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Ecological Historicity, Functional Goals, and Novelty in the Anthropocene

Eric Desjardins, Justin Donhauser*, and Gillian Barker

Rotman Institute of Philosophy, University of Western Ontario, London ON

*jdonhauser@uwo.ca

Abstract

While many recognize that rigid historical and compositional goals are inadequate in a world where climate and other global systems are undergoing unprecedented changes, others contend that promoting ecosystem services and functions encourages practices that can ultimately lower the bar of ecological management. These worries are foregrounded in discussions about Novel Ecosystems (NEs); where some researchers and conservationists claim that NEs provide a license to trash nature as long as some ecosystem services are provided. This criticism arises from what we call the "anything goes" problem created by the release of historical conditions. After explaining the notion of NE, we identify numerous substantive motivations for worrying about the anything-goes-problem and then go on to show the problem can be solved by correcting two mistaken assumptions. In short, we argue that the problem is a product of adopting an overly sparse functional perspective and one that assumes an unrealistically high degree of convergence in the trajectories of natural processes. Our analysis illuminates why such assumptions are unwarranted. Finally, we further argue that adopting an appropriate ethical framework is essential to overcoming the anything-goes-problem and suggest that a certain virtue ethics conception of ecological management provides useful resources for framing and resolving the problem.

Keywords: novel ecosystems, ecosystem function and functioning, historicity, Anthropocene, virtue ethics

1. Introduction

Many nations now recognize the urgency of developing responses to human-caused changes affecting Earth systems (see UNFCCC 2015). However, proponents of ecosystem and biodiversity protection continue to debate which ecosystem management approaches are most appropriate (cf. Beier & Noss 1998; Clark et al 1997; Minteer & Miller 2011). The traditional approach has taken historical ecosystem states as benchmarks that set the goals of ecosystem management, but some recent commentators argue for a radical rethinking of this tradition. They emphasize that it is unrealistic and possibly dangerous to adhere rigidly to historical and preservationist goals in a world where global systems are undergoing unprecedented changes due to various anthropogenic influences (e.g., Choi 2007, Hobbs et al. 2011, Hourdequin 2013). But this response elicits countervailing worries: defenders of the traditional approach point to the possible dangers of abandoning historical goals, arguing that opening ecological management up to novel goals must tend to license (and even to promote) practices that will ultimately degrade ecosystems.

This debate has focused particular attention on the possibility of recognizing some new ecological configurations as ‘novel ecosystems’ (NEs) rather than as mere perturbations of existing ecosystems. For example, in recent discussions, Murcia et al. (2014) and Simberloff et al. (2015) argue that such a move necessarily lowers the bar of ecosystems management. This new category, they say, “provide[s] a license to trash nature” since “the novel-ecosystem label can serve as a Get Out of Jail Free card for companies or individuals trying to avoid investing in research, mitigation or restoration by claiming they are producing novel ecosystems that will provide ecosystem services.” This type of criticism is rooted in the worry that once historical goals are abandoned, the door is open to any type of intervention—that if ecological management is unconstrained by the benchmarks of history, “anything goes.”

The "anything goes" worry arises because of what seems to be a sharp contrast between historical goals and all other prospective goals for ecological management: the goals set by historical ecosystem states are both comprehensive and objectively determinate,[1] whereas other prospective goals may pertain only to certain narrowly-circumscribed aspects of an ecosystem, and even within those limits may be relative to subjective preferences or interpretations. In the debate over novel ecosystems, the anything-goes worry focuses on functional goals; these are the most widely-accepted alternative to historical goals for ecological management. Two versions of the worry can be distinguished, motivated by two interpretations of a widely-promoted type of functional goal—goals characterized in terms of ecosystem services. In each case, the worry is that promoting NEs implies the acceptance of narrow service-based goals that will leave our management systems vulnerable to abuses leading to ecological degradation.

