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The Behavioral Economics of Biodiversity Conservation Scientists

Mark Vellend
Université de Sherbrooke

ABSTRACT. Values have a profound influence on the behaviour of all people, scientists included. Biodiversity is studied by ecologists, like myself, most of whom align with the "mission-driven" field of conservation biology. The mission involves the protection of biodiversity, and a set of contextual values including the beliefs that biological diversity and ecological complexity are good and have intrinsic value. This raises concerns that the scientific process might be influenced by biases toward outcomes that are aligned with these values. Retrospectively, I have identified such biases in my own work, resulting from an implicit assumption that organisms that are not dependent on natural habitats (e.g., forests) effectively do not count in biodiversity surveys. Finding that anthropogenic forest disturbance reduces the diversity of plant species dependent on shady forests can thus be falsely equated with more general biodiversity loss. Disturbance might actually increase overall plant diversity (i.e., including all of the species found growing in a particular place). In this paper I ask whether ecologists share values that are unrepresentative of broader society, I discuss examples of potential value-driven biases in biodiversity science, and I present some hypotheses from behavioral economics on possible psychological underpinnings of shared values and preferences among ecologists.

Scientists are human, and humans have values. Certain values, such as simplicity, accuracy, and objectivity, underlie the practice of science as a whole, and because they are widely viewed as important to the creation and validation of knowledge in science, these values are referred to as "epistemic" (Reiss and Sprenger 2017). In contrast, "contextual values" express individual preferences with respect to moral, political, cultural, or other related questions (Reiss and Sprenger 2017). This paper explores the question of whether such contextual values might compromise certain epistemic values and therefore the practice of science, specifically on the topic of biodiversity. For simplicity, contextual values are henceforth referred to most often simply as "values."

Values have a profound influence on our behavior and the way we process information. Relevant aspects of scientists' behavior in this context include conscious or unconscious choices of what topic to study, what hypotheses to test, what system to study, which results to emphasize in communications, and how to evaluate the validity or generalizability of other studies (Kahan 2010; MacCoun 1998; Merton 1973). At the same time, one of the hallmarks of science is its vigilant emphasis on objectivity: scientists aim to minimize the influence of their values, and to maximize the influence of empirical evidence, on what they conclude to be true about the world. As such, a certain degree of tension between contextual values and objectivity is inevitable in science (Elliott 2017; Pielke 2007; Reiss and Sprenger 2017).

If the influence of values is to be minimized, then one might conclude that values are a bad thing in science. But if we broaden the discussion to consider the role of science in society, this is not necessarily the case (Elliott 2017). If a scientist's contextual values lead them to ask previously ignored questions—for example, about the human-health consequences of pollutants—there can be considerable benefits to society. If, however, the same values prompt a researcher to accept only the evidence that fits their favored hypothesis, society can be misled and scientists as a group discredited (MacCoun 1998).

One important criterion for determining whether values might have negative consequences for science involves the question of whether scientists' collective values are "representative of major social and ethical priorities" in the broader society that they serve (Elliott 2017). If scientists represent a broad diversity of values, the impact of inevitable individual biases on an entire scientific field can be minimized. If, in contrast, scientists' values represent a narrow subset of those present in broader society, there is cause for concern that conclusions—and thus purported policy implications—will be biased in favor of those that align with the narrow value set.

VALUES IN BIODIVERSITY SCIENCE

This paper is about ecologists (including myself) who study biodiversity: the variety of plants, animals, and microorganisms found in different places and times. In order to ask whether our values are representative of the diversity of values found in broader society, we first need to establish what our shared values are. On one hand, practicing science in the field of ecology does not require any particular value set, apart perhaps from the belief that there is value in understanding how the natural world works. However, it seems safe to assert that most ecologists are, at least to some extent, also conservation biologists, concerned with protecting biodiversity.[1] As a field of scientific inquiry conservation biology is notable in being "mission driven" (Meine et al. 2006), with a set of formally proposed values that define membership in the field. Soulé (1985) articulated several normative postulates of conservation biology that include the following:

- Diversity of organisms is good
- Ecological complexity is good
- Biotic diversity has intrinsic value

In a broader perspective on shared values, Newman et al. (2017) describe a list of shared preferences among "environmentally minded" people (i.e., including ecologists) that includes

- Preference for 'natural' over modified habitats
- Preference for native over introduced species
- Preference for historical vs. changed communities and ecosystems

In short, ecologists and conservation biologists tend to consider some states of nature better than others. A habitat untouched by people, largely unchanged for centuries, with a great diversity of native species and no nonnative species, is good. A suburban lawn dominated by nonnative weeds is bad. In addition, the importance of conservation biology—and to a considerable extent ecology—as a scientific field of inquiry, is often justified by our contributions to helping reverse the strong global trend from good toward bad (e.g., Primack 2014; Schmitz 2013). In other words, doom-and-gloom stories about nature justify public support for our science.

I do not know of any studies explicitly comparing the values of ecologists to broader society. Although the outcome of such a hypothetical study seems obvious enough (e.g., there would be no need for a "mission" if our values were widely shared in society), some empirical data from the social sciences are informative here. Using records of voter registration in the United States, Langbert et al. (2016) calculated the ratio of Democrats to Republicans in university departments of economics, history, communications, law, and psychology. Across 40 universities, the median ratio was ~15:1 (> 90% Democrat), with no universities (or disciplines) having a ratio of less than 1:1. In a survey of 479 US-based sociologists, Horowitz et al. (2018) found that just 4% identified as conservative or libertarian, with the remaining 96% identifying as radical (21%), liberal (62%), or moderate (13%).

1. If you are reading this as an established ecologist (i.e., more than a few years of experience), odds are you have been (co)author on at least one or a few publications that include some text on why or how to conserve some aspect of nature.

While the mapping of values onto political affiliations is far from perfect, these data leave little doubt that politically right-leaning individuals (roughly half of the US population) and their associated value set are massively underrepresented in these disciplines.

I would predict similarly skewed distributions of political affiliation among ecologists, such that the great swaths of society that do not share the value judgments about biodiversity listed above are almost certainly underrepresented to a major degree among ecologists. I believe there is therefore clear justification for asking whether ecology and conservation biology might be prone to field-wide biases with respect to study systems, results, interpretations, and publications that support standard conservation narratives such as “people are bad for biodiversity” and “biodiversity is good.”

