# Invasive Species, Beta Diversity, and Environmental Virtues

Sarah Wright
University of Georgia
sawright@uga.edu

**Abstract:** Why should humans avoid introducing invasive species? Beyond our concern for our own interests and with the more visible types of harm invasive species cause, invasive species also cause a reduction in a particular kind of biodiversity—beta diversity. Beta diversity measures the species differences between regions; as the number of species that are unique to one region increases, so does beta diversity. As species from one region invade other regions, beta diversity is reduced. This happens both because invasive species are now non-unique, and also because invasive species often out-compete and eliminate other species that were unique in the region invaded.

The link with invasive species demonstrates that beta diversity is an important element our concept of valuable biodiversity. One way ecologists elicit this intuition by talking about human introduction of invasive species as an "anthropogenic blender," making all the worlds regions more homogenous and reducing biodiversity. But what is undesirable about this homogenized natural world (this homogocene)? Extinction involves losing a living thing and there is plausibly an entity which is harmed in extinction. But losing beta diversity is only losing a pattern. What moral reasons do we then have to avoid reducing beta diversity?

This question is answered by an application of environmental virtue ethics, which focuses on the appropriate attitude we ought to develop toward the natural world, rather than on the interests or rights of natural entities. I argue that the moral virtue of humility will provides part of the answer here and that epistemic humility fills out the account of why we ought not introduce invasive species and disrupt or destroy those patterns of beta diversity that natural forces have produced.

## The Anthropogenic Blender

One way of thinking about invasive species and the reasons we have not to introduce them begins with the concept of species introduction as an "anthropogenic blender." The idea of the anthropogenic blender is that humans, by their repeated introduction of non-native species, are serving as an agent of homogenization in the natural world. The endpoint of this metaphor is to imagine that the ecosystems of the earth are completely blended; this is the coming "homogecene" that ecologists warn us that we

may be bringing about.[1] The most extreme endpoint of these processes would be to imagine a world in which there is no remaining differentiation left between ecosystems, but rather all organisms appear everywhere (to the extent that this is climactically possible). This type of completely "blended" world is also what authors are worrying about when they warn that we are moving towards a "planet of weeds."[2] After imagining a maximally homogonous world, we can ask ourselves if this blended world is more or less valuable than our current more heterogeneous world. Even if we go so far as to imagine a focused case in which all species are preserved despite homogenization, the world still seems to be impoverished it some way; it seems to be lacking an important type of biodiversity. It is diverse than our world in which there are marked differences from one ecosystem to another; this is because the homogecene lacks what is called "beta diversity." Thus truly robust biodiversity is not consistent with the homogenization of ecosystems. These thought experiments initiated by ecologists lead us to the conclusion that beta diversity matters; it is an important part of the biodiversity that we think ought to be protected. Further, because the introduction of invasive species is an important mechanism in the anthropogenic blender, we will see that our moral relation to beta diversity gives us reasons to avoid introducing invasive species.

**What is Beta Diversity?**

Having illustrated the importance of beta diversity through the means of a thought experiment, we can now turn to its formal definition. Beta diversity is best explained by contrasting it with two other measures of diversity: alpha diversity and gamma diversity.[3] Imagine that we are focusing on the trees in a given forest, and within that forest we have many single hectare plots that have been marked off. When we look in the first plot we find examples of six different species of trees, call them species A, B,

[1] See Olden et al (2004) and Olden (2006) for the original characterization of the anthropocentric blender. The terminology of a coming homogecene was introduced by E.O. Guerrant (1992).
[2] David Quannen (1998) coined to term "planet of weeds."
[3] These terms were introduced by Whittaker (1960) and (1972), and developed by MacArthur (1965). This example explaining the difference between them is adapted from an example in Meffe (2002).

