Strangers in a Strange Land: The Problem of Exotic Species

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ABSTRACT

Environmentalists consider invasions by exotic species of plants and animals to be one of the most serious environmental problems we face today, as well as one of the leading causes of biodiversity loss. We argue that in order to develop and enact sensible policies, it is crucial to consider two philosophical questions: (1) What exactly makes a species native or exotic, and (2) What values are at stake? We focus on the first of these two questions, and offer some preliminary suggestions with regard to the second. Through a series of case studies, we show that it is not always clear whether a species is native or exotic. We identify five possible criteria that could be used for distinguishing natives from exotics. Rather than identifying one of these criteria as the 'correct' one, we suggest that the concepts of 'native' and 'exotic' function more like what some philosophers have called cluster concepts. That is, there are several characteristics that are typical of native species, and a corresponding set of characteristics that are typical of exotic species. None of these characteristics is either necessary or sufficient for identifying a species as either native or exotic. We then identify several of the values that are at stake in dealing with exotic species, and we suggest that policies need to avoid being overly simplistic.

KEYWORDS

Cluster concept, exotic species, invasion biology, native species

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INTRODUCTION

Three different lines of armadillos existed in Florida during the Pleistocene Epoch (1.6 million to 10,000 years ago). For reasons unknown, they went extinct. In 1920 several nine-banded armadillos (*Dasypus novemcinctus*) escaped from the Hialeah Zoo; in 1924 several more escaped from a private zoo in Cocoa during a hurricane; and in 1926 several more escaped near Titusville when a circus truck overturned (Carr 1994). Due to high rates of reproduction, a lack of parasites and competitors, and the decimation of predators – panthers, black bears, and bobcats – armadillos now exist everywhere in Florida except for the Everglades and the Keys. Their burrows dry out the roots of orange trees, and they destroy the organisation and productivity of the leaf-mold stratum of hardwood hammock forests, as well as eating and outcompeting native millipedes, centipedes, isopods, snails, mites, spiders, skinks, lizards, salamanders and snakes. In spite of the fact that guns and motorised vehicles kill armadillos by the tens of thousands every year, they continue to thrive. Nine-banded armadillos native to Texas have been migrating east for some time, and today they have reached north Florida and have begun to mingle and reproduce with the exotic populations descended from the zoos and the circus truck. Prior to the natural migration from Texas, armadillos had been classified as exotic pests in Florida. Should we now accept them as native fauna?

This example illustrates the problem of distinguishing native from exotic species. If we hope to create and enact sensible environmental policies for dealing with exotics, we first must answer some important philosophical questions: What exactly makes a species native as opposed to exotic? Are exotic species always bad? Under what circumstances should exotic species be killed, removed, or left alone? Attempting to answer questions such as these opens up a Pandora's box of conceptual and normative quandaries. In this paper, we argue that there are no necessary and sufficient conditions for being native or exotic. The proposition 'This is an exotic species' may be neither clearly true nor clearly false because the distinction between natives and exotics admits of degrees. When we turn to normative considerations, the number of competing values at stake pose serious problems, and the claim that exotics are bad and ought to be removed should not be held as dogma. In the final sections of this paper, we offer suggestions for answering the demarcation and values questions and offer some tentative guidelines for setting policies to deal with exotic species.

WHAT IS AN EXOTIC SPECIES?

There is a general consensus among biologists, ecologists, environmental managers, and other environmental professionals that exotic species can be readily identified, that exotic species are bad because of the deleterious effects

they have on people and nature, and that exotic species should be removed or killed whenever possible. Many of these people believe that the problem of exotic species is one of the most serious environmental problems we face today (Soulé 1990; Wilson 1992; Wuerthner 1996; Bright 1998; Devine 1998; Pimentel et al. 1999). Jared Diamond (1989) identifies exotic species as one member of the 'Evil Quartet' – four mechanisms responsible for overall species extinction and the loss of biodiversity.[1] Because of the problems posed by exotic species, some leading biologists have called for the formation of a presidential commission on exotic species in the United States (Schmitz, 1997). Deborah Dyer (1996) argues that federal laws in the United States do not adequately address the role of exotic species, and Steven Wade (1995) has called for an Exotic Species Act. Before we enact such policies, however, we should first attempt to answer the question 'What is an exotic species?' In this section, we distinguish several possible criteria for determining whether a species is native or exotic to a particular area and show some demarcation problems raised by each criterion. While we distinguish between five different criteria, we should note that considerable overlap exists between them.

The Human Introduction Criterion

One answer to the question of what makes a species exotic is that proposed by Reed Noss and Allen Cooperrider (1994, 392): An exotic species is 'the result of direct or indirect, deliberate or accidental introduction of the species by humans, and for which introduction permitted the species to cross a natural barrier to dispersal'. According to this criterion, human activity is the key element in determining whether a species is native or exotic. This criterion appeals to many people who value ecosystems because they are unhumanised (or less humanised) and continue to exist relatively free from human activity (Throop 2000), and this criterion importantly is used to establish management objectives and environmental policy by bureaucracies such as the United States National Park Service and the Society for Restoration Ecology (Hettinger 2001).[2]

One problem that this criterion faces is how to interpret indirect introduction. We have an intuitive idea of what it means for humans to indirectly introduce a species. If, for example, humans allow coyotes to move into an area which they previously did not occupy by killing off the wolves in the area, it looks as though humans have indirectly introduced the coyotes. Hence, this criterion can be understood as a counterfactual – if not for human activity, this species would not be here. However, given the extent of human impacts on the planet over the past several million years, it looks as though this interpretation would rule out far too many species from the realm of nativity. That is, the 'butterfly effect' would make it so that only those species whose existence in an area predated the existence of human beings on the planet would qualify as native.

For these sorts of reasons, one might want to say that only those species that are directly introduced by humans are exotic. However, there are further problems in understanding how to correctly apply this criterion. Consider the following case. 'Saltcedar' tamarisk (*Tamarix chinensis* and *Tamarix ramossisima)* was introduced to the United States via the nursery trade in the 1820s and 1830s. By 1880 it had escaped from cultivation and had turned up in the desert Southwest of the United States (Rodman 1993).[3] The tamarisk, which was not native to this region, has spread rapidly along river banks where it forms a dense monoculture thicket and tends to deplete water supplies and impoverish wildlife habitat. John Rodman (1993, 149) notes that 'there is no consensus on whether saltcedar (the deciduous, shrubby, incredibly prolific form of tamarisk) should be thought of as one species, several distinguishable species, or a group of highly adaptive, rapidly speciating forms'. If in fact the tamarisk has undergone adaptation and speciation since its introduction into the desert Southwest, then it is unclear whether these new species should be considered native or exotic. According to the human introduction criterion, a species is exotic if it was introduced by humans. Was this new species of tamarisk introduced to North America by humans or not? Its ancestor was introduced by humans, but the species that exists here now is not the same species that was originally introduced. Given that this species exists nowhere else in the world, and never has, it would seem odd to say that it is not native to this region. However, it would not be here now if not for the activity of humans. And it may still belong to a genus which is exotic according to this criterion. This example raises the possibility that an organism could belong to a native species and an exotic genus.