THE CONSEQUENCES OF UNREPRESENTATIVE SHARED VALUES

When values enter our thought processes, the human mind is prone to confirmation bias: the tendency to look for and interpret evidence in ways that support preexisting beliefs. Nickerson (1998) has described confirmation bias as the “unwitting selectivity in the acquisition and use of evidence” and “a single problematic aspect of human reasoning that deserves attention above all others,” providing numerous examples of confirmation bias among scientists. Loehle (1987) explored the concept in the field of ecology specifically, but based purely on a general resistance to changing one’s mind on theoretical scientific questions—that is, without the added element of contextual values that could only serve to enhance the “tenacity” of preferred conclusions. My hypothesis here is that confirmation bias exists among biodiversity scientists in favor of the standard conservation narratives (as described above). I first explore this hypothesis via several case examples, after which I speculate on some possible psychological underpinnings of the particular values shared by ecologists.

CASE 1: ASSUMING THAT NON-FOREST = NON-HABITAT

The first place I chose to look for confirmation bias in ecology was in my own research, where I believe one can find subtle but consequential examples. Below I describe a series of papers on forest plant responses to land-use history in typical north temperate landscapes, which have experienced one or both of two main phases of forest cover change in recent centuries. Since European settlement in North America, near continuous forest cover was first converted to a largely agricultural landscape. Then, in many regions, widespread farm abandonment over the past 100–150 years led to recovery of forest in much of the landscape (Flinn and Vellend 2005). Contemporary forests are thus a mix of primary stands (perhaps partially logged, but never converted to agriculture) and post-agricultural (secondary) stands (Fig. 1).

The first part of the anthropogenic landscape transition just described is typically presented in books via a pair of maps: a "before" map showing high forest cover (Fig. 1A), and an "after" map (Fig. 1B) showing small remnant forest fragments separated by white space (MacArthur and Wilson 1967; Primack 2014). The white space suggests a biological vacuum and implies that only forest-dwelling species count. This was effectively the conceptual framework underlying the papers described below, which collectively appear to support the people-are-bad-for-biodiversity narrative.

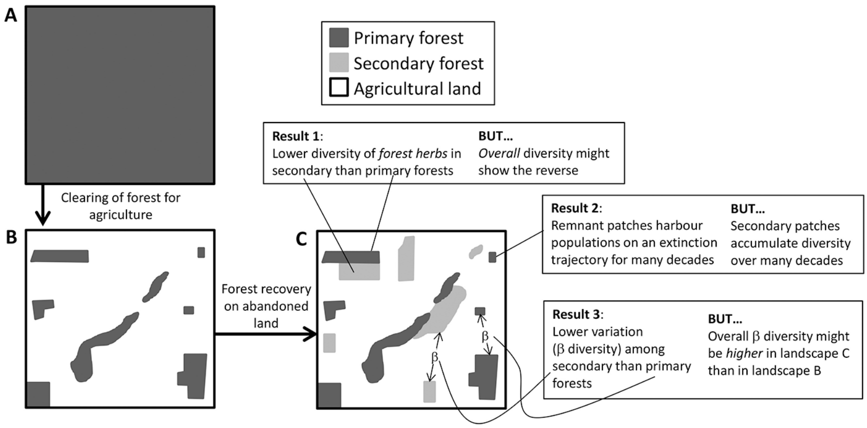

Figure 1. Schematic diagram illustrating the two main phases in the history of land use in a typical eastern North American landscape since European settlement, and research findings concerning patterns of plant diversity and composition in the contemporary landscape.

The first key decision in these studies—guided by the whitespace = non-habitat conceptual framework—was to focus exclusively on "forest herbs," which are understory plants strongly dependent on the shade of forest habitats. As such, reporting in an abstract that "secondary forests . . . had reduced diversity of both genes and species relative to primary forest" (Vellend 2004; see Result 1 in Fig. 1) is easily registered in ecologists' minds as "people are bad for biodiversity," even though no evidence was presented on *overall* plant biodiversity. The full set of species in such forests includes many that grow in young forest stands without being considered "forest herbs," such that overall species richness (i.e., the total number of species per area) can be even higher in stands just a few decades old than in centuries-old primary forests (Motzkin et al. 1996). In short, the results show that young forests support relatively few species in one carefully chosen group, but not that they support low overall plant biodiversity. In fact, the opposite may well be true.

In a different study, colleagues and I reported that forest-herb populations in small forest fragments might persist for decades or centuries despite being on deterministic declines toward local extinction (i.e., they show "extinction debt"; Vellend et al. 2006; see Result 2 in Fig. 1). Results like this have routinely been interpreted to mean something along the lines of "things are worse than they look" (e.g., Dullinger et al. 2012; Ricciardi and Ryan 2018). This is a valid interpretation, but the flipside—that many species are likely to eventually colonize successional forest fragments (Flinn and Vellend 2005)—is rarely accorded the equally valid interpretation that "things aren't as bad as they seem" (but see Jackson and Sax 2010).

Finally, Vellend et al. (2007) concluded that agricultural land use "homogenized" forest plant communities based on the result that species composition was more similar among post-agricultural forest patches than among primary forest patches (Result 3 in Fig. 1). This is typically considered a "bad" outcome for conservation, but our analysis focused on a contrast between two forest types (post-agricultural vs. primary), rather than the net effect of human activities via creation of a landscape with a mix of habitat types. Specifically, we did not compare the degree of similarity or differentiation among the full set of forest patches (primary + post-agricultural) relative to only primary patches (the assumed historical state of the landscape), so we can't actually say whether the effect of land-use history—at the scale of the whole landscape—was to create a more homogenous or a more heterogeneous set of forest patches. Because species composition varies significantly between primary and post-agricultural forests (Flinn and Vellend 2005), one may well actually expect more heterogeneity rather than less.

In sum, while these studies clearly report their methodology and results, they likely promote collective interpretations that are biased in favor of the "humans are bad for biodiversity" narrative. The bias stems from the point of departure that non-forest habitats and plants typical of open habitats effectively don't count, as well as subsequent choices about what to study, and which results to emphasize in publications. It is hard to imagine that many other programs of research have not followed similar trajectories. In addition, these papers have been cited fairly frequently (Flinn and Vellend 2005, 444 citations [the most]; Vellend 2004, 199 citations [the least]; numbers from Google Scholar, April 23, 2020), indicating that they have not gone unnoticed, and the conclusions were never seriously challenged, either during the review process or after publication. The same cannot be said of a different series of papers whose results did not fit the standard conservation narrative.

