Chapter thirty-nine

A role for scientists

Francesca Gherardi

Species introductions and their ecological consequences have long fascinated scientists. In trying to explain patterns of species distributions and abundances, Charles Darwin (1859) was faced with the problems of non-indigenous species (NIS) (Cadotte 2006). He used them as a device to illustrate his theory of natural selection and descent with modifications, but he was also the first to note marked effects that these species had on the recipient communities. Invaders ''from different quarters of the globe'', as he wrote in *The Origin of Species* (1859), have greatly reduced in number the endemic species in the southeast corner of Australia (p. 124). So, caution should be taken, Darwin recommended, ''in transporting animals from one district to another'' (p. 136). It was a century later that Charles Elton's *The Ecology of Invasions by Animals and Plants* (1958) inspired much of the interest and understanding of invasions in our lifetime. Indeed, investigating the ''ecological explosions'' (p. 15) that occur ''when a foreign species successfully invades another country'' and analyzing the ''mingling of thousands of kinds of organisms from different parts of the world'' and their induced ''changes in the natural population balance'' (p. 18) are the major tasks of the contemporary invasion biologists.

The world today is much more ''explosive'' than in the 1950s. The volume of flora and fauna that is shuttled from one geographic realm to another has greatly expanded. The ballast water of cargo vessels alone can transfer up to 3,000–4,000 species per day from one continent to the other. Extrapolating these numbers to all the kinds of vessels at sea at any given time, a total of 7,000–10,000 species are translocated per any 24 h period (Carlton 1999). The increased complexity of international trade has opened new pathways and facilitated the ease with which potentially invasive species can move along these pathways. A wide diversity of vectors can transport invaders, including aquaculture, aquaria, ballast water, and even sushi and live seafood (Carlton and Geller 1993, Chapman *et al.* 2004). Almost every aquatic or wetland plant

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designated as a noxious weed can be ordered through e-commerce from an aquatic plant nursery somewhere (Kay and Hoyle 2001). The deregulation of national and international markets has reduced the barriers to trade and their surveillance, facilitating the movement, for instance, of thousands of species into North America by the aquarium industry alone (Welcomme 1984). In addition, the impact of biological invaders has been made more intense – and elusive – by the delay with which human behavior, social norms, and cultural traditions respond to the new risks that they pose (Perrings *et al.* 2002).

Indeed, much progress in the knowledge of invasion biology has been made within the five decades following the publication of Elton's book (Williamson 1996, 1999, Lonsdale 1999) – and this volume is the expression of the proliferation of scientific interest in biological invasions also in freshwater systems. The research has emerged on several fronts, especially following the series of invasion volumes published between 1986 and 1989 as the proceedings of the SCOPE (Scientific Committee on Problems of the Environment) symposia and workshops (e.g. Mooney and Drake 1986, Drake *et al.* 1989, Davis 2006). Since then, the scientific literature has moved on from its effort to describe the characteristics that make a species a good invader, or a community invasible, to the focus on the interactions between the invader and the target ecosystem. Qualitative studies have been replaced by quantitative assessments of the attributes of the invaders and of the invaded communities. Paleobiological studies, microcosm/mesocosm experiments, and modeling exercises have contributed to raise our awareness that history, chance, and determinism interact to shape ever-changing communities.

The increased concern about the rising economic and ecological costs inflicted by invasive species has induced many constituencies in several countries to seek to reduce their occurrence and impact. Problems caused by introduced species were included as a priority item (article 8h) in the 1992 "Rio" Convention on Biological Diversity and international organizations (Global Invasive Species Programme, Convention on Biological Diversity) began to implement this article. In the last decade, many nations have recognized the impact of some introduced species as a problem and have attempted to implement and improve administrative and legal solutions (e.g. New Zealand, South Africa, the USA, and European Union). National and international initiatives have been taken to assess the risk of future introductions, the potential for establishment and expansion, and the subsequent impacts (e.g. IUCN 1987, FAO 1995, 1996, US ANS Task Force 1996, NZ MAF 2002, UK Defra 2003). Finally, the control of NIS is part of the EU's policy approach taken to attain the Göteborg's target of halting biodiversity loss by 2010 (Commission of the European Communities 2006).