In addition to distinguishing between direct and indirect introduction, one might wish to have a human introduction criterion which distinguished between intentional and unintentional introduction. What if, for example, a burr clings to the leg hair of a person walking through the area and rides its human ferry across to the other side of a mountain range? Is this not the plant's normal mechanism of dispersal? Could it not just as easily have hitchhiked on the leg of a non-human animal? Should we say that just because it happened to catch a ride on a human leg that it is exotic?

In spite of the above problems, the human introduction criterion captures an important component of the way many people think about nature as that which exists independently from human cultures. This criterion picks out a characteristic that can be typical of native species – the origins of their existence in a particular area is independent of people. Frequently people value native species just because of this fact and correspondingly regard exotic species negatively. We discuss this below in relation to the value of naturalness. While we believe that this criterion picks out an important feature of the distinction between natives and exotics (and the corresponding value), we do not believe that this criterion alone can provide a complete account of the distinction. As the tamarisk

and armadillo examples show, it will not always be clear how this criterion should be applied. Furthermore, we believe that even in the cases where this criterion can be clearly applied, it provides neither necessary nor sufficient conditions for the distinction between natives and exotics. A species may be exotic to a given area even if it has not been introduced (directly or indirectly, intentionally or unintentionally) by people. Consider the case of the finches on the Galapagos Islands. The fourteen different species of finches found on these islands apparently descended from a single species which arrived in the Galapagos from South America less than one million years ago (Lack 1983). The finches thrived in this environment relatively free from predators and formed new species as they adapted to relatively unfinchlike ecological niches. According to the human introduction criterion, the first finches to arrive in the Galapagos were native; however, these finches that evolved elsewhere were outside of their traditional range, and they were foreigners to the ecological communities on the islands. The next four criteria we discuss appeal to ideas of evolutionary origin, historical range, ecological degradation, and membership within an ecological community.

The Evolutionary Criterion

Perhaps a species ought to be considered native to an area if it originally evolved in that area. The first finches to arrive on the Galapagos Islands originally evolved on the South American mainland and were not adapted to the ecological conditions found in the Galapagos. The finches that exist on these islands today have undergone speciation and have evolved and adapted to the unique conditions of their environments. While the current species of finches seem to be native, following the evolutionary criterion, their ancestors were not. According to the human introduction criterion, both the current species of finches are, and their original ancestors were, native, but this account misses important differences between the original migrants and the subsequently evolved species. The tamarisks in the southwestern United States today may be in a position similar to the finches shortly after their arrival in the Galapagos.

The evolutionary criterion has some advantages over the human introduction criterion in that it captures the intuitive appeal of the idea that a species which has evolved in one area and just recently crossed some natural barrier to dispersal does not seem to be native to the area in which it has just arrived. Like a species introduced by humans, it has not evolved or adapted to 'fit' into this new environment. It may be highly invasive and could even wipe out species that currently exist in this area. The evolutionary criterion captures the idea that a species is native to an area if this is where the species comes from.

However, the evolutionary criterion also faces problems. How, for example, are we to determine the 'area' in which a species evolved? We tend to say that gray wolves (*Canis lupis*) are native to North America, that nine-banded

armadillos are native to Central America, and that Florida panthers (*Felis concolor coryi*) are native to Florida. We seem to have a very loose sense of what constitutes an area of origin. Trying to identify the place at which a species came into existence is plagued by the problem of spatial scale. If nine-banded armadillos first came into existence in a particular valley in Central America (if we could ever know such a thing), does this mean that these armadillos are native just to that valley, to a larger landscape, or to the entire region of Central America? Stephen Spurr (1980, 441) shows this spatial scale problem when he proposes that 'all plants and animals are exotic... except at the very point in space where the particular gene combination was constructed'. By defining the area in which a species evolved as a precise point in space, Spurr reduces the idea of nativity to absurdity.

Furthermore, the evolutionary criterion faces the problem that species are not clearly demarcated and well-defined. It is usually not possible to pinpoint the precise time at which one species divides into two. The Mexican gray wolf (*Canis lupus baileyi*) is commonly classified as a subspecies of the North American gray wolf. The Mexican gray wolf is morphologically distinct from its cousins up north. It is generally smaller, its coat looks different, and it is usually more aggressive. The Mexican gray wolf generally does not interbreed with the gray wolves from farther north, but it could in principle produce viable offspring. The German shepherd, on the other hand, is commonly classified as belonging to a separate species from the gray wolf. German shepherds and wolves do not commonly interbreed, but they are capable of producing viable offspring. This all illustrates the point that it is not always clear when two varieties of the same species have become sufficiently separate to be classified as separate species. Given the vagaries of determining when one species becomes two, application of the evolutionary criterion will be inherently difficult.

The Historical Range Criterion

While the science of conservation biology is grounded in modern evolutionary theory, few if any conservation biologists advocate the evolutionary criterion for distinguishing between native and exotic species. Instead, many conservation biologists are committed to a historical (or natural) range criterion: '*Exotic* is the adjective most commonly used by conservation biologists to describe a species living outside of its native range' (Hunter 1996, 215; see also Primack 1998). This criterion is similar to the human introduction criterion in that both involve species moving into areas where they have not previously existed. However, while human agency is all-important for the human introduction criterion, human agency is not necessary for a species to be considered exotic under the historical range criterion. As invasion biologist Geerat Vermeij (1996, 4) says:

> By invasion I mean the geographical expansion of a species into an area not previously occupied by that species. Invasions may occur as the result of climatic and tectonic changes as well as through introduction by humans.

The 'historical range' of a species presumably is identified with the areas in which it has historically been found. According to Walter Westman (1990, 252):

> As the term is used widely in park practice, an 'exotic' species is one that is newly established at a significant distance from its former geographic range. In park practice, the term includes both significant range extensions by species native to another part of the state or region, and introductions of species from distant regions or continents (whether by natural dispersal or human agency).

One difficulty faced by proponents of this criterion is that of locating the historical range of a species in space and time. Field guides to birds, mammals, trees, flowers, etc. typically illustrate the range of a species by shading in a portion of a map. However, this representation of the range is really very crude. Within the shaded area for a particular tree species, for example, there may be a valley where that tree species has never existed. If the tree species were to move into the valley, would it be moving outside of its historical range? The temporal problem may be even more complex than the spatial one. Aspens (*Populus tremuloides*) once extended as far as Southern California and the Baja Peninsula in Mexico. Due to changing climate patterns, the aspens have all but vanished from this region. Two small stands remain – one in the San Bernardino Mountains east of Los Angeles and one on the Baja Peninsula in Mexico. The nearest large groves of aspens are hundreds of miles to the north and separated from these small stands by desert. If humans decided to plant aspens in the nearby San Gabriel Mountains, where aspens apparently existed at some time in the past, would they be planting them within the historical range of aspens?