CASE 2: LOCAL BIODIVERSITY CHANGE

In Vellend et al. (2013), colleagues and I reported a meta-analysis of > 150 studies following plant diversity in small-scale plots (typically < $500m^2$) over time, in which the average change over time was very close to zero, with as many cases of increases as decreases. In order to match the scenario reflected in studies about the *consequences* of biodiversity change (i.e., plots representing an ecosystem of a given type, but with variable numbers of species), the datasets did not include places where habitats had been transformed wholesale; for example, from forest to crop field. The latter decision was explicitly described and justified in the paper, but its omission from the title or abstract could lead a casual reader to miss an important element of context dependence. Subsequently, Dornelas et al. (2014) reported similar results for many different taxa and ecosystems, and follow-up papers reported expanded datasets (Vellend, Dornelas et al. 2017) or placed the conclusions in a broader context (McGill et al. 2015; Vellend, Baeten et al. 2017). The central conclusion—running counter to the standard conservation narrative—is that in the absence of wholesale conversion of natural vegetation to croplands, local-scale plant biodiversity shows no average tendency to change over time, with increases as likely as decreases. At any sub-global scale, new species can colonize, thereby offsetting losses due to local extinction.

Reception of these studies vs. reception of the land-use history studies provides an interesting contrast. I have given many dozens of oral presentations on my research over the years. Presentations of local diversity change results are typically met with questions or comments from a few audience members about reasons one might doubt the conclusions. People frown and furrow their brows. This is in striking contrast to presentations of the land-use history results (similar venues, but with results that align with standard conservation narratives), which appear to be accepted at face value. People smile and nod. One hypothesis to explain the difference is that the local diversity change studies are flawed, while the land-use history studies are robust. An alternative hypothesis is that flaws (present in all studies) are often overlooked or not even noticed in studies whose conclusions align with the preferred narrative, while studies with conclusions that counter the preferred narrative are met with a much higher level of scrutiny. The point here is not to rehash a published debate about local diversity change specifically (see Gonzalez et al. [2016] and Cardinale et al. [2018] for arguments in support of the first hypothesis), but to suggest the existence of a potentially much broader issue of bias in ecology at several stages in the scientific process that might favor certain conclusions over others.

CASE 3: HABITAT FRAGMENTATION—BAD FOR BIODIVERSITY?

The leading cause of global biodiversity decline is habitat loss, most often manifested as the conversion of natural habitats such as forests or wetlands to intensive agriculture (Primack 2014). For a given total amount of natural habitat remaining after such conversion, the habitat might be represented by many small fragments (= high fragmentation) or by few larger fragments (= low fragmentation), and the question of whether and how habitat fragmentation *per se* (i.e., not including the effect of habitat loss) influences biodiversity or species' populations is a topic of heated debate (Fahrig et al. 2019; Fletcher et al. 2018). Reviewing a large number of studies, Fahrig (2017a) found that the effects were actually more often positive than negative, counter to the dominant conservation narrative that habitat fragmentation is a major threat to biodiversity (Fletcher et al. 2018).

More interestingly (for the present paper), Fahrig (2017b) analyzed how researchers reported results showing negative vs. positive effects of fragmentation. If a study's results showed only negative effects of habitat fragmentation, the results were described faithfully as such in the abstract of the vast majority of papers (~80%). Similarly, when both positive and negative effects were found (e.g., positive for one species, negative for another), the large majority of abstracts (about 2/3) described the results as such. However, when only positive effects were found—inconsistent with the dominant conservation narrative—only 40% of abstracts described the results in this way; most of the rest either made no mention of the direction of effects or described them as neutral/mixed. It is difficult to interpret these results in any way that doesn't involve invocation of some form of confirmation bias.

CASE 4: INSERTING VALUES INTO THE DEFINITION OF BIODIVERSITY

In some cases values enter into analyses in particularly explicit ways. As one example, Barlow et al. (2016) reported in their title that "Anthropogenic disturbance in tropical forests can double biodiversity loss from deforestation." The key conclusion was that, at the scale of a catchment, disturbances within remnant forests (e.g., partial logging) can have as big an impact as loss of forest habitat itself. But on what exactly was there an impact? The response measured was not actually biodiversity, but rather "conservation value," with the analysis "restricted . . . to 'forest species' to avoid attributing value to invasive and open-area species." The authors should be commended for clearly communicating the concept of "conservation value." However, the uptake by the scientific community—as reflected in the nature of citations (see Box 1)—indicates clearly that the dominant message transmitted and received was that people cause biodiversity to decline (a topic not actually addressed in the paper) rather than any message about "conservation value" (the actual topic of study). Slipping values into the operational definition of biodiversity thus served to ensure that the reigning paradigm was confirmed.

DO WE PRACTICE AS WE PREACH?

To the extent that the mission of conservation biology is working against an opponent, that opponent would have to be the capitalist economic system that encourages selfish pursuit of profit and wealth at the expense of the environment. A frequent target of criticism is thus the scientific research conducted on behalf of companies selling environmentally damaging products such as agro-chemicals or fossil fuels. In a broader context involving human health, research done by tobacco or pharmaceutical companies has also been subject to similar criticism. The core claim is that economic incentives bias research so strongly in favor of

In a study of tropical forests, Barlow et al. (2016) quantified the "conservation value" of different catchments using a subset of their community-level data that excluded "invasive and open-area species." In order to assess the degree to which this value-driven definition of "biodiversity" was reflected in the collective interpretation of the study by the scientific community, I analyzed statements in the 42 papers published in 2018 up to August 23, 2018 (SCOPUS search) that used Barlow et al. (2016) as supporting evidence. These papers contain a total of 60 citations (often >1 per paper), 32 of which (across 28 papers) were in support of statements about biodiversity or conservation value. Other statements related mostly to disturbance and/or ecosystem function. Of these 32 citations, only 4 made reference to conservation value, either by using the term itself (2 citations), a closely related term ("conservation capacity"), or via an indirect nod to the fact that a subset of valued species was studied ("range-restricted species"). The other 28 citations related to biodiversity, only one of which was clearly qualified as "forest biodiversity" (4 others were ambiguous in this respect). Fully 82% of these (23/28) supported statements about biodiversity that were clearly unqualified, including 4 that paraphrased the paper's title:

- ". . . illegal logging and hunting . . . can potentially double the biodiversity loss expected from deforestation alone" (Montejo-Kovacevich et al. 2018)
- ". . . apart from deforestation, destruction of key resources in a habitat . . . can actually double the loss of biodiversity from deforestation" (Cuadros-Casanova et al. 2018)
- ". . . increased anthropogenic pressures, such as hunting and fire exposure, which can double the biodiversity loss from deforestation" (Marsh et al. 2018)
- "Forest degradation poses a major threat to natural forests and . . . can result in just as much biodiversity loss as deforestation" (França et al. 2018)

Reading these citations, one could only conclude that Barlow et al.'s data must demonstrate that a disturbed landscape harbors a lower diversity of plants and animals than an undisturbed landscape. But the analyses demonstrate no such thing. Environmental changes of all kinds—anthropogenic or otherwise—are unfavorable for some species and favorable for others. Systematically excluding the latter strongly biases results in favor of showing what appear to be biodiversity declines, and this is the dominant message taken up by the scientific community from this paper. Of course analyses of the full set of species might show the same result. But they might not.

Importantly, my aim here is not to condemn either Barlow and colleagues or the authors of the citations any more than it is to condemn myself as part of the broader scientific community, for whom nuances and qualifications seem to get lost in the process of uptake of new results. For example, the land-use studies I was involved in also focus on a subset of the biodiversity in forests, and we no doubt could find unqualified citations of these papers referring to negative effects on biodiversity. Likewise, citations of Vellend et al. (2013) about temporal biodiversity change rarely communicate the qualification that we did not include cases of wholesale conversion of natural vegetation to agriculture. In none of these original papers is anything hidden. However, the concern is that as we process the overwhelming deluge of new scientific results into our human brains, there is considerable potential for even a small difference in the strength of our critical filter favoring some results (humans are bad for biodiversity) over others (human effects on biodiversity are highly context dependent) to lead to a substantial bias in what we consider our collective knowledge.

Box 1. Biodiversity and Conservation Value.

certain findings (e.g., products are safe for the environment or human health) that the results cannot be trusted (de Melo-Martín and Intemann 2018). In my opinion, the evidence behind this claim is extremely convincing, such that I do not trust research conducted inside an agro-chemical company to provide an unbiased assessment of product safety (Oreskes and Conway 2011).

Are ecologists not subject to any such biases because we have no profit motive? I'm not so sure. One of the strongest motivators of human behavior is the cultivation and maintenance of commitments and mutually beneficial relationships within our social and professional circles (Haidt 2013; Kahan 2010). If reporting a result that supports the standard conservation narrative reinforces such commitments and relationships, it is reasonable to imagine that we might harbor biases in favor of such results. Likewise, if we have a result that does the opposite, we might feel inclined to subtly or not-so subtly de-emphasize the importance or visibility of such a result. It might be true that our underlying motivation is noble (save the planet)—in contrast to the selfish profit-seeking motive of private corporations—but the end result of biased scientific conclusions might be not so dissimilar. In this light, I think there might be some benefit to some self-reflection on the question of whether we practice as we preach.

CONCLUSIONS FROM CASE EXAMPLES

I have tried to build an argument that ecologists and conservation biologists would do well by themselves to think carefully about whether confirmation bias influences our scientific process in the very same ways that we don't hesitate to criticize others for. I have seen in my own research how adoption of a particular conceptual framework (non-forest = non-habitat), and decisions about what to study and how to report results, can create bias in favor of supporting existing biodiversity conservation narratives. More broadly, entire topics of research have been given names that presuppose or imply change in a "bad" direction ("biodiversity loss," "biotic homogenization," "biological invasion"). Importantly, I am keenly aware of the risk of developing biases that favor conclusions in the opposite direction—bias can cut all ways. But when it comes to issues such as the protection vs. exploitation of nature, ecologists' values follow a distribution that is almost certainly heavily skewed compared to broader society. As such, it seems worth being concerned that subtle biases at many stages of the research process, in many researchers, compounded over many researcher "generations," might lead to a systematic bias with respect to where our collective consensus lies relative to reality (MacCoun 1998). Such concerns might be especially important to consider in efforts such as those of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES; www.ipbes.net), whose explicit aim is to inform policy with unbiased science. Simply acknowledging and recognizing such biases can be a first step toward thinking about ways to collectively counter or neutralize them.

THE UNDERPINNINGS OF SHARED VALUES

If shared values, unrepresentative of the diversity in broader society, have the potential to insert bias into science, it begs the question of where the shared values come from to begin with. Why do ecologists prefer ecosystems with native instead of nonnative species? Or ecosystems that look most like they did a few hundred years ago? Part of the answer might involve a conception of nature as separate from people, such that protecting nature equates with a preference for places that seem to be least impacted by people's actions (e.g., via exploitation or species introductions; Vining et al. 2008). With fewer and fewer places on earth free of human impacts, the same way that unique historical works of art are targets of preservation, so too are unique historical ecosystems.

No doubt many factors underpin the values of conservation biologists (Primack 2014). Given the emphasis of this article on the workings of the human mind, I would like to explore some potential psychological explanations for human preferences, often discussed under the banner of "behavioral economics." The topic of how people perceive and value different states of nature has been subject to considerable scholarship (e.g., Coates 2007), and I am by no means suggesting that behavioral economics holds the most important key to understanding this topic. Rather, I am making the more modest suggestion that considering psychological factors might contribute to understanding some component of the causes of particular values held by ecologists, in addition to the consequences of those shared values (the subject of the paper so far).

The ideas described below developed after psychologists started calling into question the assumption of economic models that humans act rationally to maximize their self-interest (Kahneman 2011; Lewis 2016). Researchers have identified a great many ways in which people act "predictably irrational" (Ariely 2010), with manifestations in many facets of everyday life. I think there is good reason to suspect that some of these ideas apply to the scientific process as well. Here I present a handful of possible examples, which can be read as hypotheses rather than conclusions.

