Florida Everglades ecosystem. In 1983 its estimated rate of spread was around eight acres per day; less than 10 years later that rate was approximately 50 acres per day (Hoffstetter 1991). In Florida this plant is destroying valuable natural resources, reducing already scarce supplies of fresh water, and creating a severe fire hazard. The introduction and dominance of cheatgrass (*Bromus tectorum*), now covering millions of acres in western North America, illustrates how an invasive species may outcompete most of the native grass species in a region. Introduced repeatedly over the past 150 years, this weed is disseminated via seeds that cling tenaciously to clothing and animal fur.

Fungi can be equally as destructive as plants and may be more difficult to control, because they are often transported and introduced unseen on plant material. Several examples in the last century exemplify the effect of introduced fungi. The towering chestnut trees that once dominated the forests of the eastern seaboard of the United States were toppled by a fungus, *Cryphonectria parasitica*, which was accidentally introduced from Asia (Anagnostakis 1987). Today the giant chestnuts exist only in old photographs published occasionally in forestry books, or as hollow logs decaying slowly on the forest floor, 80 years after the alien fungus destroyed the trees. Also familiar are the effects of the fungus that causes Dutch elm disease (*Ophiostoma ulmi*), which has killed the stately American elms that graced the streets of many US towns until the mid-1970s.

In recent decades the number of invasive plants and fungi being introduced into the United States has increased (OTA 1993), prompting many biologists to ask why and causing government regulatory agencies to reexamine their plant quarantine procedures. On 3 February 1999, former US President Bill Clinton signed an executive order "to coordinate a federal strategy to address the growing environmental and economic threat of invasive species, plants and animals that are not native to ecosystems of the United States" (Clinton 1999). As a result, the Invasive Species Council was formed to "develop a comprehensive plan to minimize the economic, ecological, and human health

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impacts of invasive species and determine further steps to prevent the introduction and spread of additional invasive species" (Clinton 1999). The overwhelming environmental destruction caused by invasive species has compelled recognition of the significance of the problem. The economic cost of damage caused by invasive plants, animals, fungi, and microbes is estimated to exceed $138 billion each year (Mack et al. 2000).

In August 1999 at the 16th International Botanical Congress in St. Louis, Missouri, the American Institute of Biological Sciences sponsored a symposium on the "Global Movement of Harmful Non-indigenous Plants and Fungi." The symposium addressed the question of how invasive plants and fungi have been transported around the globe, as well as what might be done to circumvent their continued introduction into regions where their effect is detrimental. Seven speakers from around the world presented their findings on this topic, all of which are published in this issue of *BioScience*.

Many plant invaders have been introduced purposely to serve, for example, as a rapidly growing pulp-producing plant or, more frequently, as a cultivated garden plant. Once introduced, they may escape from cultivation, occasionally becoming uncontrollably weedy. Mack and Lonsdale (2001) provide ample documentation of this process, tracing the phases of plant introduction historically up to the present day. Reichard and White (2001) continue the theme in their examination of the wholesale distribution of ornamental garden plants with the potential to become noxious weeds. They express optimism about the ability to predict which plants might become invasive species and the beneficial effect of education on wholesale distributors and the public in curtailing the sale of such potential environmental hazards. Using information derived from herbarium specimens and historical records, Novak and Mack (2001) trace the introduction and spread of cheatgrass by determining the multilocus genotype markers for native and introduced populations. A successful invader, cheatgrass has spread from its centers of origins and achieved an almost cosmopolitan distribution.

Invasive fungi are often transported unnoticed on or in plants and plant products, particularly those that are propagated or untreated. The pathways for the introduction of fungi are becoming easier to track now that scientists can "fingerprint" individuals and populations as well as distinct species. With better knowledge of the pathways by which these organisms have been transported comes a greater ability to prevent their introduction. Brasier (2001) provides detailed evidence of the hybridization and eventual speciation within populations of the Dutch elm disease fungus and its close relatives, as fungal germ plasm is repeatedly moved between the United States and Europe in raw logs and wood products. Wingfield and colleagues (2001) present examples of invasive fungi introduced inadvertently on nursery stock into newly established forest plantations. Because these plantations represent a growing, economically important industry, particularly in the Southern Hemisphere, curtailing introductions is difficult. In the United States, the Animal and Plant Health Inspection Service is charged with safeguarding the country's plant resources. Palm (2001) reports on the importance of systematics to that endeavor, especially with regard to plant pathogenic fungi on agricultural crops. Accurate identification and knowledge of the biology of these potentially pathogenic fungi are essential in making decisions about whether to allow entry of infected plant material. Indeed, greater knowledge of fungal biodiversity has helped to determine the specific pathways of introduction and to eliminate these avenues of entry, which is no small task. Campbell (2001), however, presents some provocative convictions about the importance of directing even more strenuous efforts toward reducing the risk of inadvertent introduction of invasive species.

This issue of *BioScience* brings together case studies of plants and fungi that have become biological invaders, traces their transport by humans from their natural habitats to places where they became noxious, and suggests ways to prevent the continued introduction of harmful plants and fungi. Given the prodigious damage they can cause, a heightened awareness and concomitant action are critical.

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