In the first of these interpretations, the functional goal of ecological management is taken to be the provision of goods and services to human beneficiaries. The anything-goes worry here is that this interpretation treats nature merely as a storehouse of "natural capital" for human use, so that NEs become mere tools for anthropocentric ends, where the anthropocentric ends in questions may themselves be very permissively construed. In one widely-accepted version of this interpretation the valuing of ecological services is left to individual preferences expressed through the operation of commercial markets. The worry is thus that if policymakers and practitioners promote NEs, they are implicitly accepting a permissive anthropocentric scheme of values that would license private interests to create NEs in whatever form they find profitable. This strand of the anything-goes worry has been at the heart of recent ethical debates about

[1] Of course, fixing historical goals requires that a particular historical state be selected as the one to be preserved or restored, and advocates of this approach may disagree on which historical period to take as a benchmark or on what principles should guide this choice, but the latitude that this choice affords is far more restricted than that envisaged in the "anything goes" worry.

instrumentalism, where it has been met with arguments for a more far-sighted anthropocentrism capable of finding value for humans in natural processes or historically regular conditions.[2] Our analysis below does not directly engage with this strand of the anything-goes worry, though it will yield lessons for debates about it.

In the second interpretation of ecosystem services, the goal of ecological management is taken to be the maintenance of ecosystem functions that are valuable even though they may not directly meet human needs or desires. In this context, the anything-goes worry pertains to the relations between NEs, functional goals, and potential harms to existing ecosystems and to biodiversity, and it warrants more serious attention than it has received to date. The worry arises because ecosystem functions can be realized in different ways in different contexts, so that functional goals can seemingly be pursued without reference to historic species or ecological composition. The worry thus is that if policy-makers and practitioners promote NEs, they are accepting that functional goals take priority over historical and compositional ones, and that this in turn means that functional goals may (or even should) be pursued in ways that are likely to be detrimental to current and historic species and biodiversity.

Efforts to determine the best approach for ecological management thus face more than a mere worry: they face a serious problem, what we call the "Anything-Goes Problem." The traditional preservationist goals of the historical approach are rendered increasingly infeasible by anthropogenic environmental changes that are already taking place, and this means that continuing to embrace values that commit us to preserving or restoring historical species composition and habitats forecloses on the development of functional perspectives that could enable effective and ethical responses to worsening ecological crises. In a rapidly-changing world, these perspectives are important exactly because they are capable of recognizing the

[2] See, e.g., Norton's (1984) weak anthropocentrism and Sarkar's (2005) tempered anthropocentrism.

diverse ways in which novel ecological configurations can be valuable. Yet, as the anything-goes worry reveals, this inclusiveness is useful only if it is appropriately constrained. The Anything-Goes Problem (AG Problem) is thus: *How can appropriate goals for ecological management be picked out in the absence of historical benchmarks?* More specifically: *How can the functional approach in ecological management be strengthened to enable it to provide guidance in a changing world—i.e. to endorse some novel ecosystem states yet also to ensure that not anything goes*? The broad aim of this paper is to present a closer view of the AG Problem as it is revealed by discussions of NEs, and then to propose and explore an approach to solving it.

The section-by-section progression of our argument will be as follows. After considering the NE concept and its relation to functional reasoning about ecosystems, we examine policy and management contexts where the AG Problem seems especially pressing (§2). We identify numerous substantive motivations for worrying about the problem (§3), before going on to show that it can be solved by correcting two mistaken assumptions that tacitly inform many functional perspectives in ecology: the assumption that ecological functions can often be treated as separate and independent properties, and the assumption that the trajectories of ecological processes can often be treated as convergent. These mistaken assumptions are corrected by enriching the functional perspective to take better account of cross-scale functional integration and to recognize the importance of path-dependence in ecological processes. Our analysis highlights research in biology, geography, and various social sciences, showing that Earth systems and human societies and institutions are functionally integrated at multiple scales and that the functional workings of interlinked social and ecological systems are typically path-dependent. We show that such functional integration and path dependence contribute to showing that not "anything goes" even where "novel" functional goals take priority over historical ones by restricting the space of possibilities for ecological interventions (§4). Finally, we argue that an appropriate ethical framework plays an essential role in solving the AG Problem, by providing grounds for valuing ecological functions. The ideas of virtue ethics, adapted to take account of the ways in which human lives are embedded in social-ecological systems, align fruitfully with enriched conception of ecological function that we have articulated. Together, these elements provide the resources needed to resolve the AG Problem and to illuminate some broader issues concerning ecological management in a changing world (§5).

