Save the planet: eliminate biodiversity

Carlos Santana

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Abstract   Recent work in the philosophy of biology has attempted to clarify and defend the use of the biodiversity concept in conservation science. I argue against these views, and give reasons to think that the biodiversity concept is a poor fit for the role we want it to play in conservation biology on both empirical and conceptual grounds. Against pluralists, who hold that biodiversity consists of distinct but correlated properties of natural systems, I argue that the supposed correlations between these properties are not tight enough to warrant treating and measuring them as a bundle. I additionally argue that deflationary theories of biodiversity don't go far enough, since a large proportion of what we value in the environment falls outside bounds of what could reasonably be called "diversity". I suggest that in current scientific practice biodiversity is generally an unnecessary placeholder for biological value of all sorts, and that we are better off eliminating it from conservation biology, or at least drastically reducing its role.

Introduction

Conservation biology should not aim to preserve biodiversity. This counter-intuitive thesis is normative, but it is more conceptual than ethical. Biodiversity is a concept unsuited the scientific role assigned to it.

In conservation biology, biodiversity is in principle the target of conservation, and in practice a comparative measure used to identify priority areas for conservation. Since there are epistemic limits on measuring biodiversity directly,

C. Santana (✉)
Department of Philosophy, University of Pennsylvania, 433 Cohen Hall,
Philadelphia, PA 19104-6304, USA
e-mail: cgraysan@gmail.com

biologists must choose a stand-in, or *surrogate*, such as species diversity. And since there are practical limits on measuring surrogates directly, biologists must choose a stand-in for the true surrogate, which is sometimes called an *estimator surrogate* (Sarkar 2002; Sarkar and Margules 2002; Margules and Sarkar 2007). Conservation science thus follows the following picture: *estimator surrogate → true surrogate → biodiversity → biological value*, where each arrow represents a theoretical description of how a member of the series represents the following member, and "biological value" equates to whatever it is that we are conserving biodiversity for. We can simplify and improve the practice of conservation biology by removing biodiversity from the series, because biodiversity is an ineffective theoretical link from surrogates to biological value, diminishing its usefulness as a catch-all conservation target, and because biodiversity does not pick out a single measurable natural quantity, diminishing its usefulness as a comparative measure.

Conservation science is important because humankind alters its environment significantly, and these alterations are not always in humanity's[1] best interests. Consequently, the role of conservation biology is to remedy the situation by aligning our ecological practices with our best interests. In other words, I see conservation biology as our species' attempt at prudent rather than haphazard niche construction. In what follows I seek to establish that it is imprudent to treat biodiversity as the ultimate target of conservation.

Background

Biodiversity plays a key role in conservation biology; it is the measure of both the value of a conserved unit and the success of conservation practice. The standard picture of conservation is the prioritization of places to protect on the basis of their biodiversity value, as measured using surrogates (Sarkar and Margules 2002; Margules and Sarkar 2007). Crucially, this means that biodiversity is employed as a comparative measure, both to rank places in terms of biodiversity value and to determine if the biodiversity of one place is distinct from that of another. Inasmuch as this is an accurate description of the practice of conservation biology,[2] the concept of biodiversity is the keystone of its theoretical framework. That much is uncontroversial, but as Maclaurin and Sterelny (2008, 133) have observed, "consensus on the importance of biodiversity has not been matched by consensus on the technical problem of how to measure it," or, I would add, how to define it. Despite its key role in conservation biology, biodiversity has proved to be a slippery concept.

This slipperiness is attributable in part to the fact the users of the biodiversity concept face a dilemma. Biodiversity is meant to serve as a reliable indicator of biological value, but given the vast variety of ways in which we value the biosphere,

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[1] We might hold that the interests of all sentient animals should bear on our ecological practices as well, but whether or not value is purely *anthropo*centric is irrelevant to the argument of this paper.

[2] Folke et al. (1996) criticize this focus on place prioritization, arguing that ecological processes occur on too large a scale to be captured by nature preserves. Nevertheless, conservation practice does generally seem to rely on the designation of protected places.

this requires us to employ a broad and open-ended definition of biodiversity. On the other hand, to serve reliably as a comparative measure, biodiversity needs to be observable and straightforwardly operationalizable. These two desiderata pull in opposite directions: as our definition of biodiversity becomes more broad and open-ended, it becomes more difficult to objectively quantify the amount of biodiversity in a particular unit of interest.

Even the biologists and philosophers who want to put biodiversity to work in their theories often acknowledge the near impossibility giving it a satisfactory definition. A definition of "biological diversity" from a United Nations summit, for instance, defines it as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (quoted in Maclaurin and Sterelny 2008, 1). Similarly, a conservation biology textbook defines biodiversity as "*the variety of life,* in all of its many manifestations" (Gaston 2011). As Sarkar (2002) observes, such definitions end up saying merely that biodiversity is equivalent to "all of biology." Since we expect the concept of biodiversity to help us assess the relative conservation value of particular places or other units, such vague formulations won't do. Given the fact that conservation involves triage, we can't save "all of biology." We need a definition of biodiversity which allows us to assign a value or at least a relative rank among places, and there is no straightforward sense in which one place has more "biology" than another. Those features of biology the biodiversity concept is meant to pick out must be specified precisely enough to allow for comparison across biological and geographic units.

The obvious solution to this problem of vague definition is to choose a small number of measurable parameters to represent biodiversity. But this brings us to the other horn of the dilemma. As Sarkar argues, "no single parameter, whether or not it can be realistically estimated, is likely to capture all biological features that we may find of interest" (2002, 140). A small number of parameters is likely to be nearly as ineffective. The issue here is that biological value *is* broad and open-ended, so even a few well-chosen measurable biological features will fail to index much if not most of biological value.

The next two sections will examine the candidates for a workable solution to this dilemma of measurement and definition. To reiterate why a solution is critical: if biodiversity is the aim of conservation biology, and we cannot solve this dilemma, we must conclude with Maclaurin and Sterelny that conservation biology "does not yet have a general and coherent account of what should be conserved and why" (2008, 26). In fact, I will argue that this *is* the correct conclusion, but *pace* Maclaurin and Sterelny, the remedy is to discard, not patch up, the concept of biodiversity.

