

Caulerpa taxifolia, the "killer alga," is just one dramatic example of an accelerating phenomenon—the homogenization of the biosphere by species introduced to every continent and island. Inadvertently or deliberately, humans have always carried species from one region to another and, ultimately, between continents, but the development of rapid means of transportation has greatly increased the frequency of such introductions.

Many introduced species have invaded natural habitats to the detriment of one or more native species. Aside from economic consequences of varying degree, including loss of recreation and tourism, such invasions threaten biodiversity in those habitats. To gain a better understanding of such threats, one can erect a hierarchy of impacts on biodiversity. At each hierarchical level, the gravity of the case depends on the vigor of the invader, its dominance, its rate of spread, and its persistence.

Degrees of menace

At the first level, the introduced species maintains itself in a limited range of habitats without spreading and without upsetting the equilibrium of the ecosystem. The species thus occupies an "empty" ecological niche. This situation allows two interpretations. First, one can see the introduction as an alteration of the ecosystem by an alien element that at least modifies the species composition, even if it appears innocuous otherwise. Second, one can, by contrast, see this introduction as beneficial because it has enhanced local biodiversity.

At the second level, the introduced species spreads to the detriment of one or a few native species. It thus threatens native biodiversity. The eastern North American gray squirrel (*Sciurus carolinensis*), for example, was introduced to Great Britain beginning in 1876. It has spread widely and outcompeted the native red squirrel (*Sciurus vulgaris*), particularly in deciduous woodlands and manmade habitats. Populations of the native species have continued to decline, but this is the only major impact of the gray squirrel documented in Great Britain.

At the third level, the introduced species becomes dominant and alters or upsets the entire ecosystem. One of the most dramatic and damaging invasions of the past quarter century involves a single species of comb jellyfish, a jellyfish-like marine animal also known as a ctenophore ("ten-oh-for"). Looking like a small, translucent medusa, this willowy creature demonstrates the enormous impact that a small, apparently innocuous species can have in a new habitat.

Native to estuaries along the western Atlantic coast from the northern United States to the Valdés peninsula in Argentina, *Mnemiopsis leidyi* (as this species of comb jellyfish is known scientifically) appeared in the Black Sea in 1982. It was almost certainly introduced by a ship that loaded *Mnemiopsis*-laden ballast water in the western Atlantic and then emptied its tanks in the Black Sea. At first, the ctenophore was misidentified, and not until 1989 did authorities recognize it as a species of *Mnemiopsis* and thus an invader.

The species usually has moderate population densities in the western Atlantic, but its populations exploded in the Black Sea and the adjacent Azov Sea and Sea of Marmara. *M. leidyi* has invaded the entire Black Sea, a practically closed body of water that communicates with the Sea of Marmara and thus the Mediterranean through the Turkish strait of Bosphorus.

The Black Sea has two unusual features. On the one hand, it is naturally sterile at great depths; there is no oxygen between 660 feet and the deepest regions, which surpass 6,600

feet. On the other hand, it is highly polluted, as it receives the great rivers of eastern Europe and Russia, which drain the effluent of many giant factories and large cities with inadequate sewage treatment. Indeed, the quantities of nutrients, insecticides, fungicides, herbicides, heavy metals, organic compounds, hydrocarbon derivatives, and radioactive waste found on the edges of the Black Sea near the deltas of the great rivers are all worthy of mention in the *Guinness Book of World Records*.

Despite this unenviable situation, which would not seem conducive to life, the catch of pelagic fishes (primarily anchovy, sprat, and horse mackerel) had always been good. But when *Mnemiopsis* exploded in 1988—up to 500 individuals per cubic yard—and devoured all the zooplankton, including fish larvae, the entire pelagic ecosystem was profoundly modified, and the catch plummeted. The anchovy catch fell from 204,000 tons in 1984 to 200 tons in 1993; sprat from 24,600 tons in 1984 to 12,000 tons in 1993; horse mackerel from 4,000 tons in 1984 to zero in 1993. A simple little comb jellyfish caused more damage to the fishery than the various pollutants so often decried!