2. Novel Ecosystems?

A comprehensive and frequently cited definition of NEs is offered by Hobbs et al. (2013), suggesting that:

> [a] novel ecosystem is a system of abiotic, biotic and social components (and their interactions) that, by virtue of human influence, differ from those that prevailed historically, having a tendency to self-organize and manifest novel qualities without intensive human management. Novel ecosystems are distinguished from hybrid ecosystems by practical limitations (a combination of ecological, environmental and social thresholds) on the recovery of historical qualities. (Hobbs et al. 2013:58)

Several aspects of this characterization warrant special attention. First, it is grounded in a recognition of the ongoing transformation of the earth that some have dubbed the Anthropocene. It is increasingly clear that interconnected global-scale systems significantly impact local conditions across the Earth's surface and that human activity is affecting these systems in historically unprecedented ways. Geologists now suggest looking back at the Holocene, the "modern" epoch, as the brief period when Earth systems remained unusually stable; making possible the establishment of agriculture and the kinds of human social organization that agriculture supports as well as the broad patterns of ecosystem configuration that have coexisted with the ever-expanding human ecological footprint. Our current Anthropocene epoch is then marked by massive human disruption of the global patterns characteristic of the Holocene. This shift motivates the qualifying of emerging ecosystems as "novel," and is why anthropogenic elements feature in this account of NEs.

Second, this definition takes a certain metaphysical stance by presupposing the existence of multi-equilibria and threshold dynamics that impact ecological functioning (see Hobbs and Suding 2013; Holling 1998). More specifically, NEs are those that have been transformed by humans to such a degree that a new regime has replaced a historic regime type, where a social-ecological system has evolved into unprecedented, "novel," dynamic equilibria with respect to its composition, structure, and functionality. Yet, although NEs have anthropogenic origins, they are natural systems nevertheless because—having achieved new dynamic equilibria—they are autonomous in the sense that they needn't be maintained by intensive continuous human activity (see Pulliam & Johnson 2002; Ruiz-Mirazo et al. 2004). This regime-change also means that NEs diverge from a historical state sufficiently to have crossed a threshold that makes restoration to historic conditions impracticable: this condition is critical because it bars the use of historical goals. The restoration threshold can be crossed through landscape modification, climate change, or social developments that disturb historic trajectories.

Between the extremes of "historic" and "novel" ecosystems, we have a continuum of more or less "hybrid" systems where some human modifications have taken place but the restoration threshold has not yet been crossed (Higgs 2012). Exemplary hybrids include the many systems in which non-native species or life forms that are present as a result of human influences have been naturally functionally integrated, but these changes are not yet irreversible. This is often the case with forested areas close to a dense human population: in Southern Ontario for instance, several exotic species such as the European buckthorn (*Rhamnus cathartica*) or the Norway maple (*Acer platanoides*) have had a great impact on the ecological landscape, but the seedbed still contains the fruits of the historical ecosystem, such that restoration could still be achieved.

