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Review

The Potential Conservation Value of Non-Native Species

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Abstract: *Non-native species can cause the loss of biological diversity (i.e., genetic, species, and ecosystem diversity) and threaten the well-being of humans when they become invasive. In some cases, however, they can also provide conservation benefits. We examined the ways in which non-native species currently contribute to conservation objectives. These include, for example, providing habitat or food resources to rare species, serving as functional substitutes for extinct taxa, and providing desirable ecosystem functions. We speculate that non-native species might contribute to achieving conservation goals in the future because they may be more likely than native species to persist and provide ecosystem services in areas where climate and land use are changing rapidly and because they may evolve into new and endemic taxa. The management of non-native species and their potential integration into conservation plans depends on how conservation goals are set in the future. A fraction of non-native species will continue to cause biological and economic damage, and substantial uncertainty surrounds the potential future effects of all non-native species. Nevertheless, we predict the proportion of non-native species that are viewed as benign or even desirable will slowly increase over time as their potential contributions to society and to achieving conservation objectives become well recognized and realized.*

Keywords: evolution, exotic species, invasive species, management, non-native species, restoration

El Valor de Conservación Potencial de Especies No Nativas

Resumen: *Las especies exóticas pueden causar la pérdida de diversidad biológica (i. e., diversidad genética, de especies y ecosistemas) y amenazar el bienestar de humanos cuando se vuelven invasoras. Sin embargo, en algunos casos también pueden proporcionar beneficios de conservación. Examinamos las formas en que las especies exóticas contribuyen actualmente a objetivos de conservación. Estos incluyen, por ejemplo, proporcionar hábitat o recursos alimenticios para especies raras, fungir como sustitutos funcionales de taxa extintos y proporcionar funciones ecosistémicas deseables. Especulamos que las especies exóticas pueden contribuir a lograr metas de conservación en el futuro porque su probabilidad de persistir y proporcionar servicios ecosistémicos es mayor que la de especies nativas en áreas donde el clima y el uso de suelos están cambiando rápidamente y porque pueden evolucionar hacia taxa nuevos y endémicos. El manejo de especies exóticas y su potencial integración en planes de conservación depende de cómo se definen las metas de conservación en el futuro. Una fracción de especies exóticas continuará causando daños biológicos y económicos, y una considerable incertidumbre rodea a los futuros efectos potenciales de todas las especies exóticas. Sin embargo, pronosticamos que la proporción de especies exóticas que son vistas como benignas*

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o aun deseables incrementará lentamente con el tiempo a medida que sus contribuciones potenciales a la sociedad y al logro de objetivos de conservación sean bien reconocidas y entendidas.

Palabras Clave: especies exóticas, especies invasoras, especies no nativas, evolución, manejo, restauración

Introduction

Non-native species present a range of threats to native ecosystems and human well-being. Non-native predators and herbivores can cause extinctions of native species, particularly on islands and in freshwater ecosystems (Wilcove et al. 1998; Mooney & Hobbs 2000; Sax & Gaines 2008). Furthermore, they can alter the functioning of ecosystems and can carry infectious diseases that can endanger native species and human health (Vitousek et al. 1996; Daszak et al. 2000; Ehrenfeld 2003). By damaging commercial crops and interfering with industrial activities, non-native species are responsible for annual economic losses on the order of billions of U.S. dollars per year (Pimentel et al. 2005). As a result governmental agencies and nongovernmental organizations are frequently mandated or have chosen to prevent the introduction of non-native species and minimize their negative effects (Millennium Ecosystem Assessment 2005; Lodge et al. 2006).

Not all non-native species cause biological or economic harm, and only a fraction become established and have an effect that is considered harmful (Williamson & Fitter 1996; Davis 2009). But non-native species can also have desirable effects on an ecosystem. For example, numerous species have been repeatedly and deliberately introduced outside their native range for agricultural, ornamental, and recreational purposes (Ewel et al. 1999). As a result non-native species are integral to the culture and economies of most countries. There have also been numerous recent examples of non-native species contributing to achievement of conservation objectives (e.g., Westman 1990; D'Antonio & Meyerson 2002; Gozlan 2008).