The *Mnemiopsis* population began to collapse in 1991 as its food base declined, but the comb jellyfish is still present, with drastic annual population fluctuations. Though we can reasonably hope for a reduction in pollution from the Danube, Dnieper, Don, and Dniester Rivers, what can we hope to do against *Mnemiopsis*, which has overthrown the entire pelagic ecosystem of the Black Sea (and has lately arrived in the Caspian Sea via rivers and canals connecting it to the Black)?

Threat of threats

At the fourth level, the introduced species affects several ecosystems, thus threatening an even larger swath of biodiversity. Regrettably, the number of invaders of this sort is growing. For the most part, they are species able to tolerate a wide variety of habitats, or those in such great densities that they disturb all the ecosystems surrounding the one they inhabit.

Water hyacinth (*Eichhornia crassipes*) is one of the most widespread invaders worldwide. A century after its first introduction outside its native range, the Amazon basin, it infests numerous tropical lakes, estuaries, streams, and rivers. A beautiful plant that attracted botanists seeking ornamentals for botanical gardens, it was imported to a horticultural exposition in New Orleans in 1884. Visitors were impressed by its beauty and planted it in several water bodies.

The aquatic ecosystems of the southeastern United States were then progressively colonized by vast, floating, dense carpets of water hyacinth. The economic repercussions, particularly interference with navigation, first drew attention, but the presence of an opaque covering of plants on the water surface and the eventual decomposition of dying plants devastated numerous aquatic ecosystems, both planktonic and on the bottom. At one time, water hyacinth dominated 123,500 acres of Florida waters. There it has been reduced to a minor problem, primarily by the use of chemicals and large floating mechanical reapers, but the plant remains a pest in many states, particularly Louisiana.

Water hyacinth reached Africa in 1892, then Asia in 1894 (after being brought to a botanical garden in Indonesia). Today water hyacinth is present around the globe on thousands of miles

of streams and rivers. It first appeared in great quantity in Lake Victoria in 1989; today it covers well over 12,000 acres and is spreading. It wreaks havoc with the commercial fishery, fouls boat engines and propellers, obstructs landing sites, and clogs cooling pipes for power plants, leading to massive blackouts. The impact on native species must be enormous but is largely unstudied. This insufficient scientific documentation of ecological impact is lamentably common for most ecosystems invaded by this plant.

Caulerpa taxifolia, the killer alga, is a dominant, ubiquitous, persistent, and rapidly spreading introduced species. Having colonized a wide variety of habitats, it falls squarely in level four, the highest degree of threat to plants and animals. The fact that it appears to be a single individual, a clone, of a genotype unknown in nature makes it an exceptional and particularly unsettling case.

Invading the world

In the U.S., more than 7,000 introduced species (not counting microorganisms) are established in nature, of which perhaps 15 percent cause ecological or economic damage. Some recent cases are rapidly evolving. The cordgrass *Spartina alterniflora* of the Atlantic coast of the United States has invaded the soft-bottom coasts of California and Washington, completely transforming intertidal ecosystems. Kudzu (*Pueraria montana*), a Chinese vine, has spread through the forests of the Southeast and Hawaii, covering more than four million acres with a green curtain. The European green crab (*Carcinus maenas*) is invading the Pacific coast (and also Tasmania) in enormous numbers, with major impacts on coastal benthic food webs.

Each invading species is a unique case, with characteristic impacts, degrees of dominance, and features of dispersal. Thus each invasion has been treated differently. But the succession of invasions, each dramatic in its own way, that spreads rabbits, rats, camels, horses, deer, birds, frogs, toads, snakes, fishes, insects, jellyfish, crustaceans, mollusks, starfish, sea urchins, dinoflagellates, macroalgae, ferns, and higher plants is dizzying.

Even as the atlas of plant and animal pests continuously expands, legislation to stem this tide, while drastic in a few nations, is rare or nonexistent in the majority. The scientific illiteracy with respect to the global threat posed by invasive introduced species means that other ecological horrors are much more in the news. Insidious (because it seems natural), progressive, underestimated—this is nature of the blow that human-introduced species strike against biodiversity. Has it not already surpassed that caused by the sum of all chemical pollution?

Source: <http://www.pbs.org/wgbh/nova/algae/impact.html>