The origin of NEs can be gradual, involving an extended period in a hybrid state until the interacting ecological and social dynamics pass a point of no return. They can also be more abrupt and intentional. For example, Graham et al (2014) survey numerous reef ecosystems that have rapidly transitioned into novel systems in recent years due to differential responses to climate change, range shifts, and species introductions. For instance, as reef corals have extended their range northward as quickly as 14 km/yr, in response to climate change, more highly mobile organisms (such as coral dwelling crab species) have also extended their ranges northward, creating expanding novel reef systems in areas where such systems have not been found before (ibid. 2014, p. 10). Similar range shifts and associated novel species-compositions are being seen in Australia, as corals extend their ranges southward and “tropical fish species are mixing with temperate fish species down the coast beyond Sydney leading to novel compositions and interactions” (ibid.). Many instances of NEs that are both rapidly established and intentional can be found in the literature on phytoremediation of brownfields, where non-native and engineered species are often used to make novel phytoremediation forests (Cundy et al 2016 discuss a large number of such NEs across Europe). Independent of their origin and pace of development, again, the practically significant feature of many NEs is that historical states are no longer an option as a feasible management goal. So, as we enter an era in which NEs are becoming ever more common (Perring and Ellis 2013), it is vital that we develop a theoretical framework capable of guiding management choices between different novel ecological configurations.

In light of this fuller picture of what NEs are, it is easy to see why their recognition and integration in ecological management is generally accompanied by some form of functional reasoning. The main reason for this state of affairs is quite simple: as historical goals become inaccessible and the goal of intervention moves away from historical fidelity, ecologists and ecological managers seek new ways of comparing ecological configurations, turning to functional characterizations of ecosystems and the human benefits that they provide, and to ways of understanding novel configurations that do not merely treat these as perturbations of historical ecosystem states. Of course, the study of any ecosystem, novel or not, is often tied to economic or practical interests, and thus to the recognition that ecosystems provide a host of services for, or functions that benefit, humans. These include provisioning food, water, timber, and fiber; regulating climate, floods, and wastes; and providing various recreational, aesthetic, and psychological benefits. But *functional* thinking about ecosystems needn't be interpreted under this limited, anthropocentric, guise. As Jax (2010) argues, ecologists making functional attributions often embrace a broader notion that sees an ecological function merely as a process whose outcome might be beneficial or not for different organisms. So, "ecosystem services" are functions—because they are processes within ecosystems—but happen to be functions that can benefit us. Under this interpretation, assuming that all functions must be analyzed from the viewpoint of their significance for our species is a mistake, for clearly any list of ecosystem functions can extend further than economic, aesthetic, and recreational services. Processes such as nutrient and water cycling, decomposition, or climate regulation are all examples of general functions whose effects can benefit many life forms, including humans, but which might not be tracked by traditional conceptions of economic or use valuations.

One of the advantages of historical goals for ecological management is that they are comprehensive—they take account of all aspects of an ecosystem, rather than picking out just a few aspects as the ones that matter. Making good choices in light of functional goals, including choices about NEs, similarly requires adequate consideration of the full range of processes in play in the ecosystems under consideration and of the diverse kinds of benefits they bring to humans, to other organisms, and to larger wholes both social and ecological. We thus agree with Light et al. (2013), that the evaluation of NEs should involve consideration of ecosystem functions in a way that takes account of diverse sorts of values that can focus the importance of different ecological functions. But in practical terms, the call to consider all aspects of ecosystems in choices about them rings hollow—the complexity of most ecosystems makes it impossible to obtain the kind of comprehensive picture that seems required. This practical difficulty sharpens the AG Problem by requiring that many features of ecosystems be ignored in evaluated them, and is vividly displayed in certain contexts. The next section examines some of these contexts and their implications for the AG Problem, laying the groundwork for a consideration of how rethinking the place of values in ecological management can contribute to solving the AG Problem.

3. Practical Contexts for the Anything-Goes Problem

Objections to the recognition of NEs rooted in the AG Problem have focused on the danger that individuals or businesses will be able to justify activities that degrade existing ecosystems by arguing that they are creating NEs that provide ecosystem services. Such an argument would of course require that the services provided by the NE be weighed against those lost with the original ecosystem. Just this kind of case is perhaps still only a hypothetical possibility, but the increasingly common practice of *ecological compensation* is a reality that is similar enough to these hypothetical cases to show that the AG Problem must be taken seriously as a practical issue. In ecological compensation, conservation or restoration in one location is counted as compensating for ecological degradation in another, so that a company (for example) can engage in ecologically destructive activities yet be assessed as causing no net ecological damage because the effects of those activities are balanced against conservation or restoration that it pays for elsewhere. Ecological compensation is not always associated with NEs, but this practice offers an important context for considering the functional valuing of NEs for two reasons. One of the common ways in which NEs are created is as an unplanned effect of functional "renaturalization" without historical fidelity after resource exploitation. The difference between the functions of the NEs thus created and the lost functions of the original ecosystem must be compared with the compensating intervention elsewhere in assessing net ecological impact. A second role for NEs in ecological compensation is not yet common, but likely to become increasingly so: the planned creation of sophisticated NEs as a form of compensation.