Specifying biodiversity

The standard approach to measuring biodiversity relies on *species richness*, a count of the number of distinct species occupying a place. It contrasts on the one hand

with *abundance*, which takes into account population size as well as the number of populations. On the other hand, both richness and abundance contrast with measurements in units other than species, such as genetic and morphological diversity. Species richness, however, counts among its virtues that it is ostensibly easy to measure, that it seems to correlate to some extent with most other types of biological diversity, and that it captures much of what we intuitively mean when we talk about biodiversity. Understandably, nearly all discussions of how to define and measure biodiversity fall back at least some extent on richness.

In fact, the most common method for managing the issues surrounding biodiversity is to simply equate biodiversity with species richness adjusted for abundance. For example, in *Measuring Biological Diversity*, a survey of the mathematical and computational models and techniques available for measuring biodiversity, Magurran defines biodiversity as "the variety and abundance of species in a defined unit of study," with the further assumption that all species are equal (2004, 17). Even assuming that we can successfully measure species richness, however, richness does not seem, to bring back Sarkar's phrase, "likely to capture all biological features that we may find of interest" (2002, 140).

One response is to try to capture those features with a unit of measurement capable of working in tandem with richness. Considering the fact that a large set of closely related species seems to be less diverse than a smaller set of more distinct species, some biologists have suggested augmenting or even replacing measurements of richness with some form of "disparity." Disparity might include genetic or evolutionary difference, such as Faith's proposal (1994) that phylogenetic distance can represent true biodiversity. It could also be morphological or phenotypic, since an organism that has a unique trait like the tuatara's third eye is intuitively more diverse. Unfortunately, the intuitive appeal of these types of disparity is not always matched by their tractability as measurement tool.

In response to these limitations, Sarkar and Margules (2002) suggest that we identify measurement targets such as species richness as *true surrogates* rather than equating them with biodiversity *per se*. Using this framework they can acknowledge that no unitary measure will capture everything of interest, even if their approach does not overcome that limitation. In addition, they argue that conservation biologists must agree to a conventional means of measurement, so there will be no risk of disagreeing about the relative biodiversity value of a place.

Appealing to convention looks worryingly like an attempt to ignore the problem, but Margules and Sarkar (2007) stress that conventional does not imply arbitrary. A convention can be chosen because, even if it elides certain aspects of biodiversity, "pragmatic criteria" identify it as an exceptionally good true surrogate overall (Sarkar 2002). A related worry might be that a solitary convention for measuring biodiversity will be inadequate for the wide variety of places where it would be used. Anticipating this problem, Sarkar notes that we will have to customize our approach to biodiversity based on the features of each place, leading to a "family of (related) biodiversity concepts" (2002, 135). As a final touch, Sarkar argues that we only need to measure *relative*, not absolute biodiversity for the purposes of conservation biology, so we do not need a mathematical model of how the true surrogate represents biodiversity, only reason to believe that it is a good surrogate.

By focusing on the issues surrounding the measurement of biodiversity, Margules and Sarkar are able to somewhat ignore the problem of giving it a rigorous definition. In Margules and Sarkar (2007) they define biodiversity as "the biological variety bequeathed to us by evolutionary processes over millennia," a definition which should be taken as a bit of poetic indulgence rather than an attempt at rigorous analysis, given the fact that it reduces to "all of biology."[3] A more serious definition is found in Sarkar (2002, 132), which defines biodiversity as "what is being conserved by the practice of conservation biology." In context, this definition is not as weakly circular as it might seem. On a sympathetic reading, this seems to be a deflationary definition,[4] attributing to the term 'biodiversity' the status of a placeholder. This is consistent with Sarkar's position that a different biodiversity concept is required for each geographical area, since if the best measures of biological value will vary from place to place, and biodiversity is a means of capturing biological value, 'biodiversity' merely stands in for whatever measure of value is best for a particular place.

I agree with Sarkar that biodiversity is a placeholder, but while Sarkar sees it as a useful placeholder, in fact the placeholder itself unnecessarily complicates the picture:

A. estimator surrogate → true surrogate → biodiversity → biological value
B. estimator surrogate → true surrogate → biological value

As normative descriptions of the practice of conservation biology, series B is more economical than A, and less prone to errors due to misrepresentation of one member by another. In other words, if biodiversity is not a necessary link in the series, and if what we have identified as biodiversity has a chance of misrepresenting what we value (and I will argue that it does), then we should eliminate biodiversity from the series. In brief, Sarkar is close to acknowledging that "biodiversity" means nothing at all, but if biodiversity is to be a useful concept, his definition needs more substance. On the other hand, if biodiversity, as I suggest, is not a useful concept, we should eliminate rather than deflate it. So Sarkar's functional definition of biodiversity falls short.

A supporter of Sarkar's position might retort that we have been hasty in moving from the premise that biodiversity is an unreliable index of biological value to the conclusion that it should be eliminated. Countervailing considerations might recommend retaining biodiversity as the organizing concept of conservation biology. We might think that biodiversity has become so entrenched in both the public and scientific discourse that eliminating it would incur unacceptable costs. Calling into question biodiversity's normative value, for example, could hinder the environmental movement. We therefore might be better off retaining biodiversity as a useful fiction, deflating the concept along Sarkar's lines to allow for more flexibility, but keeping it around for its rhetorical effect.

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[3] Also, restating "biological diversity" as "biological variety" accomplishes little.

[4] Some of Sarkar's recent writings lend support to understanding him along these lines, e.g. (Sarkar 2012).

This objection only succeeds if the costs of eliminating biodiversity outweigh the benefits. In the political arena the primary cost would be the undermining of pro-conservation arguments relying on biodiversity, and disruption of an organizing concept in extant conservation discourse. But there may be political benefits as well. Tying conservation science more directly to biological value should *increase* the public appeal of conservation. If biodiversity significantly misrepresents biological value, then eliminating biodiversity would therefore be politically advantageous. Whether the costs or benefits are stronger thus depends on the distance between biodiversity and biological value. As I will demonstrate at length in the next section, that distance is significant. Significant enough, in fact, that biodiversity is a harmful fiction, not a useful fiction.