Subjective Views of Non-Native Species

Scientific and societal perceptions of non-native species have likely impeded consideration of the potential beneficial effects of non-native species. Most scientists investigating the effects of non-native species try to conduct their work objectively; nevertheless, several authors have demonstrated that a bias persists against non-native species among scientists (Slobodkin 2001; Gurevitch & Padilla 2004; Stromberg et al. 2009). These biases are reflected in the assumptions commonly made about the intrinsic and instrumental values of non-native species, the language used when describing them, and in the types of studies conducted (Sagoff 2005). For example, in a landmark study in which the response of biological diversity (encompassing genetic, species, and ecosystem diversity) to several natural and anthropogenic drivers were predicted, Sala et al. (2000) considered non-native species only as potential threats, not as contributors to a region's species richness. Furthermore, in studies in which an index of biotic integrity was used, the presence of non-native species decreases the index value even if the non-native species have no or little detectable biological effect (Parker et al. 1999). Finally, the language used to describe non-native species in the scientific literature is frequently scattered with militarized and xenophobic expressions (e.g., "war on aliens" and "American ecosystems under siege by alien invaders") (e.g., Peretti 1998; Krajick 2005; Larson 2005).

The consequences of these biases are difficult to quantify, but they almost certainly have resulted in an emphasis on documenting the negative economic and biological effects of non-native species (Pyšek et al. 2008). Studies that fail to find a negative effect (e.g., Nielsen et al. 2008) are likely underreported. Furthermore, numerous researchers have evaluated the economic costs associated with non-native species, and syntheses that estimate the total economic effect of non-native species (e.g., Pimentel et al. 2005; McIntosh et al. 2009) attract substantial attention. By contrast, relatively few researchers have quantified the economic benefits (e.g., value of pollination by non-native bees, fees paid to hunt non-native game) derived from non-native species (but see Southwick & Southwick 1992; Ackefors 1999; Pascual et al. 2009). As a result, there has not been a comprehensive review of the economic benefits provided by non-native species. The direct economic costs associated with wild and feral non-native species may well be greater than the income they generate, but we think both costs and income should be quantified.

We had two aims here. First, we sought to catalog the possible ways in which non-native species can help achieve conservation objectives. We did not review all the known negative effects of non-native species because these have been described exhaustively (e.g., Mooney & Hobbs 2000; Lodge et al. 2006). We also did not focus on economic or human-health effects. Instead, we considered examples of unplanned and intentional introductions of non-native species that contributed to achieving conservation objectives. We use the term *non-native* for species that occur outside of their historic range and *invasive* for cases in which these species cause biological, social, or economic harm.

Second, we investigated the role of non-native species in the broader context of setting conservation objectives. Traditionally, conservation goals have been defined by historical, static benchmarks aimed at protecting flagship species and "pristine" ecosystems and their putative integrity and stability (Forum 2004). But many non-native species are firmly established in their recipient ecosystems and cannot be eradicated; thus, novel approaches are required to manage them (Schlaepfer et al. 2005; Norton 2009). Furthermore, the negative and positive effects of non-native species vary over time, as will the manner in which these effects are perceived by humans, which in turn will have large effects on how non-native species are managed (Maris & Béchet 2010).

Current Uses of Non-Native Species to Conserve and Restore Species and Ecosystems

Many conservation efforts focus on the protection of genes, species, ecosystems, and their interactions. Numerous researchers have documented the various ways in which non-native species positively contribute to achieving conservation goals either serendipitously (Table 1) or intentionally (Table 2). Conservation benefits include providing habitat, food, or trophic subsidies for native species, serving as catalysts for the restoration of native species, serving as substitutes for extinct ecosystem engineers, and providing ecosystem services.