C, D, E, and F. The second plot also contains six different species of tree, but some are different from those in the first plot. In addition to containing species F, the second plot also contains species G, H, I, and K. Finally there is a third plot containing species G, H, I, and K, which overlap with those in the second plot, and in addition samples of species L and M for a total of seven species.

| Species | Plot 1 | Plot 2 | Plot 3 |
|---|---|---|---|
| A | X | | |
| B | X | | |
| C | X | | |
| D | X | | |
| E | X | | |
| F | X | X | |
| G | | X | X |
| H | | X | X |
| I | | X | X |
| J | | X | X |
| K | | X | X |
| L | | | X |
| M | | | X |

Alpha diversity is an inventory type measure and it is applied to each small plot. Alpha diversity measures the number of species appearing in each plot—a species count.[4] In the example above, the alpha diversity of the first two plots is the same, since each of these two plots contains samples of six different species. The third plot however has higher alpha diversity, since seven species are represented there. Gamma diversity is also an inventory measure, but it is applied not to the smaller plots, but to

[4] Different measures of alpha diversity will be concerned not only with the number of species found but also with their relative distributions. While this more complex measure is clearly of ecological importance, I will focus on the simpler measure of species presence/absence because, as we move up to the level of gamma diversity, it more adequately captures the concerns about extinction. We are concerned with a species ceasing to exist, not with its relative distribution (except to the extent that the number of organisms may predict future extinction).

the whole forest. In the example above, the forest contains thirteen different species of tree (A–M), and this count determines the gamma diversity of the region.

Beta diversity is a different sort of measure from alpha and gamma diversity because it focuses not only on counting species within a plot but also on comparing the species counts between the different plots in the forest. Beta diversity is a between-plots measure.[5] To find the beta diversity between the first and the second plots, we need to look for the species found in the first plot but not found in the second plot (A, B, C, D, E), and the species that are in the second plot which are not represented in the first plot (G, H, I, J). We then compare this to the number of species that are found in both the first and second plots, in this case only one, species F. This results in a higher measure of beta diversity than that between the second and third plots—many more species are unique to only one of the two plots than are common to the two plots. When we move to measuring the beta diversity between the second plot and the third, we note that the second plot has only one unique species (F) and the third plot has two (L, M). Compared to the large number of species that the second and third plots have in common (G, H, I, J, K, and L), this yields a low beta diversity between the second and third plots. Thus, the beta diversity between the first and second plots is higher than the beta diversity between the second and third plots. This is true even though the third plot contains more species than either of the other two plots.

Each of these types of diversity can be measured over time. Here we can see the effects of invasive species. To understand these effect we need to have a clear understanding of what counts as an invasive species. As I will use the term, an invasive species is any non-native species that is flourishing in its new environment,

[5] Norton (2006) characterizes alpha diversity as an inventory definition of diversity since it focuses on the inventory of species in a given area. He classifies beta diversity as a different definition, since it focuses not on pure inventories in a given area but on differences between areas. Gamma diversity (defined below) also turns out to be an inventory definition.

such that it does not need to be continually propagated by humans. Following Ned Hettinger (2001), I define non-native species as any species that are not yet part of the ecological assemblage of a local region—those species that have not yet had an evolutionary impact on, nor been impacted by, the local ecosystem. This definition of invasive species does not require that these species have been introduced by humans.[6]

Imagine that an invasive species N is introduced into the forest. It takes root and thrives in all three plots. It competes directly with species A and eliminates it from the forest. Once invasive species N has entered the forest and had its effects, the beta diversity between the different plots in the forest has been reduced. The first plot is now more like the second plot than it was before. They now share another species (N) and the first plot has lost a unique species (A). Thus, even though the number of species found in the first two plots taken together remains the same, the difference between them has been reduced. The beta diversity between the second and third plots has also been reduced, even though neither of these plots has lost any species. While no species have been lost, there is now one more species (N) in common between the second and third plots and this also results in a reduction in the beta diversity between the second and the third plots. When the beta diversity between the different plots in the forest has been reduced in this way, we will also say that that forest as a whole has lost beta diversity. Thus we can characterize this example as an instance in which the introduction of an invasive species reduces the beta diversity of a forest.[7] Call this a reduction in *local beta diversity*, because the compared plots are local to each other; they are all within the same forest. Looking at change over time, a

[6] I will only consider the ethics of introducing invasive species. The complex interplay between the policies that would best prevent their introduction, the methods to best control those invasive species that are currently present, and the harm to those methods might impose is a task that goes beyond my present purposes. For a public policy approach to the benefits and costs of prevention, eradication, and biological control of invasive species see van Driesche and van Driesche (2000), Mack et al. (2000), and McNeely et. al. (2001).