In addition to these difficulties of applying the historical range criterion, many would claim that this criterion does not provide a complete account of the concepts of nativity and exoticality. This criterion captures the intuition that a species moving into an area where it has not previously existed is a stranger to this area. However, by ignoring any distinction between anthropogenic introduction and natural migration, this criterion fails to capture one of the important values many people associate with native species (Throop 2000). Further, many people are concerned about exotic species because of the harmful environmental impacts of these species – some strangers are worse guests than others. For this reason, some people identify invasive and harmful species as the significant subcategory of non-indigenous species (Scherer 1994; Devine 1998). We shall call this the degradation criterion.

The Degradation Criterion

Robert Devine (1998) uses the terms 'alien', 'non-native', 'exotic', 'introduced', and 'non-indigenous' synonymously. 'These labels', he says, 'apply to any animal, plant, or microbe found outside its natural range' (p. 4). However, he is not particularly concerned with such species unless they degrade the environment and cause harm. He says, 'It's the invasive ones that we have to watch out for, the ones that proliferate out of control, degrade our ecosystems, make us ill, and devour our crops' (p. 5). Devine uses the term 'invasive' to identify these harmful species; he claims that invasive species are almost always non-native, but not all non-native species are invasive. Thus, invasives are a subcategory of non-natives. Donald Scherer (1994) has a similar classification scheme, though he uses the terms differently. Scherer uses 'non-indigenous' to refer to species existing outside of their historical ranges. He reserves the term 'exotic' for that subset of non-indigenous species that harms or degrades the ecosystem or displaces indigenous species. Both Scherer and Devine appeal to the important idea that what is significant about many exotics is that they cause biological and ecological degradation or harm.[4]

A paradigm example of an invasive species which degrades the ecosystem and displaces or wipes out indigenous species is the brown tree snake (*Boiga irregularis*) in Guam. Less than fifty years ago the brown tree snake was accidentally introduced to the island of Guam via cargo ships. This mildly venomous snake easily adapts to many forms of prey and eats, among other things, birds' eggs. The snake has no predators on Guam, so its population has multiplied rapidly. The island of Guam is now infested with these snakes; in the areas of highest density, there are as many as 10,000 snakes per acre. The snakes have decimated Guam's bird population. Thus far, they have wiped out fifteen species of birds, and they are threatening to wipe out the Marianas crow (*Corvus kubaryi*) and the Marianas fruit bat (*Pteropus marianus*) as well (Barela 1993). The brown tree snake's decimation of wildlife on Guam is being referred to by local environmentalists and media as 'The Massacre on Guam'. The snakes are so numerous that residents have reported them coming up through the toilets, chewing through power lines, and allegedly attacking human infants on occasion. The order is out to all Guam residents to kill brown tree snakes on sight, but still their population continues to grow. Officials are currently examining different possibilities for eradicating the snakes such as poison or snake-sniffing dogs, and biologists are trying to develop a disease specific to the brown tree snake which would be introduced into the population. Brown tree snakes have caused similar problems in Australia and have been reported in Hawaii and other Pacific islands where they pose a similar threat.

While the degradation criterion captures an important sense of exoticality – both in terms of what it means to be exotic to an area and in terms of the negative values associated with exotics – this criterion is not trouble-free. Questions

remain about what it means for an ecosystem to be harmed or degraded. One question is whether an ecosystem is the sort of thing that can be harmed at all. Some people such as Harley Cahen (1988) and Dale Jamieson (1995) have argued that ecosystems are incapable of caring about what happens to them and thus lack interests. Only those beings with interests, they argue, are capable of being harmed.

Even if we can meaningfully talk about harming or degrading an ecosystem, it sometimes appears to be the case that an exotic species both harms and benefits a natural ecosystem. Eucalyptus trees were introduced into California from Australia over 125 years ago. The state of California decreed in 1979 to remove all exotic plant species capable of naturalising. While removing all the eucalyptus trees would be a difficult (if not impossible) task, the trees have been a target for removal and control. The eucalyptus trees use large quantities of water and displace other less aggressive species. In some respects, the eucalyptus trees appear to be degrading the Californian ecosystems into which they have been introduced. However, the eucalyptus' impacts on local species may not be all bad. Monarch butterflies (*Danaus plexippus*) are apparently native to California by any of our criteria. Large populations of monarch butterflies have become reliant upon the trees for their annual migrations. According to Westman (1990, 255), eucalyptus trees are 'utilised by a wide range of native species, in some cases preferentially'. In addition to the monarchs, a number of native bird species and one species of salamander are found as frequently, or more frequently, in eucalyptus forests as in native oak woodlands. Hence, eucalyptus trees are apparently beneficial to some species in this ecological community and harmful to others, and the removal of these trees at this time could be both harmful to some native species such as monarch butterflies *and* helpful to other native species.

The Community Membership Criterion

John Rodman (1993) has proposed yet another criterion. He asks us to '[s]uppose that the essence of exoticality is existence outside a community, lack of a membership in a community of mutual dependence and mutual controls' (p. 150). The central idea that Rodman captures is that a species is native to the degree that it is an integrated member or component of an ecological community. This criterion is similar to the degradation criterion in that a species is exotic to the degree that it is not integrated into an ecological community, it violates relationships of dependence and control with other species, and it degrades or harms the ecological community. However, the community membership criterion differs from the degradation criterion because a non-integrated species that causes no degradation or harm to the ecological community is still considered to be exotic under the community membership criterion. The first finches to arrive in the Galapagos Islands were not integrated members of the ecological communities of these islands, and, because of this fact, they would be classified as exotic

under the community membership criterion. To the degree that they subsequently caused disruptions to the biological and ecological assemblages and processes present in the Galapagos, the finches became exotic under the degradation criterion. In time the ecological communities of the Galapagos evolved and adapted to the newly evolved species of finches, and the finches became integrated members of these communities. The finches are now native species according to the community membership criterion.

One problem the community membership criterion faces is the ability to spell out what an ecological community is. Although ecologists have used a community model to describe nature since the 1920s (McIntosh 1985; Hagen 1992; Worster 1994; Kingsland 1995), this model today has become questionable. Kristin Shrader-Frechette and Earl McCoy (1993) claim that there has never been consensus among ecologists over what precisely constitutes an ecological community, and Daniel Botkin (1990) claims that most attempts to create mathematical equations that express the notion of an ecological community cannot be empirically verified (see also Kingsland 1995). Beyond theoretical problems of trying to describe what an ecological community is, it can be notoriously difficult to determine which species of any given ecological community are integrated natives (Diamond 1987). Accurate ecological data for any given ecological community seldom go back more than one or several hundred years. Further, paleoecologists remind us that natural communities are consistently shifting and are seldom as stable as we once thought. For example, most plant communities in the eastern United States are relatively short lived – from a paleoecological perspective, having established their current species composition in the past 4,000 to 8,000 years (Graham 1988; Hunter et al. 1988). Viewed from this perspective, ecological communities look more like relatively arbitrary collections of assemblages, and it might be difficult to define native species as species that are integrated well within a community.

