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Comment

Revisiting the Potential Conservation Value of Non-Native Species

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Human travel and transportation of goods are increasingly changing species distributions (Ricciardi 2007). Non-native species—those introduced beyond their natural ranges—often have undesirable effects at levels from genes to landscapes (Ehrenfeld 2011). However, as has long been acknowledged, not all introduced species have negative effects (Williamson 1996).

Although Schlaepfer et al. (2011) recognize much evidence of undesirable effects of species' introductions, they synthesize information on contributions of non-native species to conservation goals. Schlaepfer et al. contend that non-native species may catalyze restoration of native species and ecosystems, especially if they substitute for extirpated ecosystem engineers (organisms that modulate availability of resources to other species by changing ecosystem components; Jones et al. 1994), and may thus provide ecosystem services. Schlaepfer et al. predict that non-native species will increasingly aid conservation because they are more likely than native species to persist despite changing climate and land use. They further argue that non-native species may evolve into new taxa and thus increase species diversity. Their main message is clear: non-native species should be used for conservation given their potential desirable contributions.

We disagree with Schlaepfer et al.'s main message. It is challenging to understand a species' ecological effects, and current evidence shows that desirable (i.e., positive) effects of non-native species are much less frequent than undesirable (i.e., negative) effects. Even for species Schlaepfer et al. use as examples of the positive effects of non-native species (e.g., gorse [*Ulex europaeus*], African honey bee [*Apis mellifera*], zebra mussel [*Dreissena polymorpha*]), most published effects are negative (Clements et al. 2001; Goulson 2003; Strayer et al. 2004). Schlaepfer et al. do not accurately represent the extent of desirable and undesirable effects of non-native species with respect to conservation. This misrepresentation can suggest that effects of non-native species are mostly positive.

When a non-native species becomes abundant, even when it is highly detrimental to the ecosystem, some native species will likely benefit because it provides an additional resource. One thus expects some positive effects. However, these effects are frequently transient, and calling them *desirable* or *undesirable* is often a consequence of subjective analyses (e.g., Rodewald 2011; Lapointe et al. 2012). Schlaepfer et al.'s examples highlight positive effects of some introduced species. They state, "[w]e did not review all the known negative effects . . . because they have been exhaustively described." Furthermore, they do not acknowledge uncertainty—many effects are difficult to predict or occur only in the long term (Strayer et al. 2006). An example is the phenomenon of time lags (Crooks 2011), in which species do not immediately become problematic. Many effects cannot be detected without extensive, long-term studies (Strayer et al. 2006; Traveset & Richardson 2006; Arbačiauskas et al. 2010). Of course, subtle and delayed effects can be positive, although the catalog so far is heavily weighted toward negative effects.

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Although we disagree with some views of Schlaepfer et al., we agree that some invasions can aid conservation, as when they functionally replace an extinct species. Ship rats (*Rattus rattus*) have multiple undesirable effects (Pascal 2011). Yet ship rats pollinate some native species in New Zealand, where native pollinators have been extirpated (Pattemore & Wilcove 2012). Thus, even highly detrimental species can have some desirable local effects. The irony is that rats contributed greatly to extirpating pollinators in the first place (Pattemore & Wilcove 2012), so the net invasion effect was not beneficial.

In addition, Schlaepfer et al. overestimate ecologists' ability to forecast risks and benefits of non-native species. Prediction in ecology is difficult (Lawton 1999). Surprises emerge even in well-studied systems (Lindenmayer et al. 2010). For example, kokanee salmon (*Oncorhynchus nerka*) and lake trout (*Salvelinus namaycush*) were introduced into Flathead Lake, Montana, in the early 20th century, and 50 years later, opossum shrimp (*Mysis diluviana*) were introduced into part of the catchment to increase kokanee production (Ellis et al. 2011). By 1981 shrimp floated downstream into Flathead Lake, causing population crashes of cladoceran and copepod prey. Kokanee, competing with shrimp for prey, declined from 1 to 2 fish per standardized gill net set before shrimp were present to <0.5 fish per net. This decline caused the abundances of Bald Eagles (*Haliaeetus leucocephalus*), grizzly bears (*Ursus arctos*), and other predators to decline. Eagle abundance at one monitored site fell from 639 to 25 (Spencer et al. 1991). Lake trout became the dominant species of fish. Owing to changes in the food web associated with the increase in abundance of lake trout, the lake's population of bull trout (*Salvelinus confluentus*) may be extirpated (Ellis et al. 2011). Such indirect effects of a non-native species are common and difficult to predict, so Schlaepfer et al.'s confidence in recognizing positive effects is unwarranted.