Perhaps, however, the Sarkar supporter is willing to totally deflate the concept of biodiversity, and equate it directly with biological value, whether or not biological value is composed of things reasonably called "diversity." At first glance, this radical deflationary position appears immune to worries about the distance between biodiversity and biological value. On consideration, however, it still vulnerable. In both public and scientific discourse, biodiversity has been reified and is treated as a real property of the natural world. If we decide to treat the word "biodiversity" merely as a vacuous shorthand for "biological value," we are going to be frequently misunderstood. And the severity of the misunderstanding will track the distance between (undeflated) biodiversity and biological value. Again, given the significant disconnect between biodiversity and biological value, we should prefer elimination over even total deflation of the biodiversity concept.

The Sarkar supporter should not be too troubled. We can accept most of Sarkar and Margules' picture even if we eliminate biodiversity. The distinction between true and estimator surrogates is a genuine improvement over conflating biodiversity with the true surrogate itself. And as a means to reconcile competing values, convention and other means of negotiation will certainly factor into conservation, so Margules and Sarkar's position succeeds on some fronts—but that success doesn't require us to take biodiversity as the primary aim of conservation. To make a better case for the importance of biodiversity, we need a stronger positive account of what biodiversity is and why it matters.

Maclaurin and Sterelny (2008), attempt to address this issue. In their book *What is Biodiversity?* they adopt what they call a "multidimensional" conception of biodiversity. Biodiversity as they define it is multidimensional not merely in the commonly accepted sense of having multiple levels of organization (i.e. diversity of species as well as of other taxa), but is actually a plurality of potentially "strictly incommensurable" concepts (2008, 177). Motivating this view is the insight that despite problems defining biodiversity in the abstract, "on a case-by-case basis, it is often possible to successfully interpret claims about biodiversity" (2008, 172). In fact, they suggest that "biodiversity" only has meaning in the context of both a specific theory and a specific subset of biology. They assert, for instance, that one cannot fruitfully compare reef biodiversity to rainforest biodiversity, or the biodiversity represented by a mollusk species to that of a mammal species. Where Sarkar proposes a "family of related biodiversity concepts" customized to place, Maclaurin and Sterelny outline multiple dimensions of incommensurable

biodiversity concepts, determined at a fine grain based on place, level of organization, and phylogenetic difference.

At first glance a pluralistic definition would seem to make the measurement problem intractable. If each dimension of biodiversity requires its own method of measurement, and these dimensions are incommensurable, then these dimensions cannot all be subsumed under one concept called "biodiversity." But Maclaurin and Sterelny would deny the premise: each dimension of biodiversity, they claim, does not require its own method of measurement. On the contrary, surrogates "in all probability do not vary independently from one another" (2008, 145). I reconstruct their argument as follows: We decide on a surrogate on a case-by-case basis, based on "what aspects of biological richness we want to conserve, and why" (2008, 147). Each dimension of biodiversity will thus have its own surrogates. In general, however, the true surrogates will be chosen from a relatively small set, including but not limited to species richness, phenotypic diversity, and ecological variation. As it turns out, all the possible true surrogates tend to co-vary with species richness. Since richness is also more "theoretically precise," and "easy to measure" than the other options, we can use species richness as a common means of measurement across the dimensions of biodiversity (2008, 174). Maclaurin and Sterelny's endorsement of species richness comes with two caveats. First, it is tentative, since covariance between richness and other surrogates is an empirical claim. Second, they endorse richness only as it is "supplemented in various ways for various purposes" (2008, 173). That said, their argument is a theoretically sophisticated defense of what looks like the standard view of biodiversity: that species richness is a nearly sufficient measure.

But Maclaurin and Sterelny depart from the norm in one significant respect by restricting the types of cross-comparisons we can make. Conservation biology should be able to help us decide which choices will preserve more of what we value, but Maclaurin and Sterelny deny that we can compare "a reef and a rainforest," "mammals and mollusks," or any other sort of distant biological entities. Unfortunately, conservation biology demands the ability to make comparisons at a larger grain. If reefs and rainforests are truly biologically incommensurable, then our large-scale conservation decisions would have to be made on the basis of criteria external to conservation biology. It would seem that on the Maclaurin–Sterelny picture, conservation biology is incapable of accomplishing its task of advising us on how to prioritize our efforts so as to best conserve the things we value in nature.

Limitations of their views aside, both the Margules–Sarkar and Maclaurin–Sterelny investigations make real philosophical progress in identifying what a successful concept of biodiversity would have to look like. Taking the best from each account yields something like the following picture: Biodiversity is not a single definable property of the natural world, but a complex, multifaceted concept. We have different interests in each conservation context, so the measure we use must be flexible. The most promising method is to use species richness as the primary measure, then achieve context-sensitivity by adjusting the richness measure with other measures relevant to current interests. This creates a flexible but somewhat standardized concept of biodiversity for use in the conservation toolkit.

It is this picture of biodiversity—philosophically sophisticated and close to accepted scientific usage—which I take as my target. Whether biodiversity so defined and measured achieves its goals depends on two things. First, for Maclaurin and Sterelny's argument to succeed, species richness needs to have a close relationship with other kinds of diversity. Second, if Sarkar is right about a flexible biodiversity concept being a good index of biological value, the various facets of biodiversity must almost always track and almost never inversely correlate with sources of biological value. In the next section I will give reason to doubt that these two conditions are met.

The case against biodiversity

My strategy is to show how each plausible facet of biodiversity comes significantly apart from not only the other facets but also biological value. I will discuss how no particular kind of diversity correlates with all the others to the extent that Maclaurin and Sterelny think that richness does. I will also highlight how a variety of commonly held biological values are missed or counter-indicated by the various types of diversity, which undermines Sarkar's position that biological value can be reliably indexed by some broadly defined notion of biodiversity. Finally, I will argue that some members of the list of potential surrogates suffer from conceptual weaknesses rendering them unfit to play a role in conservation theory. While taken individually these arguments must be tentative, relying as they do on uncertain empirical claims as well as tendentious assertions of what is worth conserving, taken as a whole they are strong enough to cast serious doubt on the usefulness of biodiversity as the primary target of conservation.

Species richness

I begin with species richness, as it is central to both the usual practice of conservation biology and to the Maclaurin–Sterelny framework.