[7] Even though the gamma diversity, or the number of species found in the whole forest, stays the same. Beta diversity is independent of alpha or gamma diversity.

reduction in beta diversity will also be called biotic homogenization, since this type of change results in a local environment that is more homogenous than it was previously.

Moving from a focus on the plots within a small region like a forest, we can also think about the beta diversity between plots that are far away from each other. For example, we might compare a plot in Japan with a plot in the US. As the two countries are so far apart and isolated from each other over evolutionary time, it is unlikely that there will be much overlap between the species found in the plots in Japan and the US. However, one species might be found on both species lists—kudzu. Compare this to the species that would be found in each location before the introduction of kudzu as an invasive species. Since these plots now share a species that they did not share previously, the beta diversity between these two plots would be lower now than it has been in the past. Thus we can say that the introduction of kudzu reduced the beta diversity between these two far-flung plots. There is no forest, or other local eco-region that encompasses these two plots, and so we will count this as a reduction in global (rather than local) beta diversity. [8]

When discussing biodiversity, we do not often make distinctions between alpha, beta, and gamma diversity. But philosophical arguments for the preservation of species and against human-caused extinctions are related to concerns about gamma diversity. In most applications of gamma diversity, the regions considered are local ones. When a species is eliminated from a local region—when it is extirpated—there is a reduction in local gamma diversity. It is also possible to consider the gamma diversity of the

[8] There is some inconsistency between the way that beta diversity was originally defined by Whittaker and the way this concept is now used. Whittaker defines three measures of difference between plots, depending on the size of region that contains those compared plots. Whittaker defines these to be pattern, beta, and delta diversity. The only difference between these three is scale. Yet the scale that Whittaker gave does not really limit the way that ecologists talk about beta diversity today. Beta diversity is far more often used as a general measure of difference between plots regardless of the size of the region that contains them. So in this paper I will address only beta diversity.

whole planet, to consider all the species that would be listed in a global census. I will call this the measure of global gamma diversity. We can then interpret the extinction of a species as a reduction in global gamma diversity—when a species becomes extinct, the species count for the worldwide region is decreased by one. A consideration of this relation between extinction and global gamma diversity allows us to see the arguments that are raised for the preservation of species as likewise arguments against the reduction of global gamma diversity.

**Does Beta Diversity Describe an Entity?**

There is however an important philosophical difference that we should note as we contrast beta diversity (local or global) with global gamma diversity. A loss of global gamma diversity is equivalent to the extinction of one or more species. Thus when we say that preserving global gamma diversity has moral value, there is an entity that can serve as the holder of that value—the species that is the basis for that bit of global gamma diversity. However there is no such analogue entity to be the basis for beta diversity. Since it is a measure of difference, beta diversity captures a changing pattern over time, but does not pick out any entity like a species. This means that some of the arguments for preserving species (and hence for preserving global gamma diversity) cannot be easily extended the case of preserving global (or local) beta diversity. Any argument for species preservation that depends on treating a species as an extended entity will not be applicable to beta diversity.[9] Thus it seems that a number of arguments that might have been used to motivate the preservation of beta diversity are eliminated.