Schlaepfer et al. suggest quantifying net effects of non-native species to define when they become invasive. They also suggest that one should not try to control species with positive net effects and instead should consider them conservation resources. However, the aforementioned difficulties—especially that species have many effects and that these effects may be hard to measure or predict—make quantifying net effects extremely challenging, especially when management action is urgent (e.g., when an introduced species spreads rapidly).

Another point of contention is that Schlaepfer et al. downplay reports of invasion effects from developing countries. In developing countries, Schlaepfer et al.'s thesis might be used to support practices that promote introductions of non-native species that have highly undesirable effects. In many developing countries, introductions of species are promoted on economic grounds and no studies of potential undesirable long-term effects are conducted (e.g., Vitule et al. 2009; Lövei et al. 2012). There are more developing than developed countries, yet most research dealing with invasions is restricted to developed countries (Vázquez & Aragón 2002). Also, in general, economic development accelerates invasions (Lin et al. 2007). Invasions are therefore likely to become more frequent and to generate greater net undesirable effects in developing nations with rapidly growing economies. Such countries are generally located where species diversity is high and less information is available on effects of introductions (Lin et al. 2007; Lövei et al. 2012). These considerations lead us to disagree with Schlaepfer et al.'s prediction that an increasing proportion of non-native species will be benign or even desirable for conservation.

Finally, Schlaepfer et al. (p. 434) say they "question how human actions differ from those of other species. In other words, why is a dispersal event that is facilitated by, say, a migratory bird or storm event considered natural, whereas a human-transported species is non-native and thus undesirable?" Although migration of species is facilitated by the removal of natural barriers (e.g., the opening of the Panamanian corridor between North and South America during the Great American Interchange), these events cannot be compared with the current wave of human-assisted invasions. The rate of human-assisted invasions is orders of magnitude higher than natural or prehistoric rates (Ricciardi 2007). For instance, over the last century mammal genera have been exchanged between North and South America 10,000 times more frequently than during the Great American Interchange (Ricciardi 2007). Furthermore, human-mediated dispersal often carries species between sites that would never have been sites of species exchanges facilitated through tectonic movement or aerial or aquatic transport (Ricciardi 2007; Wilson et al. 2009), and human-mediated dispersal frequently moves more individuals and individuals from multiple sources (Wilson et al. 2009). Human-assisted dispersals are a distinct global change (Ricciardi 2007; Wilson et al. 2009).

Schlaepfer et al. downplay the danger of species introductions, and the absence of a perspective that accounts for the issues we raise here could encourage decision makers, who typically focus on short-term benefits of introductions without concern for potential long-term consequences, to approve introductions that carry a high risk of adverse consequences. The Millennium Ecosystem Assessment is more prudent. It notes that some introductions will be beneficial, but it nevertheless emphasizes that introductions have much more frequently caused loss of biological diversity, ecosystem functions, and ecosystem services (Millennium Ecosystem Assessment 2005). The Convention on Biological Diversity (UNEP 1992) also advocates a precautionary approach to species introduction when information about its effects is highly uncertain; thus, the risk of negative effects puts the burden of proof on those wishing to introduce species. We believe a more sensible alternative to Schlaepfer et al.'s proposal to encourage introductions when predicted net effects are positive is to use the best available knowledge to increase vigilance and to improve management. The issue of species' invasions is complex and necessitates a cautious, balanced view, including consideration of short-term and long-term introduction effects, both positive and negative.

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