Richness must to some extent correlate with other types of biological variety, but it is unclear that the correlation is tight or that it correlates with every property assumed to fall under biodiversity. It has been frequently pointed out that richness does not even capture intuitive ideas about what diversity is, such as abundance and disparity. The classic example is Darwin's finches, which form a rich number of species but are not very diverse in the intuitive sense, given their morphological similarity. It might be argued that cases like these are uncommon, and as a general measure richness does correlate strongly with phenetic and ecological biodiversity. But as Angermeier and Karr have observed, richness-based surrogates can only measure biodiversity loss through species extinction, but situations such as the "elimination of extensive areas of old growth forest,[5] dramatic declines in hundreds

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[5] Without the loss of anything unique, it seems a stretch to call loss of portion of old growth forest a loss of "diversity," but it would still be a loss of something valuable. Instances like these reinforce my point that biodiversity is not always a good substitute for biological value.

of genetically distinct salmonoid stocks in the Pacific Northwest, and the loss of chemically distinct populations from different portions of a species' range represent significant losses of biodiversity, regardless of whether any species become extinct" (1994, 692). Examples like these suggest that centering biodiversity on richness overestimates how well it co-varies with other types of diversity.

A proponent of a richness-centered conception of biodiversity could respond that this demonstrates only that richness is not a good *true* surrogate for biodiversity. Richness could yet make a good *estimator* surrogate for a more inclusive true surrogate. Sarkar (2002) neatly rejects this idea. He first notes five lines of evidence that would support richness as a good estimator surrogate: (1) it correlates well with ecological diversity, (2) it sometimes correlates well with diversity of higher taxa such as genera, (3) when richness is very high, it correlates with phenetic diversity, (4) it might correlate with the complexity of trophic webs, (5) high richness might correlate with topographic diversity. In all five cases, richness is supposed to correlate with some other property, which in turn is supposed to be the true surrogate. Sarkar observes (2002, 144) that "of these five points, the second and third are irrelevant since they refer to richness at the level of higher taxa or traits rather than diversity; the third[6] [sic] assumes the complexity of trophic webs is related to diversity, which is unproven in the field; and the first and fifth are relevant only if we accept environmental diversity as a true surrogate." Environmental diversity is not a plausible true surrogate, as I will argue below. So the covariance between richness and other types of diversity does not suffice to establish it as the common denominator of biodiversity.

Nor does preserving richness reliably preserve biological value. Because richness is nothing more than a count of the number of species in an area, value on the richness scale increases with speciation and decreases with extinction but this misrepresents common values. Not all species are equally valuable, so the extinction of a pollinator like a honeybee would be more lamentable than the extinction of a species of leech. A strict richness scale cannot account for variances in value, which is why Magurran's (2004) richness-based approaches, for example, assume that each species only "counts for one." Additionally, it seems to be the case that many people value keeping ecosystems as close as possible to the state of nature. But a richness scale suggests that we can improve a system by deviating from the state of nature and importing species by, say, adding fish to a lake. The defender of the richness scale could object that non-native species would decrease richness by out-competing native fish, but such a scenario might be unlikely. In a broad-ranging study, Ruesink (2003) found that introduced fish species significantly altered their adopted environments less than a third of the time, which suggests that with some careful planning we could easily increase the richness of many waterways without necessarily increasing their biological value. Of course, the most dramatic counterexample to a richness scale of value is when a species is better off dead. The extinction of smallpox was a gain in value, not a loss. As these examples indicate, if richness is a part of biodiversity, then biodiversity does not always map onto biological value.

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[6] He means "the fourth."

The final blow against species richness as the foundation for a useful biodiversity concept is that richness is plagued by a host of its own conceptual and practical problems. The concept of "species" itself is notoriously hard to define, especially with organisms that can reproduce asexually. This problem would be trivial if competing definitions of "species" carved nature at approximately the same joints, but in practice different ways of measuring species lead to drastically different results. Other issues casting doubt on richness' usefulness to conservation practice include the difficulty in finding a good estimator surrogate for total richness (Margules and Sarkar 2007), and the fact that a richness count does not account for overlapping species between places, making assessment of complementarity difficult. Species richness therefore does not give biodiversity a firm conceptual footing.

Abundance

As Maclaurin and Sterelny point out, however, richness does not need to stand alone and can be "supplemented in various ways for various purposes." The most commonly used supplement is abundance or evenness, which is meant to capture a more intuitive notion of diversity. But the relative abundance of species also fails to represent biological value well. Assume, for example, that we value the persistence of a particular ecosystem. Abundance-based measurement tells us that even population sizes are preferable, but this could miss the mark in several ways. For one thing, a small population size might be the status quo for a particular species in that area. It could be that a larger population of that species would impact other populations adversely. Or it might merely be that while small in size, that population is stable. And in terms of value to humans, rarity itself might sometimes be preferable. Booth et al. (2011) demonstrate, for instance, that the comparative rarity of a bird species determines how highly prized that species is among birdwatchers. Species abundance, like species richness, could frequently misrepresent biological value.

Phenotypic (morphological) disparity

Another mode of variety often suggested as a supplement to richness is diversity of traits or forms. "Trait" is a difficult word to define in a biological context, and it is even more difficult to quantify for purposes of comparison. For these reasons, an all-encompassing method for measuring phenotypic distance is unlikely. Restricting the discussion of "traits" to physical form alone yields a less hairy problem, since we can quantify the degree of topological transformation necessary to convert one form into another. Maclaurin and Sterelny (2008, 77) explore this possibility, but conclude that "defining a global space of morphological diversity" is not "empirically or computationally tractable." They find, however, that local morphospaces restricted to a single lineage are reasonable tools for understanding diversity within that lineages. So although mathematically described local morphospaces could provide insight into the evolution of a lineage, local morphospaces do not meaningfully capture a broad notion of biodiversity. A

biodiversity concept useful to conservation science would need to account for diversity between organisms with drastically different morphologies, which a local morphospace cannot do. We are left to look elsewhere for a firm grounding for biodiversity.

Genetic and evolutionary disparity

One possibility is to look to disparity on a lower or higher level of organization. Genetic diversity, however, is nearly a non-starter. A "gene soup" containing a random sample of genetic material from a given place would furnish little in the way of useful information for several reasons. It would only loosely correspond to phenotypic diversity since developmental plasticity varies from species to species (and trait to trait), and much of the content of a genome goes unexpressed anyway. Gene soup would correspond even less reliably to species richness, since genome size varies across organisms. Genetic diversity, however, does have close ties to what Maclaurin and Sterelny (2008) call "evolutionary plasticity," also referred to as "evolutionary potential" and "evolvability." Since evolution selects between alleles, this line of thinking goes, the number of alleles present in an environment corresponds with the potential for natural selection to occur. Diversity, on this account, is important because it enables evolution, making genetic diversity a key component of biodiversity. This approach is present in many writings on biodiversity (e.g. Frankel and Soulé 1981), but it requires the questionable assumption that evolution is in itself valuable. I reject this assumption, for reasons discussed at length in the next section.