Moving beyond arguments for the preservation of species, we can see that some of the dominate approaches to environmental ethics cannot easily tell us why a

[9] This will be true of a wide variety of arguments for the preservation of species including Rolston's (1985, 1988) argument that we ought to treat species as an extended entity. Gunn's (1980) argument based on the rarity of those species, Varner's (1987) and Johnson's (1992) more legalistic arguments that species have standing, and Callicott's (1986, 1987) argument for the value of species on the basis of bio-empathy.

reduction in beta diversity is to be avoided. On a rights-based approach, there is a need for a rights-holder towards whom we might have duties. Developments in environmental ethics have shown us that this rights holder might be a non-human organism, a species, or perhaps a whole ecosystem. But a pattern, like that encoded by beta diversity isn't a persisting entity, and so is not a clear candidate to be a rights-holder. On a consequentialist approach, we should look to include in our moral calculation the interests of all the morally considerable entities. Even if we extend our conception of which entities have morally considerable interest, beta diversity itself is not a candidate possessor of interests. Unlike global gamma diversity, the reduction of which is the elimination of a species, beta diversity does not pick out similar entities with the possibility to have their own interests. The reduction of beta diversity only changes the pattern of distribution; it need not destroy any entity. Patterns, as such, do not have an interest in preserving themselves. Of course, a reduction in beta diversity is often accompanied by other effects on the environment that can be counted as harms to other interest-possessing entities. Reducing beta diversity may result in extinction or extirpation, harming the species or sub-species in question. Reduction in beta diversity may harm the interest of naturalists who wish to study only the native organisms of a region. And the reduction of beta diversity through the introduction of run-away invasive species can have clear negative effects on the humans and other organisms living in an area. However, to capture the importance of beta diversity *per se*, we should not focus on these interests held by other entities. The thought experiment of the anthropogenic blender, in its most focused form, asks us to image a homogenization of biota, without the loss of any species, in order to highlight the moral considerability of beta diversity itself. If there is something objectionable about this image it cannot be reduced to harms to the interests of species, or even to the interests of many organisms of a variety of species. We are looking instead for any special reason (over and above other harms) that humans might have to avoid reducing beta diversity by avoiding the introduction of invasive species.

Noting that both rights-based and consequentialist approaches require an entity to be the rights-holder or interest possessor, we might reasonably turn to the third dominant approach within classical ethics, that of virtue ethics. There is a clear motivation to turn to virtue ethics because it brings our focus to the attitudes and character traits of the person acting, rather than on the features of the entities affected by the action. Of course this does not mean that virtue ethics cannot concern itself with how we ought to treat other entities, including humans; it simply begins its analysis by looking inward to the character traits of individuals.[10]

**The Virtue Approach to Beta Diversity**

To discover the virtues relevant to the issues at hand, we must first look at the human actions that typically result in the introduction of invasive species and the resultant loss of local and global beta diversity. Though there are many different examples that we might consider, they seem to fall into three broad categories:

- Accidental introduction as the byproduct of other activities
- Intentional introduction for a practical purpose
- Intentional introduction for an aesthetic/enjoyment purpose

Examples of each might help to illustrate these categories. Zebra mussels are an invasive species in the Great Lakes, and their introduction is thought to be the result of ships discharging ballast water picked up from the ocean; today millions of dollars are spent every year scraping these mussels off of infrastructure such as intake ports for water treatment plants.[11] The introduction of zebra mussels was not an intentional goal, only the byproduct of ocean/lake trade. The introduction of kudzu has a very different history. Kudzu was intentionally planted as a quick growing and hardy groundcover. [12] It is those very traits for which it was originally encouraged

[10] There may also be character virtues in groups, but my focus here will be on individuals.
[11] See Vitousek et al. (1996) and Van Driesche (2000).
[12] For information about how the planting of Kudzu was encouraged in the American south, see Blaustein (2001).

which make it such a noxious weed today, covering forests, farmland, and suburbs alike. Honeysuckle is another invasive species which was intentionally introduced, not as ground cover and forage, but as an ornamental planting. In this case it was valued for its aesthetic features and intentionally cultivated to foster an aesthetic goal. Of course these three categories are not in any way exclusive; kudzu, for instance, was originally introduced as an ornamental, not practical, plant. The same organism might be introduced in all three ways at different times. These categories may also not be exhaustive; I only claim that they characterize a large number of the instances of recent introduction of invasive species.