THE "BAD IS STRONGER THAN GOOD" PRINCIPLE

In the human mind, it is often the case that "bad is stronger than good" (Baumeister et al. 2001). This concept appears to apply in many contexts: for example, losing $1,000 will typically make you more upset than winning $1,000 will make you happy, and the pain felt when a company eliminates jobs or benefits is typically stronger than the gratification felt from equivalent gains (Kahneman 2011). The "bad is stronger than good" principle is closely tied to the concept of "loss aversion," with a rough rule of thumb being that losses "loom twice as large" as gains (Kahneman 2011), although the universality of this rule has been questioned (Gal and Rucker 2018).

In an ecological setting, we can consider a thought experiment of judging the losses and gains associated with the changes wrought by people in a landscape like the one described earlier, where near continuous forest cover has been replaced with an intermingling of towns, roads, crop fields, pastures, abandoned lands, and forest patches with different degrees of ongoing and historical exploitation. Focusing on plants, ecological studies have revealed the following changes (Vellend, Baeten et al. 2017):

- Loss of forest cover (natural habitat)
- Gain of human-modified habitat
- Loss of some native species
- Gain of many nonnative species

According to the preferences described by Newman et al. (2017), this is all bad news, and conservation textbooks communicate the news as such (e.g., Primack 2014). What's especially interesting about this scenario is that the overall changes in habitat and species diversity are actually positive in a mathematical sense (Sax and Gaines 2003; Vellend, Baeten et al. 2017):

- A gain in the variety of habitats
- A gain in the total number of species

In our overarching judgment of this scenario, both the bad-is-stronger-than-good concept and confirmation bias are likely at play. First, bad is stronger than good: even though biodiversity has increased, the losses loom so much larger in our minds than the gains that the net result is still judged as "bad." Second, with a pre-existing commitment to bad-news stories about nature—the raison d'être of conservation biology—confirmation bias seems likely to further increase the weight assigned to evidence of losses (confirming what we thought) compared to evidence of gains (not part of the standard narrative). In short, what is communicated as a general rule—human landscape modification is bad for biodiversity—is more likely a conclusion strongly contingent on scale, habitat, and focal species. In this scenario (a very common one on the planet) it might be true within individual local crop fields for forest specialists, but false at the landscape scale for all species collectively. Furthermore, if we broaden our assessment criteria to include ecosystem services (benefits to people), a major thrust of contemporary conservation efforts, the "new" landscape is likely more suited to supporting the well-being of thousands of people than the "old" landscape.

At the global scale, and within many individual regions or localities, biodiversity losses do indeed exceed gains, and so a greater focus on the losses in these cases would be justified. However, this is unrelated to the "bad is stronger than good" principle, which is about the relative weights we assign to gains and losses *of equal magnitude*: the bad of losing \$100,000 is obviously stronger than the good of gaining \$10. One could imagine a more relevant counterargument arising when a loss is justifiably considered worse than a gain of a given apparent magnitude, such as the extinction of a globally unique species (e.g., the Tasmanian tiger) vs. the creation of a new species that is very similar to other extant species (e.g., a plant species of recent hybrid origin; see Thomas [2017] for examples). However, I used the word "apparent" to describe the equality of magnitudes deliberately: in this case one would be simply using a different quantification of change (evolutionary distinctness), which is indeed greater for the Tasmanian tiger than it is for species of recent hybrid origin. In short, I am suggesting that even without recalculating things so that losses quantitatively exceed gains, ecologists are subject to the "bad is stronger than good principle" when judging changes in nature. One can further imagine that ecologists are more likely to explore methods of recalculating losses and gains such that the absolute magnitude of losses appears greater, a tendency one might ascribe to "the endowment effect" or "the halo effect" for native species and biodiversity.

THE ENDOWMENT EFFECT

The endowment effect is the tendency for possession of a thing to increase our perceived value of that thing (Kahneman 2011). One moment you're unsure if that concert ticket is really worth $100, but immediately after you've purchased it you wouldn't sell it for $200; it's worth far more than that! This tendency shares a connection with the "bad is stronger than good" principle, in that loss of the item is perceived to incur a greater cost than the price of acquisition, and it can potentially help explain not only our preference for native over nonnative species, but also how the "preferred" status of a species can change over time.

The story of the ubiquitous house sparrow, recounted in detail in Chris Thomas's book, *The Inheritors of the Earth: How Nature Is Thriving in an Age of Extinction* (Thomas 2017), provides a vivid potential example of the endowment effect. *Passer domesticus* was making its living in the wild steppes of Asia and the Middle East when, following the dawn of agriculture some 10,000 years ago, it learned to exploit the food resources (large seeds) and nesting opportunities (cracked wall and roofs) in and around human settlements. As people and agriculture spread throughout Europe and eastern Asia, so did house sparrows. Unable to cross oceans on their own accord, house sparrows had to wait until the nineteenth century to get to North America, where they were then introduced by people deliberately. In a geographical sense, house sparrows are not native to either the United Kingdom or North America, but conservationists view their status quite differently in the two places.

In North America, house sparrows are widely considered "invasive," such that their recent decline in abundance is considered good news. Some 450 years ago, house sparrows in the UK similarly had a legal status as vermin. However, they have since become beloved, such that a steep recent decline is bad news and they are now on the UK "red list" of species of highest conservation priority. So what happened over the last 450 years? One can only speculate, but it seems that if a species has been around long enough in a given place to have been seen through binoculars by both you and your grandparents' grandparents, it is considered to "belong." From the point of view of a Briton, once it is one of "our" species, it is endowed with great value. More recent arrivals are seen as a threat to our native species, and we ascribe value to the latter by virtue of being ours. At some time point in between the general consensuses that a species is foe or friend, there is scope for considerable disagreement among people on the conservation value of a given species (Coates 2007). None of it makes much sense from a scientific ecological viewpoint, but perhaps our psychological tendencies—in the form of the endowment effect—can help us make sense of the situation.