Beyond the difficulties involved in determining a particular ecological community, proponents of the community membership criterion also face difficulties in determining what Rodman calls 'mutual dependence and mutual controls'. Rodman (1993, 153) claims that members of an ecological community participate in a form of 'balance in a disturbed world'. This might lead us to see some form of ideal balance of multispecies, ecological communities (or balance of nature) that can be used as a yardstick to distinguish natives from exotics: organisms and species are native to the degree to which they fit into such a balance and exotic to the degree to which they upset or alter such a balance. However, we must reject a simplistic notion of balance because it originates largely from a now-defunct ecological understanding of nature. Disturbance ecologists tell us that natural systems may rarely exist in stable forms of balance and instead are more properly characterised by persistent changes and disturbances (Pickett and White 1985; Botkin 1990). The community membership criterion is problematic because it presupposes a pristine, balanced ecological

community composed of native species against which we can compare exotic outsiders, and such communities may be nothing more than fictions (Peretti 1998).

Ned Hettinger (2001) argues that Rodman's community membership criterion requires not merely community membership for nativity but *good* community membership. That is, for a species to be considered native, it must have adapted well into the ecological community. Holmes Rolston (1994, 115) proposes a similar standard when he argues for the removal of feral mustangs in the western United States because these mustangs are not 'good adapted fits on today's landscapes', in spite of the fact that they've been on such landscapes for hundreds of years and now have federal, legal protection via the U.S. Wild and Free Roaming Horses and Burros Act of 1971. In place of this strong version of a community membership criterion as advocated by Rodman and Rolston, Hettinger (2001, 198) argues instead for a weaker version of this criterion:

> In contrast with native species, an exotic species is one that is foreign to an ecosystem in the sense that it has not significantly adapted to the resident species and/or abiotic elements that characterise this system and, perhaps more importantly, the system's resident species have not significantly adapted to it. [On this account] species that are introduced to new geographical locations by humans, or that migrate or expand their ranges without such assistance, may or may not be exotics in these new regions. Species are exotic in new locations only when the species movement is ecological and not merely geographical.

The mere act of geographical movement does not make a species exotic because species that move into a type of ecological assemblage that already exists in the 'home range' of the species would be considered native, according to Hettinger, in spite of the fact that the species now has a new geographical location. Because Hettinger focuses on ecological assemblages rather than on ecological communities, his criterion might get around two of the problems associated with the community membership criterion: the problem of what constitutes an ecological community and the problematic notion of a balance of nature. A version of the community membership criterion might appeal to people who advocate a holistic environmental ethic such as Rolston (1994).

NATIVE AND EXOTIC SPECIES AS CLUSTER CONCEPTS

We have identified five different criteria for classifying a species as exotic. Using case studies, we have illustrated that a species may be classified as exotic using one criterion, but non-exotic using another criterion. The selection of a criterion for classifying a species as exotic will have significant practical consequences when it comes to the establishment of policies for dealing with native and exotic species. Which criterion then should we use? Our suggestion is that there is no

'bright line' which separates native species from exotic species. We believe that none of the five criteria we have identified constitutes either a necessary condition or a sufficient condition for a species being exotic. Rather, we suggest the concepts of 'exotic' and 'native' as applied to species are *cluster concepts*.

As Heather Gert (1995) says, there has been an ongoing debate in philosophy between those who believe that conceptual analysis is a matter of determining the necessary and sufficient conditions for falling under a concept – the so-called classical view – and those who believe that the attempt to do so is generally futile. Critics of the classical view argue that we cannot always give necessary and sufficient conditions because many concepts lack 'sharp borders' and may admit of some degree of vagueness. In response, one might wish to point out that the classical view does not always rule out the possibility of vague concepts (Gert 1995). We might wish to maintain, for example, that there are necessary and sufficient conditions for being a bachelor and that one of the necessary conditions is being an adult. Since adulthood seems to have fuzzy boundaries, one who accepts the classical account might reasonably maintain that the concept 'bachelor' is vague. But perhaps this only pushes the problem back. Unless one can give necessary and sufficient conditions for being an adult, one has not really given necessary and sufficient conditions for being a bachelor. Any analysis which uses concepts that have not been, or cannot be, analysed properly without vagueness is not a complete analysis.

A second reason for criticising the classical view is that according to the classical view, no property can be mentioned in the analysis of a concept unless that property is a necessary condition for falling under the concept. For example, since having four legs is not a necessary condition for being a dog, the property of having-four-legs would not be a part of the analysis of the concept 'dog'. One alternative which has been offered is that of cluster concepts.[5] On this view, an analysis of a concept will include a variety of properties, but it is only required that something possess some subset or cluster of these in order to fall under the concept. Hence, something might be a dog if it possess a sufficiently large subset of the properties associated with the species *Canis domesticus*, although it need not exhibit all of those properties.[6] As applied to extocality, the traits which are characteristic of exotic species are exemplified by each of the five criteria we have identified in this paper. An exotic species typically will exhibit the following traits:

- The species' existence in the area is the result of human introduction at some time. That introduction may be intentional or unintentional, direct or indirect.
- The species originally evolved somewhere else.
- The area is outside of the historical (or natural) range of the species.
- The species tends to damage or degrade the local ecosystem, displacing or eliminating native species.

- The species is not an integrated member of the ecological community. It has not developed significant relationships of mutual dependence and mutual control with other species in this community.

Any one of these traits on its own will not be sufficient to make a species clearly exotic. Consider, for example, the first trait. Are all species whose presence in a particular area is a result of human introduction clearly exotic? We contend that they are not. The Guam rail (*Rallus owstoni*), a flightless bird endemic to Guam, has been virtually wiped out by the brown tree snake. Guam rails are now being bred in captivity and 'reintroduced' to the small nearby island of Rota which has no brown tree snakes. Although Rota is ecologically similar to Guam, rails have never existed on Rota. Is the Guam rail on Rota an exotic species? Further, is a species which was indirectly introduced to an area by humans in the past always exotic? Consider again the case of the saltcedar tamarisk discussed above. Are the new species, which may have evolved since the tamarisk was introduced, exotic to the southwestern United States? Their presence there now is a direct result of human introduction; however, these new species evolved in the southwestern U.S. and exist nowhere else. Human introduction is not *sufficient* to make a species exotic, though it is a trait which is characteristic of exotic species. The same is true of the other traits that are characteristic of exotic species, although we lack the space here to demonstrate this in each case.

Furthermore, none of the above traits is a *necessary* trait for an exotic species. That is, a species could be exotic while lacking any one of the five traits. Consider again human introduction. Must a species be introduced by humans in order to be exotic? We think not. Consider a species of bird which manages to find its way onto an island where it has not previously existed. This island is not part of the historical range of this species; the species originally evolved somewhere else; it may be quite disruptive to the ecosystem of this island, displacing native species; and it has not yet become an integrated member of the island's ecosystem. It seems reasonable to say that this species is exotic to the island, even though it was not introduced by humans.