Thinking about these three categories of introduction can help us to understand which virtues might be relevant to morally evaluating human introduction of invasive species. One potentially relevant virtue that has been explored in environmental virtue ethics might be the virtue of benevolence.[13] While benevolence is clearly a relevant virtue when considering how we treat individual animals and perhaps even when we think about how to treat an entity as complex as an ecosystem, it is more difficult to see how benevolence could apply to the destruction of beta diversity. For benevolence, as applied to both humans and natural beings, takes an entity as its target; benevolent actions aim to serve the interests of that entity. But, as noted above, beta diversity isn't itself an entity, but rather picks out a pattern; it is hard to see how in individual cold take the attitude of benevolence towards a pattern, since there is no entity to be the target of benefit.

Thomas Hill Jr., when he introduced the idea of environmental virtue ethics, also motivated his introduction by considering cases where there is no entity whose rights have been violated and no entity whose interest have been harmed. One example he gives is that of a grandson who waits for his inheritance but then spits on the grave of his grandmother once she is dead. While there seems to be something monstrous

[13] As Geoffrey Frasz has developed in his (2005).

about this action, its monstrosity doesn't arise from the violation of anyone's rights nor the harming of the interests of anyone (living). A parallel (though less shocking) example which is relevant to a discussion of beta diversity because it focuses on the destruction of patterns might be someone who sneaks out on the beach after a sandcastle competition and knocks down each of the meticulously crafted sand sculptures. Even if our castle-smasher arrives only a few minutes before the high tide, which would have washed away those same castles, it still seems that there is something wrong with his action; it reveals some flaw in his character. Following Hill's further development of environmental virtue, we might claim that the missing character virtue is that of humility or a proper appreciation for one's own place in the world.[14] The castle-smasher is clearly demonstrating a kind of excessive pride in smashing the creation of another. Particularly when we are considering environmental issues, we have a tendency to overvalue ourselves and our interests. Thus virtues can explain what is wrong with a wanton destruction of beta diversity; it reveals a prideful character in the actor. This is true both when we introduce species intentionally, and so perhaps consciously consider ourselves to have a lauded position in the world, and also when we introduce species accidentally. Accidental introduction reveals a lack of concern as well; just as it does with the person heedlessly turns cartwheels nearby and so falls into the sand sculptures. Though this is not intentional destruction, the carelessness of the person reveals that he is not taking into account his true place in the world and the value he should give to the work of others.

So far we have been considering only the moral virtues directly relevant to the isolated introduction of invasive species, without considering any of the possible effect of such an introduction. When we reconsider these effects, we may also note that there is a second kind of humility equally relevant to our considerations about

[14] Hill (1983).

invasive species – epistemic humility.[15] When a species is introduced either the person introducing makes some consideration of the outcomes of this action or that person ought to make such a consideration. When we overvalue our own intelligence and knowledge we will tend to make errors in these considerations. Kudzu was intentionally planted in a widespread manner in part because those encouraging the planting thought that they knew what would happen as a result of their efforts. They thought that kudzu would serve as good ground cover, benefiting the soil by nitrogen-fixing while at the same time providing farmers with an effort-free source of fodder. They did not think about, or perhaps thought about and underestimated, the possibility that kudzu would extend beyond the areas planted and become a noxious weed. Their confidence in their own knowledge, and unwillingness to consider potential dangers, lead them to take an action which they regretted soon after. Epistemic humility would be an antidote to such action; it would encourage the gathering of more information about kudzu growth patterns in the North American ecosystem before encouraging any extensive planting. This appropriately cautious approach would be the result of both moral and epistemic humility and their interaction. Epistemic humility would recommend caution with respect to what we think we know, while moral humility would lead us not to overvalue any predicted benefits for ourselves. The overvaluation of benefit is relevant to both the practical and aesthetic benefits predicted from the introduction of invasive species.