A similar approach looks at evolutionary distinctness on a higher level. Faith (1994) argues, for instance, that we can quantify biodiversity by counting the number of speciation events between two taxa. This clade-based measure of diversity is appealing because it intuitively seems to correlate with both species richness and diversity of phenotypes. Unfortunately, evolutionary diversity and species diversity are often distinct, as demonstrated, for example, by Mooers (2007), who describes a case study on the flora of South Africa's cape region showing that the eastern region of the cape has higher diversity on a clade-based measurement, while the western region has higher species richness. Evolutionary diversity often fails to correspond to morphological diversity as well. To recycle a useful example, Darwin's finches underwent a large number of speciation events, but all have a very similar form. But not only does evolutionary diversity fail to strongly co-vary with other types of diversity, approaches such as Faith's assume that counting speciation events is possible. Given the paucity of the fossil record and an inconsistent rate of speciation, it probably is not. Finally, if evolutionary diversity does not correlate well with other kinds of diversity, it is unclear why it matters. As Maclaurin and Sterelny (2008, 141) put it, "If Faith-diversity is a measure of a causally important dimension of biological systems, we need an explicit case for that view." And if it doesn't measure anything causally important, it probably doesn't represent anything of value.

Ecological diversity

Ecological or environmental diversity is the next plausible center for a cohesive biodiversity concept. On a broad scale, at least, environmental differences correspond with both the number of species and their phenotypic disparity. A tropical rainforest, for example, differs from an arctic island in both the number of species it supports and the individual features of those species. A typology of environment types can tell us which places are likely have more species richness. And if we preserve a variety of different ecosystems, we will likely preserve more diversity than if we protected only one type of environment. Ecological diversity thus has much to recommend it.

Even so, theorists have cast serious doubt on its usefulness as a cornerstone of biodiversity. The reader should not be surprised by this point to learn that environmental diversity often fails to correlate with species diversity (Araujo et al. 2003). The hypothetical ecosystem-richness correlation relies on an assumption that any environment has more or less a set number of "niches" that species will evolve to fill. But in reality, "niche occupation appears much more active in some species than others" (Maclaurin and Sterelny 2008, 35), because organisms are capable redefining the niche space. And even if niche construction played only a minimal role, environmental diversity would not capture the difference between convergent species, such as marsupials and their placental analogs (Sarkar 2002). So ecological diversity, like the other measures we have examined, fails to correlate reliably with other types of biological diversity.

Nor does ecological diversity function as a reliable means to assess the biological value of an area. Consider how we could analytically describe ecological diversity for use in ecological models. A mathematical ecospace would include each salient feature of the ecosystem as a dimension, but this means that "a total ecospace is of high and somewhat arbitrary dimension. Would we have a dimension for every duck in the regional biota?" (Maclaurin and Sterelny 2008, 111). Either we are back to square one, and ecological diversity reduces to "all of biology," or we have to choose a manageably small set of dimensions. Which dimensions of an ecosystem are relevant, however, depends on our goals (Tylianakis et al. 2010). So ecological diversity can be useful, but only once we have specified an account of biological value from which our goals will emerge. But by doing so we cut out the middleman—the biodiversity concept—because the selected ecological dimensions have become a *direct* surrogate for biological value. Ecological diversity does not, therefore, solve the issues plaguing biodiversity.

Process diversity

One final option considers the diversity of biological processes and services such as biogeochemical cycles. Biological processes are indubitably often valuable, but I fail to see how they can be directly incorporated into a concept of biological diversity. In fact, if our goal is to preserve valuable processes, the focus on biodiversity is often counterproductive. Kareiva and Marvier (2003) show how the trend in conservation biology of prioritizing biodiversity hotspots distracts from

attending to endangered ecological processes in biodiversity "coldspots." In addition, we are not generally concerned with maintaining a *diversity* of processes, but instead preserving a few large-scale patterns such as carbon transfer and river catchment. Angermeier and Karr (1994, 692) observe that places vary in process rates rather than process types (virtually all ecosystems have the same major processes), so using process diversity to jury-rig a failing biodiversity concept "adds ambiguity without utility."

"The utility," a proponent of biodiversity might retort, "is that the stability of processes is *related* to diversity." She might cite Paine's famous experiment (1966) detailing how the removal of a single species of starfish disrupted the processes of a tide pool, allowing a mussel species to dominate the environment. Diversity, she can point out, is a prerequisite for the processes we value. While this line of thought is correct, it does not establish the grounds for a general biodiversity concept. Nature does not usually turn out to be a house of cards, ready to fall upon the removal of any single species (Baskin 1994). And although a variety of functional roles must be occupied to keep biological processes in place, we can explain those roles and those processes without needing to call on a biodiversity concept. Finally, if we can explain those processes, we understand them well enough to preserve them. The need to preserve biological processes will not motivate the introduction of the concept of biodiversity.

At the beginning of this section we made note of two reasons why we might want a concept called "biodiversity" to play a central role in conservation biology. As Sarkar noticed, biodiversity is often used as a placeholder for the real target of conservation: a plurality of biological values. The usefulness of the biodiversity concept would be that it could stand in for all those values at once, as long as it reliably represented each of them. But I have explained how the various facets of biodiversity can misrepresent biological value. A similar motivation for employing biodiversity comes from Maclaurin and Sterelny, who acknowledge the plurality of biological values but suggest that a common means of assessment can capture most or all or them. Our examination of the commonly suggested biodiversity surrogates, however, has found them to be largely independent of each other. Each surrogate, that is, might capture something of value that the other surrogates miss.

An obvious response to these facts would be to suggest a strong pluralism about biodiversity, wherein the targets of conservation biology are $biodiversity_1$, $biodiversity_2$ and so on. But as we saw in the case of certain biological processes, many instances of biological value cannot be reasonably labeled "diversity." Better to just indicate the targets of conservation directly, and find direct surrogates for biological values.