Biodiversity offsets are a paradigmatic form of ecological compensation. According to the Business and Biodiversity Offset Program (BBOP):

> Biodiversity offsets are measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken. The goal of biodiversity offsets is to achieve no net loss and preferably a net gain of biodiversity on the ground with respect to species composition, habitat structure,

ecosystem function and people's use and cultural values associated with biodiversity. (BBOP 2016)

The BBOP and similar compensation frameworks recommend using offsets only as a last resort in a series of mitigation actions. They also call for impact assessments and insist on the involvement of stakeholders. Yet, the language they use here already begins to reveal the problems inherent in the concept of ecological compensation. It is misleading to present offsets as "conservation outcomes." The supposition that it is possible to promote conservation while engaging in the development of roads, highways, or mines that will cause ecological damage, because this damage is "offset" in other places, is dubious at best. It is thus more accurate to understand an offset as a "mechanism for pricing certain negative environmental externalities into development projects" (Bull et al. 2012, 371).

Even on its own terms, however, the practice of employing such offsets involves obvious difficulties in defining and measuring the features that the offsets are supposed to protect (Bull et al. 2012). The idea of 'no net loss' presupposes that we have clear ways to measure, compare, and sum features that are ecologically valuable in a selected place. However, we will see that the reality is that there are neither universally applicable, nor clear, principles of equivalence for systemic compositional features (like biodiversity) or functionality—especially when dealing with out-of-kind trades (e.g., replacing environmental damage due to a certain type of area or life form by promoting an area or life form of another type). In this context, the AG Problem appears as a substantive practical problem.

Consider oil sands extraction, mining, and extensive tree harvesting, which are known to be extremely disruptive for long periods of time. A common form of compensation for these activities consists not in restoring the same area after exploitation, but protecting other areas of equivalent or larger superficies. For instance, Shell Oil in Canada has "committed to spend $2 million over ten years to help mitigate, and partially offset, land and habitat disturbances resulting from existing mining operations."[3] The money will mostly be used to protect some existing forest in Alberta containing mixed natural habitats such as woodland, wetland and grassland, and restore some areas that were used for agriculture into Boreal forest. Although efforts like these can prevent further habitat degradation and promote ecosystem services, determining whether the newly protected sites will actually compensate for losses resulting from oil mining is impossible.

To be able to show that compensation, or "offset," will occur, there would need to be a transparent way to assess and compare the ecological composition and functionality of the two sites, and the value of different kinds of such composition and functionality. As noted above, NEs could become common currency for realizing such out-of-kind trades, and would raise the same type of valuation and commensurability issues, complicated by the fact that the trade now involves a "kind" that has no natural match against which to calibrate its value (Quétier and Lavorel 2011, Poulton 2015). For example, making the case that prairie or wetland displacement for housing development can be compensated for by planting islands of NE forest within and around a city requires devising some metrics by which the diversity and ecological functions of an area of one ecosystem type is comparable to the diversity and ecological functionality of another area of a different type. Without clear regulations based on well-grounded principles of equivalence, commensurability cannot be demonstrated and the very idea of 'offset' becomes questionable.

Along with this measurement problem comes the challenge of prioritizing which processes and features should be restored or protected, a step commonly called the choice of

[3] http://www.shell.ca/en_ca/sustainability/environment/land-conservation.html#tnf, accessed January 9, 2017.