THE HALO EFFECT

When someone places great value in something based on certain attributes, there is a tendency to subsequently exaggerate the positive aspects, or dismiss the negative aspects, of unrelated attributes. This is the halo effect (Kahneman 2011). Most familiarly, we regularly inflate the virtues and excuse the shortcomings of whichever political leader or party we support, even when the attributes in question are unrelated to the initial reasons for our support. It is difficult not to see the halo effect in conservation. If you are in favor of protecting wolves, losses of livestock to predation will seem small and effects on the ecosystem large and desired. If you are in favor of exterminating wolves, losses of livestock will loom large and benefits to the ecosystem might seem uncertain and value-neutral.

The halo effect may also apply to biodiversity writ large. For example, some studies have revealed cases in which it appears that greater biodiversity (e.g., of nonhuman mammals) reduces the risk of disease transmission to humans (e.g., of Lyme disease; Ostfeld and Keesing 2000). If this were a general phenomenon, ecologists would have a strong addition to their arsenal of arguments in favor of conservation, and indeed there have been claims that biodiversity generally reduces disease risk to people (Schmidt and Ostfeld 2001). However, other researchers see a great deal of context dependence, with the opposite effect (biodiversity increasing disease risk) a distinct possibility (Wood et al. 2014). I am not an expert on this particular topic, but the halo effect seems like an entirely plausible hypothesis to explain the enthusiasm of ecologists for generalizing evidence showing positive benefits to humans of greater biodiversity.

THE ANCHORING EFFECT

This final concept from behavioral economics is relevant not so much as an explanation for our values, but as a concept likely applied by advocates for biodiversity conservation in public communications. The anchoring effect (Kahneman 2011) is most familiar in advertising, whereby the presence of an overpriced model of something (e.g., a $1,000 pair of ice skates) serves largely to anchor consumers' minds to a high price, such that what would otherwise seem like a ridiculous amount to pay (e.g., $400) is made to seem like a reasonable price. A few suckers actually buy $1,000 skates, but mostly they serve to encourage people to pay far more than the $100 they would probably pay otherwise.

Given that ecologists values are not shared by a large slice of the general public, one component of the mission of conservation biology is to "sell" the message of ecological deterioration and the importance of conservation to the general public. A study by Young and Larson (2011) suggests that many ecologists are well aware of their tendency to overstate doom-and-gloom scenarios. Invasion biologists were asked to agree or disagree (or neither) with many different statements, one of which was "The ambiguities surrounding invasive species have been neglected or glossed over in the haste to sound the alarm of a crisis." (The ambiguities concern the reality that while some nonnative species have large ecological impacts, most have very little impact, or even positive impacts of one kind or another.) Fully 41% of respondents agreed with this statement, while 30% disagreed. Ecologists are regularly called upon to make public statements about the state of various aspects of nature, most often painting a bleak picture. One must wonder to what degree we hope that an exaggerated picture will act as an anchor, helping generate public acceptance that at least there is a problem in need of tackling (see also Takacs 1996).

CAUTION AND CAVEATS

I have made an argument that an unrepresentative set of strongly held and shared values among a group of scientists has the potential to bias the conclusions made by that same set of scientists. For a tobacco company's scientists the core value might be financial profit, while for an ecologist it might be the desire for nature to be free of human impacts. However, it is critically important not to equate the potential for bias with the notion that conclusions are untethered to objective reality in an extreme postmodernist or relativist way. Science is done by people, and so it has always been and always will be subject to biases of various sorts, but this has not prevented science from revealing unambiguous facts about the workings of the universe, or from permitting awe-inspiring advances in technology or medical care (as two examples). Many areas of science—the life sciences and social sciences in particular—involve a great deal of context dependence with respect to outcomes predicted from a given causal change (e.g., climate warming), and so there is frequently room for legitimate debate (Sarewitz 2004). But over the long haul, science is exceptionally good at self-correction, such that one can only stray so far from the data before being reeled back in. In short, I am not hypothesizing that ecologists' values allow them to ignore data, but that subtle biases may have systematically favored some conclusions disproportionately to their probability of being true.

In questioning whether scientists have allowed their values to bias their conclusions, I must of course recognize that I too am one of those scientists. Having become convinced that there is some validity to the arguments presented here, I am perhaps now prone to confirmation bias on this topic itself, disproportionately favoring interpretations of the facts that support my claim of a particular manifestation of confirmation bias among ecologists. That said, dismissing my argument by simply putting a stamp of "confirmation bias" on it will not greatly advance this discussion, so I welcome any and all evidence or anecdote that counters or supports the arguments I have presented here. In my own research I have found what I think is compelling evidence of subtle biases favoring the standard conservation narratives, and I have been accused of bias in favor of interpretations that counter the standard conservation narratives. The point here is simply to recognize that I do not consider myself immune to the psychological tendencies and attendant problems for science that I've outlined here. I leave it to readers to evaluate the validity of my arguments on their own merits.

A LOOK FORWARD

The perspective presented here shares some commonalities with the chorus of voices arguing in recent years that aspects of the standard conservation narrative are logically inconsistent, or even counterproductive to the goal of promoting thriving ecosystems in a world of rapid environmental change (Fahrig et al. 2019; Kareiva et al. 2017; Marris 2011; Pearce 2016; Schlaepfer et al. 2011; Thomas 2017). Human activities have altered the Earth's ecosystems in profound ways, to the detriment of many species and ecosystems. At the same time, a great many species have thrived and expanded their distributions across the globe, with new and unique combinations of species often forming productive 'novel' ecosystems.

The sense that ecologists tend to characterize almost all changes as 'bad' has provided the motivation to present a more nuanced view of both losses and gains of biodiversity, with local consequences that may often be bad, but sometimes good, or neither, depending on the values at play and the criteria for judgment (Thomas 2017). I think this shift in perspective brings us closer to characterizing the true state of affairs in the world, while others may argue that its proponents have overblown a small minority of counterexamples and themselves fallen prey to confirmation bias in the 'other' direction. Either way, following the lead of social scientists (Horowitz et al. 2018; Langbert et al. 2016; Nuzzo 2015), I think ecologists can only gain by paying more attention to whether and how their values might be inserting possibly subtle but ultimately consequential biases into their science.

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REFERENCES

Ariely, D. 2010. *Predictably Irrational, Revised: The Hidden Forces That Shape Our Decisions*. New York: HarperCollins.