Biodiversity's inertia

In outlining the weaknesses of biodiversity, I drew on the same biologists and philosophers who attempt to rescue the biodiversity concept. The weaknesses of biodiversity, that is to say, are generally acknowledged. So why is biodiversity still central to conservation theory and practice?

One answer to that question is probably sociological. The term "biodiversity" has been adopted into the lay and political discourses, making it more difficult to abandon. But if this is a concern, we could retain the use of the *word* "biodiversity" for purposes of rhetoric and popular explanation while nonetheless abandoning biodiversity as a *scientific concept* employed in conservation theory.

Another motivation for keeping biodiversity on its throne is to ensure that the target of conservation really is "all of nature." We have a wise reluctance to play god, in part because of worries that we might bring unforeseen disaster on ourselves, and in part because we do not see ourselves as justified in pronouncing one place or species more worthy of conservation than another. So we try to save everything by including it all under biodiversity. Unfortunately, it is too late to save everything, as ideal as that might be. In the current ecological crisis, conservation biology is more often than not an act of triage. Given this situation, biodiversity is only a useful concept if it enables us to prioritize.

"Prioritizing is difficult," one could object, "especially since human values are many and conflicting. Biodiversity might misrepresent some types of biological value, but it still seems to correlate with many others. Targeting biodiversity might therefore be a useful heuristic—a means of overcoming difficult cross-value measurements and comparisons." But since we do not have a clear general definition of biodiversity or means to measure it, this is equivalent to *hoping* that if we conserve biodiversity we will achieve our valued ends. As some recent authors have argued, instead of forcing consensus by subsuming all biological value under a single ecological concept, a better approach is to resolve value conflicts in conservation using the same tools that political science and economics use to arbitrate value conflicts in other arenas (Frank and Sarkar 2010; Colyvan et al. 2011).[7] Our ecological measurements can then be tailored to protect those values directly.

Another line of objection might argue that diversity is an end in itself. Sober (1986) outlines a view of this sort, noting that in nature as in art we tend to assign aesthetic value to variety, novelty, and uniqueness. Diversity comprises variety, novelty, and uniqueness, so diversity itself becomes an end, but only an instrumental end aiming ultimately at aesthetic value. Since aesthetic values are only one of many components of biological value, arguments like Sober's do not entail that biodiversity should be the primary target of conservation.

A stronger view would ascribe to biodiversity inherent value, but any value intrinsic to biodiversity is of diminished import in conservation decisions (Maguire and Justus 2008). Our limited resources for conservation demand that we prioritize some units over others, so if all units are equally intrinsically valuable, recognizing intrinsic value fails to help us make comparative decisions. Strong accounts of intrinsic value might even undermine the ability to make rational conservation

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[7] While this suggestion is similar to the view in Margules and Sarkar (2007) about the role of convention in conservation biology, there is a notable difference. They propose conventions to settle to content of the biodiversity concept, but the proposals cited here call for negotiations between competing stakeholders. This latter option provides more transparent recognition of value conflicts as well as broader inclusion of values which fall outside the bounds of anything reasonably called biodiversity. These facts recommend the latter approach over biodiversity-focused conventions.

decisions at all (Colyvan and Steele 2011). Furthermore, biological units have an instrumental value on top of any possible inherent value, and I will argue that biodiversity alone would misrepresent those instrumental values. So even if biodiversity in some sense is intrinsically valuable, we are not justified in setting it as the primary target of conservation.

Many claims that biodiversity is a worthy goal in itself, however, are most charitably understood as claims that diversity is instrumentally valuable, just strongly and directly so. For example, a common explanation for why we should preserve biodiversity is that we do not want to lose undiscovered but useful resources such as medicinally efficacious molecules. I agree with this line of thought, but note that: (1) It is unclear that preserving general biodiversity will best prioritize the organisms that will ensure achieving this goal. (2) The biochemical potential of unknown biota is generally exaggerated, especially since methods of rational and computer-aided drug discovery are generally more effective than foraging through the Amazon (Ehrenfeld 1988). (3) Diversity, thus construed, is one goal among many. We cannot claim that this alone is "biodiversity" and make it the unitary goal of conservation biology.

But the most common accounts of how biodiversity is directly valuable are more sophisticated. On these accounts, biodiversity is valuable because it promotes, paradoxically, both evolution and stability.

References to the role of biodiversity in promoting evolution are common,[8] but is the link between diversity and evolution tight enough or important enough to independently motivate keeping the troubled concept of biodiversity around? The presence of a diversity of alleles within a population is certainly a prerequisite for natural selection, but it is less clear that biodiversity as traditionally construed bears any close relationship to rates of evolution, and it must be *rates* these authors are concerned with, since no one believes evolution will halt entirely. As a matter of fact, sometimes biodiversity *losses* lead to rapid evolution: the Cambrian explosion was preceded by a mass-extinction (Knoll and Carroll 1999), and in some documented cases (Palumbi 2003) humankind's destructive ecological impact has increased selective pressures, leading to more rapid evolution. So we have good reason to question the correlation between biodiversity and evolutionary rates.

But even if that correlation does turn out to be so strong that the best way to promote evolution is to make biodiversity the primary target of conservation, we should question why promoting evolution should be our chief goal. We have, I hope, justly abandoned a teleological worldview that assumes that evolution is progress. Some have argued that evolution in the sense of "higher speciation rates" is beneficial because it leads to greater species richness (Forest et al. 2007; Palumbi 2003). In other words, evolution might be valuable because it leads to greater biodiversity. But this argument cannot support the claim that biodiversity itself is

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[8] A sample of examples, emphases mine: (note that in each case, evolution is itself considered the end goal of conservation) "Conservation area networks should primarily be seen as holding operations, repositories of biota for *evolution* to work with in the future" (Margules and Sarkar 2007, 107); "Genetic variability is of particular significance to conservation biology, but only because it's an important contributor to [evolutionary] *plasticity*" (Maclaurin and Sterelny 2008, 87); an article in *Nature* (Forest et al. 2007) entitled "Preserving the *evolutionary potential* of floras in biodiversity hotspots."

important, because it would lead to a vicious regress: biodiversity is important because it promotes evolution, which is important because it promotes biodiversity… We are left to turn elsewhere in our search for a good justification for the primacy of the biodiversity concept in conservation biology.