Shelter and Food for Native Species

Non-native species can provide shelter (e.g., Wonham et al. 2005; Severns & Warren 2008) or be a nutritional resource (e.g., Bulleri et al. 2006; Carlsson et al. 2009) for native species. The potential role of non-native species in providing resources for rare native species is likely to be particularly important in situations when restoration of the native species that formerly provided shelter or an energy source is impractical due to limited economic resources or changes in the physical environment (e.g., Zavaleta et al. 2001; Hershner & Havens 2008). In the case of the non-native tamarisk (*Tamarix* spp.), preconceived notions appear to have contributed to an underestimation of its potential contributions to conservation. Tamarisk is a non-native woody plant that has become relatively common in riparian areas throughout the southwestern United States as a result of human activity and changes in hydrology (Stromberg et al. 2009). Initial reports suggested tamarisk were causing a drop in water table levels and reducing habitat quantity and quality for native riparian species, including the Southwestern Willow Flycatcher (*Empidonax traillii extimus*), which is listed as endangered under the U.S. Endangered Species Act. As a result millions of U.S. dollars were spent removing tamarisk with mechanical treatments, herbicides, and a herbivorous beetle (*Diorabda elongate*) (DeLoach et al. 2006). Nevertheless, results of recent field studies reveal that in some areas up to 75% of the Southwestern Willow Flycatchers nest in tamarisk and that fledgling success associated with nests built in tamarisk was indistinguishable from success associated with nests built in native trees (Ellis et al. 2008; Sogge et al. 2008). In a recent review Stromberg et al. (2009) argue that many undesirable changes to water tables and displacement of native biota attributed to tamarisk are exaggerated or unfounded.

Given the substantial modification to flooding regimes by dams throughout the southwestern United States, it may be difficult in many areas to reestablish native taxa that formerly supported the Flycatcher. Thus, although removing tamarisk may provide a step toward restoring historic vegetation in these regions, doing so may unexpectedly cause direct harm to an endangered native species that now depends in part on tamarisk (Zavaleta et al. 2001; Shafroth et al. 2008). In locations with multiple non-native species, the control or eradication of one species will not necessarily result in the desired outcome because species interactions may be altered (Courchamp et al. 2003; Norton 2009; Chiba 2010).

Catalysts for Restoration

Non-native species that increase structural heterogeneity or complexity of an area are positively correlated with increases in abundance or species richness (Crooks 2002), and in some instances non-native species may therefore be useful catalysts for ecosystem restoration (Ewel & Putz 2004) (Tables 1 & 2). For example, former pastures with sparse vegetation and eroded soils in Puerto Rico (U.S.A.) are not readily recolonized by native trees. By contrast, non-native plantation trees are able to survive and subsequently attract seed dispersers and establish microclimates in which native plants can reestablish (Lugo 1997; Rodriguez 2006). In one study, 20 native woody species recolonized deforested land 8 years after non-native trees were planted, whereas only one native woody species colonized unplanted control plots (Parrotta 1999).

Substitutes for Extinct Taxa

Non-native species are sometimes deliberately introduced to fill an ecological niche formerly occupied by a closely related species (Donlan et al. 2006; Griffiths et al. 2010) (Table 2). Non-native species do not have the same cultural and historical value as native species, but they have been used as acceptable ecological substitutes in cases where the benefits of their ecological function are perceived to exceed the potential risks of introducing a non-native species. For example, Aldabra giant tortoises (*Aldabrachelys gigantea*) have been introduced to several small islands surrounding Mauritius, where they appear to have successfully

Table 1. Examples of positive (+) and negative (−) roles of non-native species that were not intentionally introduced for conservation purposes.*