Barlow, J., G. D. Lennox, J. Ferreira, E. Berenguer, A. C. Lees, R. Mac Nally, J. R. Thomson, S. F. de Barros Ferraz, J. Louzada, and V. H. F. Oliveira. 2016. "Anthropogenic Disturbance in Tropical Forests Can Double Biodiversity Loss from Deforestation." *Nature* 535:144.

Baumeister, R. F., E. Bratslavsky, C. Finkenauer, and K. D. Vohs. 2001. "Bad Is Stronger Than Good." *Review of General Psychology* 5:323.

Cardinale, B. J., A. Gonzalez, G. R. Allington, and M. Loreau. 2018. "Is Local Biodiversity Declining or Not? A Summary of the Debate over Analysis of Species Richness Time Trends." *Biological Conservation* 219:175–83.

Coates, P. 2007. *American Perceptions of Immigrant and Invasive Species: Strangers on the Land*. Berkeley: University of California Press.

Cuadros-Casanova, I., C. Zamora, W. Ulrich, S. Seibold, and J. C. Habel. 2018. "Empty Forests: Safeguarding a Sinking Flagship in a Biodiversity Hotspot." *Biodiversity and Conservation*:1–12.

de Melo-Martín, I., and K. Intemann. 2018. *The Fight against Doubt: How to Bridge the Gap between Scientists and the Public*. Oxford: Oxford University Press.

Dornelas, M., N. J. Gotelli, B. McGill, H. Shimadzu, F. Moyes, C. Sievers, and A. E. Magurran. 2014. "Assemblage Time Series Reveal Biodiversity Change but Not Systematic Loss." *Science* 344:296–99.

Dullinger, S., A. Gattringer, W. Thuiller, D. Moser, N. E. Zimmermann, A. Guisan, W. Willner, C. Plutzar, M. Leitner, and T. Mang. 2012. "Extinction Debt of High-Mountain Plants under Twenty-First-Century Climate Change." *Nature Climate Change* 2:619.

Elliott, K. C. 2017. *A Tapestry of Values: An Introduction to Values in Science*. Oxford: Oxford University Press.

Fahrig, L. 2017a. "Ecological responses to habitat fragmentation per se." Annual Review of Ecology Evolution and Systematics 48:1–23.

Fahrig, L. 2017b. "Forty Years of Bias in Habitat Fragmentation Research." In *Effective Conservation Science: Data Not Dogma*, edited by P. Kareiva, B. Silliman, and M. Marvier, pp. 32–38. Oxford: Oxford University Press.

Fahrig, L., V. Arroyo-Rodríguez, J. R. Bennett, V. Boucher-Lalonde, E. Cazetta, D. J. Currie, F. Eigenbrod, A. T. Ford, S. P. Harrison, J. A. Jaeger, N. Koper, A. Martin, J.-L. Martin, J. P. Metzger, P. Morrison, J. R. Rhodes, D. Saunders, D. Simberloff, A. Smith, L. Tischendorf, M. Vellend, and J. Watling. 2019. "Is Habitat Fragmentation Bad for Biodiversity?" *Biological Conservation*. 230:179–186.

Fletcher, R. J., Jr., R. K. Didham, C. Banks-Leite, J. Barlow, R. M. Ewers, J. Rosindell, R. D. Holt, A. Gonzalez, R. Pardini, and E. I. Damschen. 2018. "Is Habitat Fragmentation Good for Biodiversity?" *Biological Conservation* 226:9–15.

Flinn, K. M., and M. Vellend. 2005. "Recovery of Forest Plant Communities in Post-agricultural Landscapes." *Frontiers in Ecology and the Environment* 3:243–50.

França, F., J. Louzada, and J. Barlow. 2018. "Selective Logging Effects on 'Brown World' Faecal-Detritus Pathway in Tropical Forests: A Case Study from Amazonia Using Dung Beetles." *Forest Ecology and Management* 410:136–43.

Gal, D., and D. D. Rucker. 2018. "The Loss of Loss Aversion: Will It Loom Larger Than Its Gain?" *Journal of Consumer Psychology*. 28: 497–516.

Gonzalez, A., B. J. Cardinale, G. R. Allington, J. Byrnes, K. Arthur Endsley, D. G. Brown, D. U. Hooper, F. Isbell, M. I. O'Connor, and M. Loreau. 2016. "Estimating Local Biodiversity Change: A Critique of Papers Claiming No Net Loss of Local Diversity." *Ecology* 97:1949–60.

Haidt, J. 2013. *The Righteous Mind: Why Good People Are Divided by Politics and Religion*. New York: Vintage Books.

Horowitz, M., A. Haynor, and K. Kickham. 2018. "Sociology's Sacred Victims and the Politics of Knowledge: Moral Foundations Theory and Disciplinary Controversies." *American Sociologist*:1–37.

Jackson, S. T., and D. F. Sax. 2010. "Balancing Biodiversity in a Changing Environment: Extinction Debt, Immigration Credit and Species Turnover." *Trends in Ecology and Evolution* 25:153–60.

Kahan, D. 2010. "Fixing the Communications Failure." *Nature* 463:296.

Kahneman, D. 2011. *Thinking, Fast and Slow*. Canada: Doubleday.