On the other hand, when a species is introduced accidentally, we do not consider the effects of the introduction, being as it is, unknown. The benefits of the introduction can't be overvalued if the introduction itself is not predicted. However there are other relevant benefits which might be overvalued though a lack of humility. For example, one might overvalue the ease with which ocean-going ships can provide

[15] I am presenting here a picture of the virtues on which the moral and epistemic virtues are intertwined, and, and I will show here complementary. Such a picture naturally follow form an approach to virtue on which both the moral and epistemic virtues require practical wisdom. For an environmentally informed account of wisdom, see Frasz (ms.)

goods to ports in the Great Lakes and allow people there access to export their own goods. One might notice and value the benefits of shipping (and the resultant ballast water releases) while failing to consider the results that might be brought about by this method of shipping. A lack of epistemic humility might cause us to disregard evidence that an action will introduce a species, or evidence that such an introduction may have negative effects. Even if there is no present evidence to disregard, an attitude of epistemic humility should lead us to seek out relevant evidence about the effects of each of our actions. However epistemic humility should not paralyze us from taking all action, in the same way that proper moral humility should not lead us to totally disregard our own value. On an Aristotelian account, moral and epistemic virtues will be found as a mean between extremes.[16] In the case of moral humility, this means that we avoid the more common extreme of overvaluing ourselves and our interests, but that we also avoid the less common extreme of treating ourselves and our interests as worthless.[17] In this way proper humility is consistent with a kind of proper pride. Both capture the appropriate attitude to have in understanding ourselves and our role in the larger world. Since the more tempting extreme is that of having excessive pride, it is more natural to call the mean state humility, but I do not have in mind here the state of consistently undervaluing one's self.[18] Nor is epistemic humility characterized by consistently undervaluing one's epistemic abilities and state of knowledge. Rather it is a correct evaluation of both. Thus epistemic humility will often lead us to seek more information about topics and issues about which we are underinformed. But epistemic humility does not require that we always put off action to seek more information; only that we stop and seek information when we

[16] Or perhaps a neo-Aristotelian account of the epistemic virtues. I am here following Zagzebski (1999) in using Aristotle's account of the moral virtues as a template for epistemic virtues that do not follow his own picture of the intellectual virtues.

[17] As Philip Cafaro notes in his study of the environmental vices (2005) virtue has traditionally be though to be compatible with "legitimate self-concern."

[18] Thus I am not characterizing humility here in the way that Julia Driver characterizes modesty in her (1989) as a moral virtue that is in tension with intellectual virtue because it requires a systematic mis-evaluation of the self. Rather moral and epistemic humility here are seen as compatible on an account (of modesty) like that given by Ronald Sandler (2005) which only emphasizes our "fallibility in our moral judgments."

reasonably judge that more information is called for. Thus proper epistemic humility will not paralyze us from acting, but will only instil in us an appropriate amount of caution.

Finally, putting together moral and epistemic humility, we can construct an explanation for the intuition with which we began – that we have reasons to avoid creating a homogocene through processes that introduce invasive species and create an "anthropogenic blender." Even in the extreme case, where homogenization does not result in the loss of any species, we can still point to the lack of moral and epistemic humility revealed in our rash and thoughtless introduction of invasive species. Moral and epistemic humility will combine to make us appropriately cautious about (though will not absolutely prohibit) any action that will result in the destruction of local or global beta diversity.

**Works Cited**

Blaustein, Richard. 2001. Kudzu's invasion into Southern United States life and culture. In *The Great Reshuffling: Human Dimensions of Invasive alien Species*, ed. Jeffrey McNeely, 55–62. Cambridge UK: ICUN Publications.

Cafaro, Philip. 2005. Gluttony, Arrogance, Greed and Apathy: an Exploration of Environmental Vice.. In *Environmental Virtue Ethics* eds. Ronald Sandler and Philip Cafaro. Lanham, MD: Rowman & Littlefield.