Purpose	*Example*	*Reference*
Habitat, shelter, and food for native species	+non-native tamarisk (*Tamarix* spp.) provides nesting habitat for Southwestern Willow Flycatcher (*Empidonax traillii extimus*)	Sogge et al. 2008; Stromberg et al. 2009
	+ native butterflies oviposit or feed on non-native plants in California, U.S.A.	Graves & Shapiro 2003
	+ reclaimed mine grasslands composed of non-native species provide habitat for Henslow's Sparrow (*Ammodramus henslowii*) in Indiana, U.S.A.	Bajema et al. 2009
	+ non-native melaleuca (*Melaleuca quinquinervia*) provides habitat for Snail Kite (*Rostrhamus sociabilis plumbeus*) in the Everglades (Florida, U.S.A.);	Chen 2001
	− non-native melaleuca may cause decrease in the kite's primary food source, apple snail (*Pomacea paladusa*)	Chen 2001
	+ non-native mudsnail (*Potamopyrgus antipodarum*) abundant prey item for native fish in western U.S.A.	Vinson & Baker 2008
	− non-native mudsnail are food for native rainbow trout (*Oncorhynchus mykiss*) but when fish feed exclusively on mudsnails they lose 0.5% of body weight per day	Vinson & Baker 2008
	+ native avian predators in Spain increase in abundance as a result of foraging on non-native crayfish (*Procambarus clarkii*)	Tablado et al. 2010
	+ non-native plant (*Casuarina*) protects native snails (*Ogasawarana optima* and *O. discrpans*) in Japan from predation by non-native black rats (*Rattus rattus*)	Chiba 2010
Catalysts for restoration	+ non-native guava trees (*Psidium guajava*) support native frugivorous birds and promote forest regeneration via seed dispersal in Kenya	Berens et al. 2008
	+ non-native trees established on abandoned pastures facilitate restoration of native tree species in Puerto Rico	Lugo 2004
	+ non-native zebra mussel (*Dreissena polymorpha*) filters water and control toxic cyanobacteria in shallow eutrophic lakes	Elliot et al. 2008; Dionisio Pires et al. 2009
Ecosystem engineers	+ non-native birds in Hawaii disperse native plant seeds	Foster & Robinson 2007
	+ non-native Pacific oyster (*Crassostrea gigas*) colonizes unvegetated tideflats and forms hard reefs thereby increasing densities of native invertebrate species relative to native oyster beds	Ruesink et al. 2005
	+ non-native ascidian in intertidal waters in Chile creates dense three-dimensional structural matrix that increases local and regional species richness	Castilla et al. 2004
Ecosystem services	+ non-native African honey bees (*Apis mellifera*) pollinate native plants in fragmented forest landscapes in Brazil and Australia	Dick 2001; Gross 2001
	+ pollination of the ieie vine (*Freycinetia arborea*) in Hawaii by non-native Japanese White-eye (*Zosterops japonica*) replaces the role formerly held by now-extinct native birds	Cox 1983
	+ biofiltration rates of non-native Pacific oyster (*Crassostrea gigas*) in estuaries may reduce production of phytoplankton caused by anthropogenic nutrient loading	NRC 2004

*Negative roles listed are not exhaustive and include only those that directly oppose the listed positive roles. Many of the non-native species listed have other negative effects on conservation objectives.

Table 2. Examples of positive (+) and unintended negative (−) roles of non-native species that were intentionally introduced for conservation purposes.*