And that brings us to the strongest argument in favor of biodiversity, the diversity-stability hypothesis. One compelling version of the argument runs along these lines: Each species in an ecosystem fulfills one or more functional roles. An ecosystem is stable as long as each functional role is occupied, but if a certain role goes unoccupied the whole system must adjust. Too many adjustments, and the system may cease to function. A disturbance is less likely to leave a role unoccupied if that role is occupied by many species rather than few. Species richness creates redundancies at each functional role, thus protecting ecosystems from disturbance. And resilient ecosystems are important because ecosystem processes are necessary to sustain human existence. Therefore, biodiversity is important because "redundancy is required to maintain an ecosystem's resilience" (Rockstrom et al. 2009).

I have some sympathy for this line of thought. At the very least, it demonstrates that we must conserve a sufficient number of species to preserve necessary biological processes. But that was never in question; the question is whether we should rely on a scientific concept of biodiversity to preserve biological value. And the diversity-stability hypothesis is not strong enough to warrant a positive answer to that question.

First of all, the hypothesis itself is controversial, its history in ecological science characterized by unclarity and disagreement rather than consensus (Justus 2008a). Maclaurin and Sterelny (2008) discuss the evidence for it in detail and conclude that the diversity-stability hypothesis is plausible, but unproven. For one thing, "the experimental evidence in favor of the diversity-stability relationship depends on measuring plant biomass," not general biodiversity (2008, 122). Diversity and stability may correlate solely because both depend on a common cause such as abiotic factors, not because diversity promotes stability. In fact, in a review of the empirical research regarding the diversity-stability hypothesis, Johnson et al. (1996) conclude that diversity is at best a rough guide to stability, that there are better indices for stability than diversity, and that the relevant index will always be place-specific. For example, Tilman and Downing (1994) demonstrated that the variety of vascular plants seems to correlate strongly with how quickly Minnesota grasslands recover from disturbance, whereas Vitt and Chee (1990) discovered that in Alberta peat bogs the nutrient content of soils accounted for resilience, with vascular plant diversity being merely causally downstream from the same source. Additionally, some researchers have indicated that diversity and stability are often at odds. Invasive species, for example, successfully invade precisely because they are more resistant to perturbation than native species, so an invaded ecosystem might be more resilient while less diverse (Tylianakis et al. 2010).

This last example highlights how the status of the diversity-stability hypothesis depends on what we take "stability" to mean. "Stability" may refer to the persistence of valuable biological processes, but as we learned above, processes only weakly correlate with standard measures of biodiversity. We would therefore be better off identifying the specific factors enabling the processes we want to

preserve, rather than using a vague concept of biodiversity as a surrogate. On the other hand, we might take "stability" to be the persistence of species, populations, or other biological units. To an extent this is trivial, since conservation by definition involves the preservation of biological units. But we cannot preserve all of biology, and stability so defined gives us no method to make prioritization decisions. It gives us no method to *evaluate* which units to conserve.

Of course, we could define "stability" more generally, and assign value to a unit based on its contribution to general stability. In order to justify the use of the biodiversity concept, however, general stability would have to both be adequately represented by biodiversity and itself represent the bulk of biological value. I doubt that any specification of general stability could do so. Persistence, I think, is desirable often but not always: some change is bad, some change is good, and much change is inevitable. Many species extinctions are a loss of value, but it would be hard to argue that the extinction of certain pests and parasites would be. And some ecologically disruptive human activity, such as the development of agriculture, is probably quite positive in the balance.

A theorist wishing to use general stability to rescue the concept of biodiversity must define stability in such a way as to allow for the good change, but not the bad change. Stability as mathematical equilibria of communities will not suffice, since such equilibria are uncommon (if present at all) in nature, and many mathematical equilibria are undesirable—a population density of zero is quite stable (Cuddington 2001). Moreover, the standard attempts to give rigorous mathematical definition to the intuitive notion of ecological stability fall short (Justus 2008a, b). Proponents of stability as the end of conservation have not yet been able to operationalize the notion of stability in a way which distinguishes what is worth preserving from what is better off changed.

In failing to do so, they may be drawing on an entrenched pre-scientific notion of "balance of nature" (Cuddington 2001). As Kricher (2009, 1) puts it, "That there is a balance of nature is one of the most deep-seated assumptions about the natural world." It is an old assumption[9] that equates stability with the good. The balance of nature metaphor informs conservation practice, which is why we might think that stability, as buffered by biodiversity, is a worthy end in itself. But as we have seen, nature is not typically in balance in terms of mathematical equilibria, and Darwin put a fitting end to the idea that the units of the biological world are static. "Balance," in our day, seems to refer instead to nature unimpeded by human intervention. Consider Margules et al. (2002, 310) statement on biodiversity (emphasis added): "if populations of all species persist, or are allowed to pursue an *unimpeded* course of events to wider dispersal, evolution, or natural extinction, then biodiversity will have been successfully protected." On this account, which reflects a standard attitude in conservation,[10] we should aim for persistence of the "natural," because the natural state of things is good.

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[9] Plato, for example, wrote millennia ago that "Whatever is in good condition…admits least of being changed by anything else" (Republic 381b, tr. Grube).

[10] We often attempt to reintroduce species to their historical geographies, heedless of what may have changed in their absence. Or consider the pretense in popular discussions of environmentalism that conservation involves setting aside plots of land to be "untouched" by human hands.

The influence of the balance of nature metaphor is far disproportionate to its philosophical robustness. First of all, the natural/artificial distinction is more aesthetic than scientific. Second, not all natural change is desirable. Finally, if our goal is to keep humankind from interfering with the course of nature, then conservation biology has no room to get off the ground[11] (Sarkar 2011). A science of conservation is tasked with finding which human interference in the environment is advisable. Designation of wildlife reserves is human interference with the course of nature, as are giant panda breeding programs, gray wolf reintroductions, and tree plantings in city parks. The elevation of "nature" to a privileged moral status creates room for the introduction of general stability as the goal of conservation, which in turn supports the use of a biodiversity concept. But because this relies on a fallacy, the notion of general stability fails to motivate the use of biodiversity in conservation science.