When we say that 'exotic' is a cluster concept as it applies to species, what we mean is that there are a number of traits which are typical of exotic species. We have identified five of these traits. None of the traits is either necessary or sufficient for a species to be exotic. The more of these traits a species has, the more likely we are to think of it as exotic. As a contrast to extocality, there are a number of corresponding traits which are characteristic of native species:

- The species' presence in the area is not the result of human introduction.
- The species originally evolved in the area.
- The area is part of the historical range of the species.
- The species does not tend to degrade the ecosystem or displace or eliminate other native species.

- The species has become an integrated member of the ecological community, forming mutual relations of dependence and control with other species.

Once again, none of these traits is, on its own, necessary or sufficient for a species being native. They form a cluster of traits which are characteristic of native species. The more of these traits a species has, the more likely we are to think of it as native.

There are two ways in which nativity and exoticality can be understood either as indeterminate or as admitting of degrees.[7] First, they may be vague in the way that concepts such as 'adult' are vague – having fuzzy boundaries. If we think of a native species in terms of its historical range, for example, the historical range may be vague both geographically and temporally. Secondly, if the categories of 'native' and 'exotic' function as cluster concepts, as we have suggested, then we will often find species which exhibit some, but not all, of the characteristics which are typical of native species. It seems reasonable to say that a species which exhibits more of these traits is 'more native', or at least more clearly native, than one which exhibits fewer of these traits. That is, because there is no bright line separating native and exotic species, a particular species might be more or less native, depending on the presence of traits listed above which are characteristic of native species, and a particular species might be more or less exotic, depending on the presence of traits listed above which are characteristic of exotic species.

People frequently use the terms 'naturalisation' or 'naturalised species' to refer to species which were considered exotic in the past but which are now native. This sense of naturalisation matches up well with the community membership criterion. Hettinger (2001, 209) says that '[a]n exotic species naturalises in an ecological sense when it persists in its new habitat and significantly adapts with the resident species and to the local abiota'. Rather than calling such species 'naturalised', we propose to call such species 'native' and to reserve the term 'naturalised' to refer to species that are on their way to becoming native. That is, we understand naturalisation to represent a grey area between extocality and nativity. To the degree that a formerly exotic species is beginning to exhibit traits that seem more characteristic of native species, that species is now naturalised. At some future point in time naturalised species might come to be considered native. As Walter Westman (1990, 252) notes: 'Today's exotics may be tomorrow's naturalised species… In turn, it is unclear how long a species must be naturalised before it can be considered native'. When the first species of finches arrived in the Galapagos Islands, this species was probably exotic in every sense except that of being introduced by humans. As the finches began to adapt and evolve, and as the ecological communities of the Galapagos began to evolve and adapt in response to the finches, the finches became naturalised. Further adaptation and evolution has led to the nativity of the finches that now exist in the Galapagos.

While we are primarily interested in non-human species such as finches and tamarisks in this paper, we wish to point out that the five different criteria for nativity and extocality also might be applied to humans (*Homo sapiens sapiens*). According to the human introduction criterion, human actions (direct or indirect, intentional or unintentional) make a species exotic. This suggests that we are always exotic in any environment. Rolston (1994) argues that we are a nicheless species strongly separated from non-human nature because of the development of our cultures. Making such a distinction is crucial for people such as Robert Elliot (1997) who value naturalness because it connotes having a non-human origin and causal continuity with other non-human origins. According to the evolutionary criterion, a species is exotic to an area if it did not evolve there. Because *Homo sapiens sapiens* probably originally evolved in Africa, perhaps people today are exotic to all other continents. As indicated by the title of Neil Evernden's (1993) book *The Natural Alien*, we are exotic, and we are exotic according to Evernden because of the development of human technology which takes us out of environments in which we evolved. According to the historical range criterion, a species is exotic if it is outside of its historical range. What is our historical range? Proponents of the historical range criterion might argue that when people first arrive and colonise a new area – such as when people first came to North America at least ten to fifteen thousand years ago – they are exotic if outside their historical range. Further, when people first arrive in a new area, typically they cause ecological and biological harm (Nabhan 1995), thus making people exotic as per the degradation criterion. Because of extensive anthropogenic harms to the environment today, we might still be exotic over much of the Earth. Finally, according to the community membership criterion, a species is exotic to an ecological community if it has not forged mutual relations of dependence and control. Because we typically fail to adapt to ecological communities and establish such relations and instead alter and/or destroy ecological communities to fit our own needs and wants, we are usually exotic following this criterion. And just as non-human exotic species can become naturalised and eventually native, so might people. As per the community membership criterion, we become naturalised to the degree that we restrain our control over ecological communities and instead become 'plain member and citizen' (Leopold 1949, 204) of these communities; this might help make sense of the idea many people have that groups of people such as so-called 'indigenous peoples' who live closer to and more in harmony with non-human ecological communities are more native.[8] Similar to this and as per the degradation criterion, to the degree that we create minimal ecological and biological harm, we become naturalised. As we become established over time in various areas, such areas then become part of our historical range, and we become naturalised following the historical range criterion; e.g., while people might have been exotic in North America ten thousand years ago, perhaps today naturalisation has

occurred here. As we continue to evolve as a species, perhaps culturally as well as biologically, we can become naturalised as per the evolutionary criterion in given locations. But if we are always exotic as per the human introduction criterion, naturalisation and nativity will always elude us.[9] In those relatively natural areas where humans would qualify as an exotic species according to most or all of the criteria we have identified, we ought to take active measures to prevent the introduction of humans, as we would with any exotic species. For the same reasons that we desire to control other exotic species – their lack of naturalness, their impact on the biological integrity of the ecosystem, etc. – we also must control the introduction and impacts of humans as an exotic species.

Accounts of nature from invasion biologists – who study how exotics invade, impact, and change native flora and fauna – may be helpful in rounding out our discussion of nativity and extocality as cluster concepts.[10] One of the central tasks for invasion biologists is to develop a theory of community assembly that explains the patterns and processes of how flora and fauna assemble to form given ecological communities (Townsend 1991; Moyle and Light 1996; Vermeij 1996).[11] We begin with an existing community of native species. Following the evolutionary, historical range, community membership, and the human introduction criteria, many of these natives may have at one time been exotics. Three ongoing stages of community assembly may be gleaned. At the first stage of *colonisation*, new exotic organisms that did not previously visit or occupy the existing community arrive. They may arrive via speciation as per natural evolution; arrive via natural means outside of their historical range; be transported directly, indirectly, intentionally, or unintentionally by people; or arrive by some combination of these means. As newly arrived exotics, these organisms are not integrated within the existing community and are exotic as per the community membership criterion. It is quite possible that these organisms are exotic as per the degradation criterion because they are causing harm or degradation to the existing ecological community and/or to native organisms. Those exotic organisms who stay find and follow ecological opportunities. Many exotic organisms might either leave or die due to an inability to find food, establish a habitat, successfully mate, compete with other organisms, etc. Those exotics who stay in a community stay precisely because they become established and persist through either local reproduction or continuous recruitment of new breeding members from outside the community, and these exotics establish viable bridgehead populations (or viable beachhead population colonies in the case of insects (Moller 1996)). At this second stage of *establishment*, exotics are not integrated members of the ecological community (as per the community membership criterion). In the third stage of *integration*, exotics forge ecological links with native species, and an altered ecological community results that has adapted to the exotics.[12]