Callicott, J. Baird. 1986. On the Intrinsic Value of Non-Human Species. In *The Preservation of Species*, ed. Bryan Norton, 138–72. Princeton, NJ: Princeton University Press.

------. 1987. In *Companion to A Sand County Almanac: Interpretive and Critical Essays,* ed. J. Baird Callicott, 186-214. Madison, WI: University of Wisconsin Press.

Driver, Julia. 1989. The Virtues of Ignorance. *Journal of Philosophy*, 86(4): 373-384.

Frasz, Geoffrey. 2005. Benevolence as an Environmental Virtue. In *Environmental Virtue Ethics* eds. Ronald Sandler and Philip Cafaro. Lanham, MD: Rowman & Littlefield.

------. ms. Wise Eve: A Green Account of Wisdom and It's Connection to Environmental Virtues.

Gunn, Alastair S. 1980. Why Should We Care about Rare Species? *Environmental Ethics*, 2: 17-37.

Hettinger, Ned. 2001. Exotic Species, Naturalisation, and Biological Nativism. *Environmental Values,* 10(2): 193–224.

Hill, Thomas Jr. 1983. Ideals of Human Excellence and Preserving Natural Environments. *Environmental Ethics* 5: 211-24.

Johnson, Lawrence E. 1992. Toward the Moral Considerability of Species and Ecosystems. *Environmental Ethics*, 14: 145–57.

Mack, Richard. N. et al. 2000. Biotic Invasions: Causes, Epidemiology, Global Consequences, and Control. *Ecological Applications*, 10(3): 689–710

McNeely, J.A. et al. 2001. *A Global Strategy on Invasive Alien Species*. IUCN Gland, Switzerland, and Cambridge, UK.

Meffe, Gary. 2002. *Ecosystem management: adaptive, community-based conservation*. Washington, DC: Island Press

Norton, Bryan. 1986. On the Inherent Danger of Undervaluing Species. In *The Preservation of Species*, ed. Bryan Norton, 110–37. Princeton, NJ: Princeton University Press.

------ . 1987. *Why Preserve Natural Variety?* Princeton, NJ: Princeton University Press.

------ . 2006. Toward a Policy-Relevant Definition of Biodiversity. In *The Endangered Species Act at Thirty: Conserving Biodiversity in Human-Dominated Landscapes*. Eds. M. Scott, D. Goble, and F. Davis, 49–58. Washington DC: Island press.

Olden, Julian D. 2006. Biotic Homogenization: A New Research Agenda for Conservation Biogeography. *Journal of Biogeography*, 33: 2027–39

Olden, Julian D. et al. 2004. Ecological and evolutionary consequences of biotic homogenization. *Trends in Ecology and Evolution*, 19: 18–24.

Quammen, David . 1998. Planets of Weeds: Tallying the Losses of Earth's Animals and Plants. *Harpers Magazine*, 297: 57–69.

Rolston, Holmes III. 1988. Environmental Ethics: Duties and Values in the Natural World. Philadelphia, PA: Temple University Press.

------ . 1985. Duties to Endangered Species. BioScience 35: 718-726.

Sandler, Ronald. 2005. Ignorance and Virtue. *Philosophical Papers*, 34(2): 261-272.

Van Driesche, Jason and Van Driesche, Roy. 2000. *Nature Out of Place: Biological Invasions in the Global Age*. Washington, DC: Island Press.

Varner, G. E. 1987. Do Species Have Standing? *Environmental Ethics,* 9: 57–72.

Vitousek, Peter M. et al. 1996. Biological Invasions as Global Environmental Change. *American* Scientist 84: 468–78.

Whittaker, R.H. 1972. Evolution and the Measurement of Species Diversity. *Taxon* 21: 213-251.

Zagzebski, Linda. 1996. *Virtues of the Mind*. Cambridge, UK: Cambridge University Press.