Purpose	*Example*	*Reference*
Habitat, shelter, and food for native species	+ American shad (*Alosa sapidissima*) introduced into the Columbia River Basin and California as a forage fish for Pacific salmonids	Petersen et al. 2003
	+ non-native crayfish introduced across North America to provide forage for recreational fishes (e.g., largemouth bass [*Micropterus salmoides*])	Kats & Ferrer 2003
	− introduced non-native crayfish resulted in declines of several native amphibian taxa	Kats & Ferrer 2003
Catalysts for native species	+ non-native trees planted on abandoned pastures to facilitate restoration of native tree restoration species in Puerto Rico	Lugo 1997
	+ non-native cattle maintain early-successional vegetation that favors native fishes and reptiles	Brown & McDonald 1995; Tesauro & Ehrenfeld 2007
	− removal of cattle may result in proliferation of non-native grasses, which would have detrimental effects on the vulnerable (IUCN Red List) native skink (*Cyclodina whitakeri*)	Norton 2009
	+ non-native black locust (*Robinia pseudoacacia*) provides cover and restores soil fertility on mined lands	Ashby 1987
	+ European legume gorse (*Ulex europaeus*) acts as a nurse plant for native forest regeneration in New Zealand in old fields once livestock grazing stops	Sullivan et al. 2007
	− plant succession under European legume gorse follows a different trajectory resulting in lower species richness of native forest species	Sullivan et al. 2007
Taxon substitution	+ Aldabra giant tortoise (*Aldabrachelys gigantea*) replaces the ecological role of extinct giant *Cylindraspis* tortoises in the Mascarene Islands	Griffiths & Harris 2010
Ecosystem services	+ non-native *Chrysolina* beetles control invasive St. John's wort (*Hypericum perforatum*) in Australia and North America	Morrison et al. 1998
	− failed biocontrol of non-native cane beetle (*Dermolepida albohirtum*) through introduction of non-native cane toad (*Bufo marinus*) in Australia	Lever 2001
Preservation of species	+ species are transplanted to islands outside their historical range to mediate threats from non-native predators or transplanted poleward to mediate concerns about species' ability to shift their distributions in response to changing climate	Jolly & Colbourne 1991; Fontenot et al. 2006; Richardson et al. 2009; Willis et al. 2009

*Negative roles listed here are not exhaustive and include only those that directly oppose the listed positive roles. Many of the non-native species listed have other negative effects on conservation objectives.

substituted the herbivory and seed-dispersal functions of native tortoises that recently became extinct (Griffiths et al. 2010).

In other cases the substitute roles provided by non-native species have been more serendipitous (Table 1). For example, in Hawaii (U.S.A.), non-native species of birds are now the primary dispersers of seeds and fruits of some native plant species with native dispersers that have become extinct or been extirpated from lowland vegetation (Foster & Robinson 2007). Non-native birds may have contributed to the extinction of several native bird species (by serving as vectors of avian malaria to which native bird species are susceptible (Kilpatrick 2006)), but the remaining native species of plants and current ecosystems may now depend on the ecological roles of such substitute species.

Augmenting Ecosystem Services

Non-native species can alter and degrade ecosystem services, but in other cases they can also provide or augment ecosystem services (Pejchar & Mooney 2009). For instance, non-native species can serve as plant pollinators, especially in fragmented landscapes. Dick (2001) found that native pollinators are absent from forest fragments in Amazonia, Brazil, but that non-native African honey bees (*Apis mellifera scutellata*) move between forest fragments. Honey bees therefore not only pollinate the tall, native, canopy-emergent trees, but also ensure long-distance gene flow between forest fragments. In Utah (U.S.A.) non-native plants provide nectar and pollen to insects, thereby increasing the carrying capacity of both generalist and specialist native pollinators (Tepedino et al. 2008). In a review of the ecological effects of 2 non-native wetland plant species (*Hydrilla verticillata* and *Phragmites australis*) in North America, Hershner and Havens (2008) suggest these plants provide as much or more waterfowl habitat, biomass production, and nitrogen retention than native wetland plant species, although *H. verticillata* also decreases habitat quality for native fishes (Hershner & Havens 2008).

Non-native species can function as biocontrol agents to limit undesirable effects of invasive non-native species in both agricultural and natural settings. Introduced natural enemies have prevented the loss of billions of dollars and saved human lives by limiting the abundance of agricultural pests such as cottony cushion scale (*Icerya purchasi*) and cassava mealybug (*Phaenococcus manihoti*) (Messing & Wright 2006). Biocontrol agents, however, are sometimes less host-specific than initially thought and may parasitize native species. There is also the potential than novel host preferences may evolve over time (Messing & Wright 2006; Thomas & Reid 2007).

Future Role of Non-Native Species

A subset of non-native species will undoubtedly continue to cause biological, economic, and social harm. But we venture that other non-native species could become increasingly appreciated for their tolerance and adaptability to novel ecological conditions and their contributions to ecosystem resilience and to future speciation events.