Valued Ecological Components (VEC) in the context of Environmental Impact Assessment (EIA) (Duinker and Greig 2006). Here the problem is further complicated by the fact that complex system properties such as biodiversity and ecosystem functioning must be assessed and monitored by using proxies; in particular, processes and features that can be observed and measured to give an indication of the state of VECs. As is pointed out by other philosophical analyses of biodiversity (e.g., Sarkar 2005, Maclaurin and Sterelny 2008, Casetta and Delord 2014 and references therein), even if several measures of biodiversity exist, there remain important conceptual ambiguities that make the choice of proxy a difficult and controversial matter. We will not repeat what can be found elsewhere, but instead will briefly spotlight another VEC that has received less attention: ecosystem functioning. Like biodiversity, ecosystem functioning, or quality of functioning, is VEC for which it is difficult to find satisfactory proxies.

We have already noted the range of senses associated with the term "ecological function." The concept of *ecological functioning* is similarly difficult to pin down. Often studies on 'ecological functioning' offer no definition of it at all, and those that do tend to be rather vague (see Jax 2005, 2010, and Picasso and deLaplante 2011 for analysis). The holistic nature of the notion of functioning makes it particularly difficult to characterize and study. A typical treatment sees such functioning as the overall performance or sum of activities taking place within a system. Of course, researchers cannot track all activities taking place in an ecosystem and they must choose carefully the properties that reflect the overall performance of an ecosystem. However, this situation can result in a lack of conceptual clarity about ecosystem functioning when researchers don't see the need to be very precise about such properties (cf. Sagoff 2013) because all they need to do is operationalize "functioning" by using plausible proxies.

The problem at hand is comparable to measuring health. An organism's health, like an ecosystem's overall functioning, encompasses a multiplicity of elements and processes that are known to depend on the inner workings of the organism and external background conditions. When assessing health, researchers and health professionals measure things like heart rate, blood pressure, glucose level, etc. In doing so, they do not assess all the variables that matter for the general healthy functioning of their subject. They simply look at processes recognized as *informative about* the systemic functioning we call health. Ecologists make the same kind of inferences; they look at indicators of the inner workings and performance of ecosystems.[4]

There is, however, a lot of room for interpretation when choosing ecological proxies. The latter include the magnitude of certain key processes (e.g., productivity, resource use, decomposition, nutrient cycling), the size of relevant pools (e.g., biomass, carbon storage), the presence of characteristic food-web structures (e.g., number of trophic levels, connectivity), as well as some indicator of stability (e.g., extinction risk, resilience, compositional stability). While having options is often a good thing, here options mean that finding a generally adequate proxy for assessing ecosystem functioning is not straightforward, for different proxies can be appropriate for different cases. Yet there is little agreement about the essential variables that ought to be measured in different contexts (Jax 2010:57). Without adequate regulatory guidance, the need to use proxies to assess functioning can rapidly lead to situation in which, from a practical point of view, anything goes. If environmental guidelines leave open how to interpret and operationalize ecological functioning (or whatever system property enters into the consideration of the ecological value of a place), then developers and assessors could pick and

[4] Jax (2005) and deLaplante and Picasso (2011) observe that the analogy we make here can be dangerous because ecosystems, unlike organisms, are almost always instrumental entities; they are delimited by the researchers, but they are not as clearly identifiable as organisms. We are not going to engage here in this debate, but simply mention that the boundaries of ecosystems are not always as clear as the analogy with organismal health seems to suggest.

choose whatever indicator is convenient. An acceptable offset could thus, for example, be a place that merely has a similar size, productivity, and carbon sequestration capacity, or one that supplies comparable elements that a restricted number of protected or charismatic species need. Here the AG Problem thus appears very real.