While we have noted difficulties with each of the five different criteria used to distinguish natives from exotics, each of these criteria still can play a useful role in helping explain the phenomenon of biological invasions as studied by invasion biologists. While some biologists make no distinction between anthropogenic and non-anthropogenic means of invasions, others wish to regard these different means as significant (Vermeij 1996). There may be functional, historical (non-anthropogenic) and evolutionary limits in any natural system (Pickett et al. 1992), and this helps explain what might be attractive about the human introduction criterion. Further, anthropogenic invasions may be more harmful to the ecological community (following the degradation criterion), and it may be harder for organisms that arrive via anthropogenic means to become established within an ecological community (following the community membership criterion). The evolutionary criterion plays an important role in helping explain the process of biological invasion. Invading exotics can be exotic because they have not co-evolved with other species in a particular area. A number of exotic organisms undergo genetic, evolutionary changes following a successful invasion into a new ecological community (Carroll and Dingle 1996), such as the Galapagos finches. Although there are problems in trying to determine the precise historical range of many species, the historical range criterion helps capture the important idea that an organism is exotic because it is a stranger to a new land. Residents – natives – do not invade the homes where they live, and invasion biologists rely upon the notion of a non-resident – exotic – to help explain the process of invasions. The degradation criterion helps capture the idea that an organism is exotic because it is a stranger in a strange land. The organism is new to an area, and, because of the deleterious presence of the organism (or, more probably, groups of organisms), the ecological community has become strange for the worse.[13] The community membership criterion corresponds well with accounts of community assembly from invasion biologists. We can examine the role an organism or species plays within the larger context of an ecological community: exotics are organisms and species whose presence and behaviour fail to conform to historical functions and patterns in a particular ecological community and who are not integrated members of the community.

While each of the five different criteria for distinguishing natives from exotics can help ground invasion biology, we should note that there can be considerable overlap between these five criteria. One hundred and forty-five exotic fishes, invertebrates, fish disease pathogens, plants, and algae currently exist in the North American Great Lakes (Mills et al. 1994).[14] Virtually all of these exotics have been documented as being introduced by humans. None of these exotics have evolved in the Great Lakes. All of these exotics are outside of their historical ranges. Many of these exotics are causing harm to native species and to the ecological communities of the Great Lakes. Few of these exotics are

integrated members of these ecological communities. Convergence of all five of the different criteria for distinguishing natives from exotics clearly indicates the presence of exotic species. This leads to important questions concerning what to do about these 145 exotic species in the Great Lakes. Before we can begin to suggest policy guidelines, however, we must first examine the values at stake in matters concerning native versus exotic species.

ARE EXOTICS BAD?

While some scientists and environmental managers who make policy decisions regarding exotic species might wish to avoid talking about values, values are at the heart of such policy decisions. That is, the problem of exotic species, as alluded to in the title of this paper, is a problem precisely because of conflicts of values.

A good example of this is the case of feral pigs in Hawaii. The first humans to arrive in Hawaii – Polynesian settlers sometime between 400 and 800 AD – brought small pigs to a pigless Hawaii. The presence of the pigs, along with other settlement impacts such as farming, led to the extinction of at least thirty-five species of birds (Royte 1995, 26). When Europeans arrived in Hawaii over two hundred years ago, they brought numerous exotic flora and fauna, including large European boars. These flora and fauna have proliferated, and today Hawaii is considered the endangered species capital of the United States. Three quarters of all extinct American plants and birds once lived in Hawaii, and more than a third of the plants and birds currently listed as endangered and threatened in the U.S. are found in Hawaii. According to *National Geographic* magazine,

> The causes of Hawaiian species' decline are numerous and complicated, but if conservation biologists had to name the most significant threat to native rain forest species today, they would, without hesitation, indict the feral pig. (Royte 1995, 14)

The feral pigs in Hawaii today are a breeding combination of the small domestic pigs brought by the Polynesians and the larger European boars. These pigs cause large-scale destruction as they uproot shrubs, gnaw at plants, disturb soils, and spread seeds from harmful alien plants. Efforts to remove the pigs have been hampered by the fact that they often inhabit remote and heavily forested areas. In a well-publicised dispute between the Nature Conservancy and People for the Ethical Treatment of Animals (PETA), PETA has opposed methods such as neck-hold traps used by the Nature Conservancy to kill pigs in Hawaiian forests.

What are the values at stake in this example? Some people such as conservation biologists argue that the pigs threaten the health of the Hawaiian rainforests and native Hawaiian biodiversity. The solution then is to kill and remove the pigs. Other people such as animal activists argue that it is wrong to

harm and kill the pigs because they are sentient animals. The solution then is to leave the pigs alone. Still other people such as wilderness advocates might find some of the efforts to remove and kill the pigs problematic because these efforts can be highly invasive and threaten the naturalness of Hawaiian rainforests. And still other people might object to efforts to remove and kill the pigs because these efforts interfere with aesthetic appreciation of and outdoor recreation in the rainforests. The solution to the pig problem becomes less clear.[15]

What is clear from this example is that there are a number of different values at stake that create the problem of exotic species. While we lack the space here for an adequate discussion of these values, we wish to identify five of them. This list is not meant to be exhaustive. First, there is the value of **ecosystem health** (Costanza et al. 1992). Conservation biologists argue that the pigs threaten or harm certain features of the Hawaiian rainforests. Such features include integrity, stability, disturbance regimes, resilience, and other such ecological functions. An analogy is made between human health – something most people find valuable – and the health of an ecosystem.[16] Second, there is the value of **biodiversity** (Noss and Cooperrider 1994). Conservation biologists also argue that the pigs threaten the biodiversity found in Hawaiian rainforests. While the focus typically is on biodiversity at the species level and at the level of sustainable metapopulations (or minimum viable populations), biodiversity also may include genetic and ecosytemic biodiversity (Noss and Cooperrider 1994).[17] Third, there is the value of **naturalness** (Woods, forthcoming). Wilderness advocates argue that the management efforts needed to remove and kill the pigs can be highly intrusive to the naturalness of the Hawaiian rainforests. Some people value this naturalness because it has a non-human origin and causal continuity over time (Elliot 1997). Fourth, there is the value of **animal welfare**. Animal activists argue that it is wrong to harm or kill individual pigs because the pigs are sentient (Singer 1990) and/or because the pigs have basic rights (Regan 1983).[18] Fifth, there are **anthropocentric values of nature** such as economic, aesthetic, and recreation values. Some people who engage in outdoor recreation in Hawaiian rainforests might oppose management efforts to remove or kill the pigs because such efforts interfere with a recreational or aesthetic appreciation of the rainforests; other people might question whether such management efforts are economically efficient. In identifying these values, we do not intend to provide an exhaustive list of all the possible values at stake for each and every case involving exotic species. We have picked out some of the values which we believe are most important, and in doing so we hope to show that policy decisions cannot be reduced to a single value.