In this section I have examined several potential reasons for trying to repair the biodiversity concept despite its numerous weaknesses. Having found each reason wanting, I tentatively propose the retirement of biodiversity from conservation science and philosophy.

Conclusion

Biodiversity is generally the assumed target of conservation biology, but the biological world is composed of a number of distinct types of diversity, which only loosely correlate with each other and with biological value. Since the function of the biodiversity concept in conservation science is to help us preserve or increase biological value, we should therefore consider eliminating biodiversity from its privileged position in conservation theory and practice.

This position is not anti-environmental. I have argued that we should not be aiming to conserve biodiversity, we should be aiming to conserve and promote biological value. And biological value is found in the environment, which accordingly deserves our protection. If we were to replace the vague concept of biodiversity with the specific biological values we want to conserve, conservation would probably become *more* socially and politically appealing. But if we want to save pristine nature, untouched by human hands nature, it's too late. We have the responsibility to decide what to prioritize and value, and taking shelter behind the vagueness of 'biodiversity' will not protect us from the consequences of shirking that responsibility.

References

Angermeier PL, Karr JR (1994) Biological integrity versus diversity as policy directives. Bioscience 44(10):690–697

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[11] Unless conservation biology is nothing more than the mass suicide of our species in order to free nature from human interference. But this would presumably be a loss of biodiversity.

Araujo M, Densham P, Humphries C (2003) Predicting species diversity with ED: the quest for evidence. Ecography 26(3):380–383

Baskin Y (1994) Ecosystem function of biodiversity. Bioscience 44(10):657–660

Booth JE, Gaston KJ, Evans KL, Armsworth PR (2011) The value of species rarity in biodiversity recreation: a birdwatching example. Biol Conserv 144(11):2728–2732

Colyvan M, Steele K (2011) Environmental ethics and decision theory: fellow travellers or bitter enemies? In: deLaplante K, Brown B, Peacock K (eds) Philosophy of ecology. Elsevier, Amsterdam, pp 285–299

Colyvan M, Justus J, Regan H (2011) The conservation game. Biol Conserv 144(4):1246–1253

Cuddington Kim (2001) The 'balance of nature' metaphor and equilibrium in population ecology. Biol Philos 16:463–479

Ehrenfeld David (1988) Why put a value on biodiversity? In: Wilson EO (ed) Biodiversity. National Academies Press, Washington, DC, pp 212–216

Faith D (1994) Phylogenetic pattern and the quantification of organismal biodiversity. Philos Trans R Soc Biol Sci 345(1311):45–58

Folke C, Holling C, Perrings C (1996) Biological diversity, ecosystems, and the human scale. Ecol Appl 6(4):1018–1024

Forest Félix, Grenyer Richard, Rouget Mathieu et al (2007) Preserving the evolutionary potential of floras in biodiversity hotspots. Nature 445(7129):757–760

Frank D, Sarkar S (2010) Group decisions in biodiversity conservation: implications from game theory. PloS One 5(5):e10688

Frankel O, Soulé M (1981) Conservation and evolution. Cambridge University Press, Cambridge

Gaston K (2011) Biodiversity. In: Sodhi N, Erlich P (eds) Conservation biology for all. Oxford University Press, Oxford, pp 27–44

Johnson K, Vogt K, Clark H, Schmitz O, Vogt D (1996) Biodiversity and the productivity and stability of ecosystems. Trends Ecol Evol 11(9):372–377

Justus J (2008a) Complexity, diversity, and stability. In: Sarkar S, Plutynski A (eds) A companion to the philosophy of biology. Blackwell, Oxford, pp 321–350

Justus J (2008b) Ecological and lyapunov stability. Philos Sci 75:421–436

Kareiva P, Marvier M (2003) Conserving biodiversity coldspots. Am Sci 91(4):344–351

Knoll A, Carroll S (1999) Early animal evolution: emerging views from comparative biology and geology. Science 284(5423):2129–2137

Kricher J (2009) The balance of nature: ecology's enduring myth. Princeton University Press, Princeton

Maclaurin J, Sterelny K (2008) What is biodiversity?. University of Chicago Press, Chicago

Maguire L, Justus J (2008) Why intrinsic value is a poor basis for conservation decisions. Bioscience 58:910–911

Magurran A (2004) Measuring biological diversity. Blackwell, Oxford

Margules C, Sarkar S (2007) Systematic conservation planning. Cambridge University Press, Cambridge

Margules C, Pressey R, Williams P (2002) Representing biodiversity: data and procedures for identifying priority areas for conservation. J Biosci 27(July):309–326

Mooers AØ (2007) The diversity of biodiversity. Nature 445(February):717–718

Paine R (1966) Food web complexity and species diversity. Am Nat 100(910):65–75

Palumbi S (2003) An evolutionary perspective on the importance of species: why ecologists care about evolution. In: Kareiva P, Levin S (eds) The importance of species: perspectives on expendability and triage. Princeton University Press, Princeton, pp 292–304

Rockstrom J, Steffen W, Noone K (2009) A safe operating space for humanity. Nature 461:472–475

Ruesink J (2003) One fish, two fish, old fish, new fish: which invasions matter? In: Kareiva P, Levin S (eds) The importance of species: perspectives on expendability and triage. Princeton University Press, Princeton, pp 161–178

Sarkar S (2002) Defining 'biodiversity'; assessing biodiversity. Monist 85(I):131–155

Sarkar S (2011) Habitat reconstruction: moving beyond historical fidelity. In: deLaplante K, Brown B, Peacock K (eds) Philosophy of ecology. Elsevier, Amsterdam, pp 327–362

Sarkar S (2012) Environmental philosophy: from theory to practice. Wiley, New York

Sarkar S, Margules Chris (2002) Operationalizing biodiversity for conservation planning. J Biosc 27:299–308

Sober E (1986) Philosophical problems for environmentalism. In: Norton B (ed) The preservation of species: the value of biological diversity. Princeton University Press, Princeton, pp 173–194

Tilman D, Downing J (1994) Biodiversity and stability in grasslands. Nature 367(January):363–365

Tylianakis J, Laliberté E, Nielsen A, Bascompte J (2010) Conservation of species interaction networks. Biol Conserv 143(10):2270–2279

Vitt D, Chee W-L (1990) The relationships of vegetation to surface water chemistry and peat chemistry in fens of Alberta, Canada. Vegetation 89(2):87–106