Ecological Roles in Rapidly Changing Ecosystems

Non-native species could come to fill important ecosystem and aesthetic functions, particularly in places where native species cannot persist due to environmental changes. Indeed, some non-native species may be preadapted or adapt rapidly to the novel ecological conditions (Byers 2002). Furthermore, the ability of non-native species to tolerate and adapt to a broad range of biotic and abiotic conditions, as well as to expand their ranges rapidly, suggests they may persist under a variety of future climate scenarios (Dukes & Mooney 1999; Muth & Pigliucci 2007; Williams & Jackson 2007).

Non-native species contribute to local species richness (Sax & Gaines 2008) and thus may also contribute to ecosystem resilience and stability. Research has focused on species interactions (e.g., predation, herbivory) that can lead to declines in abundance of native species. Nevertheless, much less attention has been given to how food webs may be altered by the presence of non-native species (although see Byrnes et al. 2007) and whether long periods of time are necessary for strong positive links to form among species. Certainly, ecosystems that are composed mostly of non-native species can have complex species interactions and community structure (Wilkinson 2004). Therefore, it seems likely that non-native species will often contribute to some of the putative benefits of species-rich ecosystems, such as increased productivity and stability (Hooper et al. 2005; Cardinale et al. 2007), but this proposition has not been tested.

Novel Evolutionary Lineages

Given sufficient time, non-native species can increase global species richness through speciation. In situations in which gene flow is absent or low between a species' native and introduced populations, the combination of adaptation to novel selective regimes in the introduced region and drift (particularly with small founder populations) is expected to result in genetic divergence between native and introduced populations (Hendry et al. 2007). Divergent selective pressures can also rapidly arise among introduced populations (Lee 2002). For example, distinct subpopulations of European house sparrows (*Passer domesticus*) have evolved since 1850 in ecosystems in North America that range from deserts to moist, temperate forests (Johnston & Selander 1964).

Non-native species can also contribute to the formation of novel evolutionary lineages among native species. For instance, native soapberry bugs (*Jadera haematoloma*) have colonized non-native plants in the soapberry family in North America, where their lineages have diverged from bugs that remained on the original host (Carroll et al. 1997). Ultimately, such distinct lineages are likely to give rise to reproductively isolated, endemic species. Although speciation is generally believed to occur over centuries or longer, evidence of reproductive isolation was documented in allopatric populations of introduced salmonids after fewer than 13 generations (Hendry et al. 2000).

Non-native species can also catalyze hybridization events between native species that result in novel evolutionary lineages. For example, the *Lonicera* fly is a novel native species that resulted from the hybridization of two native *Rhagoletis* fly species. The parental fly species normally specialize on different native host plants and so rarely encounter each other. But both parental species occasionally visit the invasive honeysuckle (from the *Lonicera tatarica* complex) since its introduction to North America (Schwarz et al. 2007). Thus, the invasive plant provides a location for hybridization to occur. The plant now also serves as a resource on which the novel *Rhagoletis* hybrid species has become specialized.

Speciation events can also result from hybridization between certain non-native and native species and between pairs of non-native species (Vellend et al. 2007). For example, repeated speciation events of salsify (*Tragopogon* spp.) plants have occurred following their hybridization with multiple species introduced to the United States (e.g., Tate et al. 2006). Thus, although non-native species initially contribute to the homogenization of the world's biota (Olden et al. 2004) and may cause a delayed extinction debt (Jackson & Sax 2010), they also represent the source material for future speciation events and could eventually result in instances of evolutionary diversification. A conservation strategy that eradicates species simply because they are non-native could undermine the very biological entities that may be the most likely to succeed in a rapidly changing world.

Managing Non-Native Species

Efforts to manage non-native species generally focus on two approaches that have proven effective: preventing the introduction of novel species that are likely to become invasive and, in the event a non-native species is introduced and rapidly detected, controlling or eradicating the species (Lodge et al. 2006). Challenges to managing non-native species that are firmly established include uncertainties over future effects of a non-native species, divergent values among stakeholders, varying interpretations of sometimes sparse historical records, and dynamic conservation goals.