As the case of the pigs in Hawaii shows, exotic species typically diminish or destroy some of these values. This is why many people believe that exotic species are bad. But such a blanket condemnation cannot be made against exotics because in many cases exotics also can enhance and even create values. Traditional subsistence farming at the oasis of Ki:towak in the Sonoran Desert

can enhance biodiversity by creating habitat for more species of birds (Callicott 1991), and modern monoculture farming in North Dakota creates economically valuable wheat that is exported all over the world. Of course, some environmentalists might wish to oppose both of these farming practices because the naturalness of the Sonoran Desert and the naturalness of the North Dakota prairies are diminished. Such opposition involves a conflict of values, and this precisely is the problem of exotic species.[19]

While we have argued elsewhere (Moriarty and Woods 1997) that there are some cases where a conflict of values can be resolved without a net loss of values, we recognise that in many cases involving exotic species hard decisions will have to made that necessitate sacrificing one or more values in order to promote other values. We wish to point out, however, that in many cases such hard decisions are circumvented simply by ignoring values. Some conservation biologists simply fail to see the value of animal welfare at stake in the Hawaiian rainforests, while some animal activists simply fail to see the values of ecosystem health and biodiversity at stake. In many other cases a decision is made that a species is exotic, it is bad, and therefore it should be removed or killed.[20] We have argued above that it is problematic to define a species as 'exotic' simply by using only one of the five criteria for distinguishing an exotic from a native while ignoring the other four criteria. Similarly, it is also problematic simply to appeal to only one or two values at stake to show why an exotic species is problematic while ignoring other values.[21] When making policy decisions concerning what to do about an exotic species, all the values at stake should be articulated.

ENVIROMENTAL POLICY IN A VALUE PLURALISTIC WORLD

Many policies concerning the elimination of exotics are written and implemented with the assumptions that exotics can be easily identified and that removing them is our sole concern. As Walter Westman (1990, 251–252) notes:

> Current policies for managing exotic plant species in most park reserves in the United States reflect the influence of the report produced by A. Starker Leopold and colleagues (1963) for the National Park Service. The Leopold Committee suggested that the goal for biotic management within the National Park Service be to maintain or recreate biotic associations "as nearly as possible in the condition that prevailed when the area was first visited by white men."

Westman further notes that 'As such language became translated into public policy in federal and state park systems throughout the country, the goals of exotic species management were framed in more absolutist terms' (p. 252). Policy directives generally call for the removal of all exotic species from federal and state park lands. However, given the limited budgets available for management of exotic species, park managers are forced to prioritise, focusing their

efforts on only a few species. In the absence of guidelines for prioritising, such decisions are often made on pragmatic grounds such as which species are easiest to control and the estimated economic costs of control, rather than on ecological grounds.

While absolutist policies which use only one criterion for identifying exotic species and call for the removal of all exotic species have the benefit of providing theoretically consistent procedures which might seem easy to follow, they are problematic for a number of reasons. Such policies are overly simplistic in their interpretation of what it means for a species to be native or exotic, and they are impractical without guidelines for determining which species and locations should be given the most attention. Furthermore, such policies can be inconsistent with the ecosystem level goals of environmentalists, conservation biologists, and environmental managers. For example, policies of eradicating exotic species do not always benefit native plants and animals. Removal of exotic plants may simply open the door for invasion by other, more aggressive, exotics. It may also harm native wildlife which utilises the exotic hosts. As Westman (1990) points out, native birds and butterflies utilise the exotic eucalyptus trees in California, and if those trees were removed, it would be decades before a native forest of equivalent stature could develop. Finally, the removal of exotic species may have a number of costs – economic, aesthetic, ethical, and environmental.

The removal of exotic plants is often achieved with the use of herbicides, the environmental impact of which is not always confined to the target species. The removal process may also require heavy machinery, which can also be ecologically damaging. When exotic plants are removed, increased erosion may become a problem until native plants become reestablished. The removal of exotic animals often involves inhumane trapping or poisoning. Furthermore, the removal of exotics often involves the introduction of other exotics, such as predators or diseases, which are intended to eliminate the target species, but which may themselves become invasive exotics.

Rather than seeking policies which give absolute answers about whether a particular exotic species should be removed, we need to develop policies which are sensitive to the genuine complexities of these issues. Policies should recognise that ‘native’ and ‘exotic’ are not absolute categories which can be clearly identified. Rather, the concepts of ‘native’ and ‘exotic’ should be treated as cluster concepts such that a species may have some, but not all of the characteristics which are generally associated with exotic species. Policy makers should recognise that there are a number of competing values at stake. The ecological impact of a species must be weighed against the ecological impact of removing the species. Likewise, the economic costs brought about by exotic species must be weighed against the economic costs of removal and restoration programmes. The naturalness which is lost due to the spread of anthropogenically introduced exotic species must be weighed against the naturalness which is lost through long-term programmes for controlling exotic species – programmes

which may themselves be quite invasive. Then these values must be weighed against each other and against other values such as animal welfare and human recreation.

Rather than developing blanket policies for dealing with the very serious problems posed by exotic species, we should develop policies which allow for the individual evaluation of each species, and we should develop guidelines for prioritising our efforts at controlling exotic species. We should ask questions such as, 'In what sense is this species native?', 'What impacts does it have on ecological and human resources?', 'What would be the costs (economic, ecological, etc.) of controlling or removing this species?', and 'What are the prospects of successfully controlling or removing this species?'

We offer the following tentative guidelines for prioritising efforts to control exotic species.

(1) The first priority should be the prevention of anthropogenic introduction (intentional or unintentional, direct or indirect) of species, especially into relatively natural areas. This is illustrated by the current efforts to prevent brown tree snakes from being introduced to other islands in the Pacific. Species introduced to a new area via humans tend not to be well-integrated members of ecological communities, they denude the naturalness of the area, and, in many cases, these new species may cause damage or degradation to other species and/or to the ecological community. Emphasis should be placed on protecting wild areas that have not been severely impacted by the anthropogenic introduction of exotic species. This will require severely limiting human activities in and access to these areas.

(2) The next priority should be given to the removal of recently introduced species where the prospects for success are high and the costs of removal (economic, ecological, costs to sentient life such as pain and death) are low.

(3) For species which have become well established, we should be cautious about heavy-handed management. Before engaging in a management project of a well-established species, we should ask, 'Is it clearly exotic by all criteria?', 'What impacts does it have on values such as ecosystem health, naturalness, biodiversity, animal welfare, economics, aesthetics, etc.?', and 'For each type of value, would the attempt to eliminate or control the exotic species do more or less to conserve that value than a laissez-faire policy?' We may decide to do nothing about well-established species if the species is so well established that we would be fighting a losing battle or if the species has become sufficiently 'naturalised' and is in the process of becoming native.