Due to the inevitable interplay in this issue among science, environmental ethics, and public policy (Lodge and Shrader-Frechette 2003), new areas of conflict have been opened in the recent times (cf. Simberloff 2003). A number of authors from different cultural fields (e.g. Sagoff 1999, 2005, Theodoropoulos

2003) joined with a few ecologists (e.g. Slobodkin 2001) in a "rearguard action" (Simberloff 2006, p. 915) to convince scientists and laypeople that the threat posed by introduced species is overblown. Criticisms were mainly directed towards the apparent "lack of adherence to sound scientific practices" (Thedoropoulos 2003) and to the formulation of unscientific generalizations or "reifications" (Slobodkin 2001). Among the other objects of contention, invasion biologists have been accused of a biased interpretation of the effects that invasive species exert on global biodiversity (Rosenzweig 2001, Gurevitch and Padilla 2004), of their adoption of "stipulative definitions" (Sagoff 2005) – such as the concept of biodiversity opposed to xenodiversity (in the meaning of Leppäkoski and Olenin 2000), and of their use of military and pejorative metaphors in their writings (Larson 2005). Finally, biological invasion research captured the attention of the media, which often magnified existing misunderstandings among scholars (e.g. Devine 1999).

A consequence is that invasion biologists are working today in an emotionally charged atmosphere where they are subject to the inevitable tension between the strong appeal that biological invasions elicit as ideal objects of study and their personal concern about the threats they pose to biodiversity. Davis (2006) coined the terms "Asilomar" (a town in California where the first Symposium of the International Union of Biological Sciences was held in 1964) and "Eltonian" (from Charles Elton) as attributes to label the two apparently contradicting attitudes assumed by scientists when they face the problem of invasions. On the one hand, some of them share the exclusive interest in ecological theories shown by the conveners in Asilomar and view invasions as very rich sources of information for capturing the complexities of ecological systems. In the same way that the physiology of an organism may be better studied during illness, anomalies of ecological systems – i.e. species introductions – are thus fundamental in understanding their functioning. On the other hand, an increased sense of social responsibility among scientists and their willingness to participate to the political forum made several of them believe that their findings on biological invasions might also assist resource managers in restoring and rebuilding the "ill" ecological systems.

As Soulé (1986) puts it, "fiddling" with ideas until the world is in ashes – like the Emperor Nero who is alleged to have continued playing his lyre while Rome burned – may lead to severe penalties (Gherardi 2006). Research is often "an unaffordable luxury that provides information only for the eulogy" (Coblentz 1990); on the contrary, efforts are to be directed "to construct ecological research program that dictate possibilities for managers, that investigate alternatives where the options used for management have failed, and that evaluate the processes of management" (Underwood 1995, p. 232). Research should be elevated to "a primary component of environmental decision-making", rather than being relegated to "an increasingly peripheral procedure" (Underwood 1995, p. 232), and in their turn scientists should allocate more time to practical concerns – rather than simply producing publications (Caro 1998). Real progress cannot be made in affecting environmental policy and management until scientists become more effective in the "processes" (the steps used to reach decisions, such as law, credibility, etc.) and in the "relationships" (related to human behavior, such as networks in communities), and not only in the understanding of objective and factual data ("substance") (Meffe 2002). In sum, "scientists need to make concerted efforts to learn these other skills and to become more active players in ensuring that good science is a real part of policy and management" (Meffe 2002, p. 367).

Particularly in the field of invasion biology, any attempt to manage the invasive species problem will greatly benefit from the role played by scientists of advocate on the one hand, and of their constructive partnership with resource managers on the other (Byers *et al.* 2002). Researchers are expected to identify and control pathways of accidental introductions, to promote measures that may prevent unwanted introductions, and to produce protocols for pre-introduction environmental risk assessment. They should stimulate cooperative actions among States, recognizing the risk – particularly high in Europe – that activities within their jurisdiction or control may pose to other States as a potential source of invasive species. By quantifying how invasive species affect native biodiversity, scientists also have the capacity to individualize effective systems for the early warning of the newcomer species and safe methods for the control/eradication of already established invaders.

Research has the potential to determine metrics reflecting all the biological changes that accompany any intervention; it can evaluate the role of NIS after their integration in the systems and suggest strategies that are flexible and in line with biogeographic and evolutionary realities (Cox 2004). Finally, research helps prioritize ecosystems at risk through assessing their invasibility and the duration of lag phases between the establishment and the spread of specific invaders. Risk assessment, decision theory, and epidemiology all offer useful insights for the development of policies to control NIS through a process that should involve both scientists and policy makers (Byers *et al.* 2002).

Certainly, much useful knowledge of NIS already exists – it merely requires reanalysis or reassembly into a form that managers can use (Byers *et al.* 2002). Despite the progress, to date much has still to be done – and scientists have not yet missed the boat (Puth and Post 2005).

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