Kareiva, P., M. Marvier, and B. Silliman. 2017. *Effective Conservation Science: Data Not Dogma*. Oxford: Oxford University Press.
Langbert, M., A. J. Quain, and D. B. Klein. 2016. "Faculty Voter Registration in Economics, History, Journalism, Law, and Psychology." *Econ Journal Watch* 13:422–51.
Lewis, M. 2016. *The Undoing Project: A Friendship That Changed Our Minds*. New York: W. W. Norton.
Loehle, C. 1987. "Hypothesis Testing in Ecology: Psychological Aspects and the Importance of Theory Maturation." *Quarterly Review of Biology* 62:397–409.
MacArthur, R. H., and E. O. Wilson. 1967. "The Theory of Island Biogeography." Princeton, NJ: Princeton University Press.
MacCoun, R. J. 1998. "Biases in the Interpretation and Use of Research Results." *Annual Review of Psychology* 49:259–87.
Marris, E. 2011. *Rambunctious Garden: Saving Nature in a Post-Wild World*. London: Bloomsbury.
Marsh, C. J., R. M. Feitosa, J. Louzada, and R. M. Ewers. 2018. "Is β-diversity of Amazonian Ant and Dung Beetles Communities Elevated at Rainforest Edges?" *Journal of Biogeography* 45:1966–79.
McGill, B. J., M. Dornelas, N. J. Gotelli, and A. E. Magurran. 2015. "Fifteen Forms of Biodiversity Trend in the Anthropocene." *Trends in Ecology and Evolution* 30:104–13.
Meine, C., M. Soulé, and R. F. Noss. 2006. "'A Mission-Driven Discipline': The Growth of Conservation Biology." *Conservation Biology* 20:631–51.
Merton, R. K. 1973. *The Sociology of Science: Theoretical and Empirical Investigations*. Chicago: University of Chicago Press.
Montejo-Kovacevich, G., M. G. Hethcoat, F. K. Lim, C. J. Marsh, D. Bonfantti, C. A. Peres, and D. P. Edwards. 2018. "Impacts of Selective Logging Management on Butterflies in the Amazon." *Biological Conservation* 225:1–9.
Motzkin, G., D. Foster, A. Allen, J. Harrod, and R. Boone. 1996. "Controlling Site to Evaluate History: Vegetation Patterns of a New England Sand Plain." *Ecological Monographs* 66:345–65.
Newman, J. A., G. Varner, and S. Linquist. 2017. *Defending Biodiversity: Environmental Science and Ethics*. Cambridge: Cambridge University Press.
Nickerson, R. S. 1998. "Confirmation Bias: A Ubiquitous Phenomenon in Many Guises." *Review of General Psychology* 2:175–220.
Nuzzo, R. 2015. "Fooling Ourselves." *Nature* 526:182.
Oreskes, N., and E. M. Conway. 2011. *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming*. London: Bloomsbury.
Ostfeld, R. S., and F. Keesing. 2000. "Biodiversity and Disease Risk: The Case of Lyme Disease." *Conservation Biology* 14:722–28.
Pearce, F. 2016. *The New Wild: Why Invasive Species Will Be Nature's Salvation*. Boston, MA: Beacon Press.
Pielke, R. A. 2007. *The Honest Broker: Making Sense of Science in Policy and Politics*. Cambridge: Cambridge University Press.
Primack, R. B. 2014. *Essentials of Conservation Biology*. Sunderland, MA: Sinauer.
Reiss, J., and J. Sprenger. 2017. "Scientific Objectivity." In *The Stanford Encyclopedia of Philosophy*, edited by E. N. Zalta. https://plato.stanford.edu/archives/win2017/entries/scientific-objectivity/.
Ricciardi, A., and R. Ryan. 2018. "Invasive Species Denialism Revisited: Response to Sagoff." *Biological Invasions* 20:2731–38.
Sarewitz, D. 2004. "How Science Makes Environmental Controversies Worse." *Environmental Science and Policy* 7:385–403.
Sax, D. F., and S. D. Gaines. 2003. "Species Diversity: From Global Decreases to Local Increases." *Trends in Ecology and Evolution* 18:561–66.
Schlaepfer, M. A., D. F. Sax, and J. D. Olden. 2011. "The Potential Conservation Value of Non-native Species." *Conservation Biology* 25:428–37.
Schmidt, K. A., and R. S. Ostfeld. 2001. "Biodiversity and the Dilution Effect in Disease Ecology." *Ecology* 82:609–19.
Schmitz, O. J. 2013. *Ecology and Ecosystem Conservation*. Washington, DC: Island Press.
Soulé, M. E. 1985. "What Is Conservation Biology?" *BioScience* 35:727–34.
Takacs, D. 1996. *The Idea of Biodiversity: Philosophies of Paradise*. Baltimore, MD: Johns Hopkins University Press.
Thomas, C. D. 2017. *Inheritors of the Earth: How Nature Is Thriving in an Age of Extinction*. PublicAffairs, Milton Keynes, UK.

Vellend, M. 2004. "Parallel Effects of Land-Use History on Species Diversity and Genetic Diversity of Forest Herbs." *Ecology* 85:3043–55.

Vellend, M., L. Baeten, A. Becker-Scarpitta, V. Boucher-Lalonde, J. L. McCune, J. Messier, I. H. Myers-Smith, and D. F. Sax. 2017. "Plant Biodiversity Change across Scales during the Anthropocene." *Annual Review of Plant Biology* 68:563–86.

Vellend, M., L. Baeten, I. H. Myers-Smith, S. C. Elmendorf, R. Beauséjour, C. D. Brown, P. De Frenne, K. Verheyen, and S. Wipf. 2013. "Global Meta-analysis Reveals No Net Change in Local-Scale Plant Biodiversity over Time." *Proceedings of the National Academy of Sciences* 110:19456–59.

Vellend, M., M. Dornelas, L. Baeten, R. Beauséjour, C. D. Brown, P. De Frenne, S. C. Elmendorf, N. J. Gotelli, F. Moyes, and I. H. Myers-Smith. 2017. "Estimates of Local Biodiversity Change over Time Stand up to Scrutiny." *Ecology* 98:583–90.

Vellend, M., K. Verheyen, K. M. Flinn, H. Jacquemyn, A. Kolb, H. Van Calster, G. Peterken, B. J. Graae, J. Bellemare, O. Honnay, J. Brunet, M. Wulf, F. Gerhardt, and M. Hermy. 2007. "Homogenization of Forest Plant Communities and Weakening of Species–Environment Relationships via Agricultural Land Use." *Journal of Ecology* 95:565–73.

Vellend, M., K. Verheyen, H. Jacquemyn, A. Kolb, H. Van Calster, G. Peterken, and M. Hermy. 2006. "Extinction Debt of Forest Plants Persists for More Than a Century Following Habitat Fragmentation." *Ecology* 87:542–48.

Vining, J., M. S. Merrick, and E. A. Price. 2008. "The Distinction between Humans and Nature: Human Perceptions of Connectedness to Nature and Elements of the Natural and Unnatural." *Human Ecology Review*:1–11.

Wood, C. L., K. D. Lafferty, G. DeLeo, H. S. Young, P. J. Hudson, and A. M. Kuris. 2014. "Does Biodiversity Protect Humans against Infectious Disease?" *Ecology* 95:817–32.

Young, A. M., and B. M. Larson. 2011. "Clarifying Debates in Invasion Biology: A Survey of Invasion Biologists." *Environmental Research* 111:893–98.