The future effects of a non-native species are uncertain because biotic interactions are notoriously difficult to predict and because current and future environmental conditions may differ substantially (Walther et al. 2009). For example, expected positive effects will not necessarily be realized. In addition, non-native species may become invasive at some point in the future and potentially result in the extirpation or extinction of other species. These uncertainties have led some to assume all non-native species undesirable until proven otherwise (e.g., Ricciardi & Simberloff 2009). We disagree with this perspective because it assumes the magnitude of negative effects will always be greater than the positive effects. Risk analyses may reveal that some non-native species are more likely to have positive impacts.

Major sources of uncertainty are not only whether a species will become invasive in the future, but also for how long negative effects will persist. Theoretically, there will be strong selective advantage for species that exploit an abundant non-native species; thus, initial negative effects are not expected to endure indefinitely. Empirically, the abundance of some non-native species declines after a period of initial growth (Simberloff & Gibbons 2004; Hawkes 2007), but there is insufficient data to predict how long this growth period will last.

Cost-benefit analyses of any management option for non-native species must include the subjective valuation of species (Evans et al. 2008; Sandler 2010). Stakeholders frequently have different value systems and prefer different management outcomes. There may be strong differences in opinion even among individual conservation professionals. For example, some place a premium on the integrity of native ecosystems or fear the future negative effects of non-native species (Ricciardi & Simberloff 2009), whereas others may value the ecosystem function provided by a non-native species (Dudgeon & Smith 2006) or the potential of translocation to preserve species in the wild (Hoegh-Guldberg et al. 2008).

A recurring issue in the valuation of non-native species is whether a species "belongs" to a given region. Strong opposition to non-native species comes from those who wish to retain the historical character of a region. We argue that the character of a region is likely to change over time as a non-native species becomes naturalized and humans grow accustomed to its presence. Evidence of such changes in normative values is already apparent in citizen groups that mobilize for the protection of non-native species such as the dingo (*Canis lupus dingo*) in Australia and *Eucalyptus* trees and Red-masked Parakeets (*Aratinga erythrogenys*) in California (U.S.A.). Philosophically, we 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 (e.g., Censky et al. 1998) considered natural, whereas a human-transported species is non-native and thus undesirable (Brown & Sax 2005; Cassey et al. 2005)? Furthermore, the past distributions and dispersal events of most species are poorly known, and this reduces one's ability to clearly distinguish native from non-native species, especially for lesser-known taxonomic groups (Carlton 1996). Because of these uncertainties and philosophical differences, we believe it is preferable to distinguish species on the basis of how long they have been present with terms such as *long-term resident species*, *recently arrived species*, and *new species* (Pyšek et al. 2004; Davis 2009). We surmise that species will increasingly be evaluated for reasons independent of their recent range distributions.

Because communities and species characteristics are so dynamic (e.g., Mace & Purvis 2008; Hobbs et al. 2009), we anticipate that conservation professionals will increasingly look toward the future rather than to the past when setting benchmarks and devising strategies. Instead of determining what species formerly occurred in an area and how to restore these species, they might determine what they want the area to look like in the future. Species that are economically or biologically damaging will likely be controlled, regardless of their historic origin. Conversely, species that are considered desirable for their aesthetic beauty, rarity, economic, or intrinsic value will likely be protected, subsidized, or left alone, regardless of whether their former status was native or non-native (Briggs 2008; Hoegh-Guldberg et al. 2008). In the past, risk analyses focused on negative events associated with non-native species, and a species was termed invasive if any significant negative effect was documented. Here, we suggest that both negative and positive potential effects of non-native species should be tallied. We also suggest that a more meaningful definition of an invasive species would be one for which there is a *net* negative effect. A dynamic view of nature that recognizes that species characteristics and human valuations thereof change over time, not only reflects ongoing evolutionary processes, but also leads to a more balanced and objective approach to the management of non-native species.

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