A good example that illustrates the problem of heavy-handed management is the attempted control of knapweed, particularly Russian knapweed (*Centuria ripens*) and spotted knapweed (*Centuria noculousia*). The roots of knapweed link themselves with the roots of native grasses via soil fungi, and this allows for

knapweed to suck energy from native grasses. The end result is that knapweed flourishes, and native grasses diminish and ultimately die. For many years the solution to this problem has been to kill knapweed by poisoning or burning it. This, however, has failed to halt the spread of knapweed throughout the northern Rockies in spite of massive eradication efforts. Further, pesticides used to poison knapweed also poison native plants, and the constant eradication efforts can diminish the naturalness of the surrounding areas. The latest solution to the problem of knapweed has been to release exotic insects that eat and destroy the seed heads of knapweed (the insects are native to Eurasia – the native home of knapweed – and, as such, are 'native' pests of knapweed). While these insects might destroy 95% of the seeds of each knapweed plant, the remaining 5% of the thousands of seeds from each plant still survive. And these seeds still thrive because knapweed plants respond to the introduced insects by drawing more energy from the native grasses with which the knapweed roots are linked. Further, the exotic insects are now ubiquitous and harm native plants.[22] Fighting knapweed appears to be a losing battle, and, as the use of exotic insects shows, the 'solution' to the problem of knapweed might be no solution at all.

(4) Some of the most difficult cases with which we are faced might be those in which we must try to weigh different types of value against each other – for example, the value of sentient life (pigs, goats, etc.) against the ecological value or biodiversity represented by native plants The case of the pigs in Hawaii discussed above illustrates this. This issue of killing exotic animals in order to protect native plants is often seen as an issue that divides environmentalists and animal activists. A friend who considers himself an environmentalist once said to us, 'I would have no problem killing a few animals in a situation like that in order to save some native plants'. Another friend who considers himself an animal advocate said, 'I would have no problem sacrificing a few plants in order to save those animals.' We would have a problem killing a few animals (or a few thousand animals as the case may be) in order to protect some native and endangered species of plants. *And* we would have a problem sacrificing the last members of a native and endangered species of plant in order to save a few animals. Multiple values such as biodiversity and animal welfare are all relevant. This means that there might be some genuine moral dilemmas, and on occasion there might be no good solution. We hope to avoid these difficult situations by appealing to (1), (2), and (3) above. However, a number of these cases do arise. In these cases we should avoid oversimplifying by focusing on only one value. By identifying different criteria for distinguishing between natives and exotics and identifying some of the different values at stake, we hope that new policies for managing exotic species can avoid some of the pitfalls of existing policies. However, it would be a mistake to believe that we will find absolute answers to these most difficult policy questions.

In conclusion, we suggest that in order to deal with the wide variety of cases involving exotic species of plants and animals, we must avoid absolutist policies which use only one criterion for determining whether a species is native or exotic. We also must create policies that are sufficiently flexible to acknowledge the multiplicity of values which are at stake. We hope that by recognising this the policies which govern the strangers in strange lands will themselves become less strange.

NOTES

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[1] Exotic species are the second most destructive member of the evil quartet (following anthropogenic habitat destruction). In the United States, about forty percent of the threatened and endangered species listed on the U.S. Endangered Species Act are at risk primarily because of exotic species (Pimentel et al. 1999).

[2] See Seligsohn-Bennett (1990) for a discussion of some of the problems that have resulted from the National Park Service's reliance on the human introduction criterion in relation to 'exotic' ponies in Assateague National Seashore.

[3] T.W. Robinson, *Introduction, Spread, and Aereal Extent of Saltcedar* (Tamarix) *in the Western United States* (U.S. Geological Survey Professional Paper 491-A) (Washington, D.C.: U.S. Government Printing Office, 1965), cited in Rodman (1993).

[4] Interestingly enough, the degradation criterion raises the possibility that even natives could be classified as 'exotic' because they degrade their native landscapes. The United States National Park Service (1988) has policies for managing native species that cause degradation. We thank Ned Hettinger for pointing this out to us. See Garrot et al. (1993) for a discussion of how overabundance of a species – whether native or exotic – can cause ecological and biological degradation.

[5] See Putnam (1975) and Searle (1958).

[6] Gert (1995) points out that this view need not be seen as a radical departure from the classical view. It may be possible for one to give a classical analysis in terms of necessary and sufficient conditions in which one of the conditions is a long disjunct or a long conjunct. For example, 'X is a dog *iff* ((A&B&C)⁄(A&B&D)⁄(A&C&D)...)'.

[7] B.J. Garrett (1988) points out that we can distinguish between the thesis that an identity statement is *indeterminate* as a result of vagueness and the more radical thesis that an identity relation is one of *degree*. Thus, one might wish to maintain that the claim that a species is native may be of indeterminate truth value while denying that nativity is a matter of degree.

[8] See Callicott (1996) for an interesting discussion of how people can be native and can become naturalised within a human community.

[9] See Jackson (1996) and Snyder (1990) for discussions of how people might become native to a place.
[10] As Holland (1995) argues, it is problematic to derive philosophical accounts of what nature is – in this case in terms of native and exotic species – from scientific accounts. We agree. We discuss invasion biology to show how philosophical accounts of the different criteria for nativity and extocality already are at work within the science of invasion biology.
[11] See also Groves and Burdon (1986), Drake et al. (1989), and Hengeveld (1989).
[12] Westman (1990) discusses how plant species with generalised traits may be already *preadapted* for the final stage of integration when these species first colonise a new area.
[13] According to Bright (1998, 25), about ten percent of the newly introduced exotics in an area will establish breeding populations, and about ten percent of these breeding populations will become highly invasive and cause degradation. This is known as the 'tens rule'.
[14] While Mills et al. (1994) count 139 exotic species in the Great Lakes, five more species recently have been discovered in this region.
[15] See Graber (1995) for a discussion of some of the management problems caused by competing values such as these.
[16] As mentioned above, some people dispute this analogy and the policy implications that can be drawn it. See the special issue of *Environmental Values* **4** (1995) devoted to philosophical discussions of ecosystem health.
[17] While the new arrival of exotic species in an area might immediately increase species biodiversity in that area, over the long term exotic species tend to lead to decreased biodiversity because they tend to homogenise landscapes (Hettinger 2001). Bright (1998, 17) calls this 'evolution in reverse'.
[18] In addition to arguing against the killing of exotic animals by appealing to sentience or rights, animal activists sometimes also appeal to ecosystem health by arguing that in some cases exotic animals are not harmful to native species because exotics may be replacing native species that have already been extirpated from an area (Clifton 1991). Thus, according to such activists, the health of the ecosystem now depends on these exotic replacements..
[19] According to Pimentel et al. (1999), the economic benefits of exotic species in the United States – estimated to be $800 billion annually – exceed the economic damages caused by exotics species.
[20] Peretti (1998) argues that the 'nativist' trend in conservation biology to regard natives as good and exotics as bad may be rooted in xenophobic and racist attitudes in people. We lack the space here to discuss this. See also Evans (1998). See Pollan (1994) for a discussion of what he calls the unfair stereotyping of exotics.
[21] And in some cases a value singled out is attached to a single defining criterion. An example is this is 'The Nasty Necessity: Eradicating Exotics' where Stanley Temple (1990) argues for killing exotics solely because they threaten biological and ecological diversity.
[22] We thank George Nickas from Wilderness Watch for this knapweed example.

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