Endorsing an excessively liberal attitude in choosing and assessing ecological indicators is problematic for at least two reasons. First, if there is too much latitude for choice of proxy to be used as an indicator of general functioning, then researchers and managers may settle prematurely on the few that prove easiest to measure. The danger here would be to assume that any other processes involved in overall ecological functioning are adequately accounted for by the most accessible proxies. Making such an assumption would be like assessing overall health by taking a patient's temperature alone. Second, if managers rely uncritically on indicators or proxies, aspects of ecological functioning may be ignored and possibly altered to the detriment of an ecosystem. On this point, Duinker and Greig (2006) highlight a knowledge gap about the response thresholds of many VECs, emphasizing the unfortunate tendency to treat this absence of evidence as evidence of absence. The results can be catastrophic, as in the notorious case of the collapse of the North Atlantic cod population and fisheries (see Bavington 2010).

We saw, in Section 2, that the introduction of NEs in ecological management opens the door to the pursuit of functional goals, raising worries about the ability of these goals to provide effective guidance for ecological management. This section has reviewed practical contexts in which these worries are justified, and the AG Problem proves to have substantial force, showing that one of the main difficulties arising in the study and realization of ecological functions, and functioning, is that simple proxies are rarely adequate to gauge the performance of complex systems such as organisms and ecosystems. The following sections will propose a shift in perspective that can guide researchers and decision-makers away from unwarranted assumptions that underlie the uncritical use of proxies as well as other misapprehensions in the valuing of ecological functions—and that can thereby help to solve the AG Problem.

4. A Shift in Perspective on Function and History

In this section, we highlight research showing that Earth systems and human societies, including their institutions, are functionally integrated at multiple scales—from the very local to the global—and that the functioning of interlinked social and ecological systems are typically path-dependent. Accordingly, we defend a functional perspective that suggests using multiple indicators and complex socioecological indices to evaluate environmental policy and management strategy options (cf. Hobbs et al. 2014; Quétier and Lavorel 2011:2993). We contend, moreover, that the integration and path dependence of socioecological systems offer reasons one should *not* conclude that "anything goes" even if "novel" functional goals are given priority over historical ones—since the composition of a social-ecological system (in the form of biodiversity and specific life forms) and its history (and historicity) are key aspects that shape and constrain its functioning whether or not it is novel.

4.1. Two functional approaches

This section considers the relationships between functional systems at different scales, from individual organisms, to local ecosystems, to Earth systems at the global level, and considers the problem of ecological management for NEs against the global background of the Anthropocene. Increasingly, scientists, environmental activists, stakeholders, and policy-makers cast the challenges of the Anthropocene in functional terms, urging the importance of finding responses that correct, support or improve the operation of disrupted ecosystems and other Earth systems at every scale. Their ideas about what this means are extremely disparate, however. Two differing conceptions of natural functions and human relations to them seem to shape how one may understand the salient problems and possible solutions.

The received perspective focuses on physical and industrial processes, understood in mechanistic terms; treating human activity and natural processes as fundamentally distinct while aiming to develop ways for humans to control the global "machine." Mainstream climate change mitigation and geoengineering plans both take this approach. Research and planning using this approach takes for granted the values that make economic growth and industrial development central aims, and seeks ways of intervening in earth systems that will ensure that these values can continue to be satisfied. Where ecological functioning is in question, this approach easily accommodates seeing it through the lens of ecosystem services. This isolates for attention those effects of ecosystems that have direct value for human beings, thus separating the non-human ecosystem components (as service providers) from human consumers, and also separating these effects from each other as providing different services. This common approach has a characteristic epistemic style: it is reductive, seeking explanations of the functional behavior of complex systems in the categorical properties of their parts, and tends to foster confidence that current science already has the key factors well in view. It does not expect big epistemic or practical surprises, and seeks to control natural systems so as to avoid the latter. It encourages the uncritical use of simple proxies for complex functioning that we examined in the last section. We agree with the numerous critics who argue that this approach is inadequate on many counts to provide guidance through the crises of the Anthropocene (see, e.g., Walker and Salt 2006; Scott 2012).

A different approach—increasingly visible in public discussions—focuses on the role in Earth systems of organisms, ecosystems, and other complex adaptive systems, where these are understood in inherently functional terms. We call this the ‘geofunctional perspective.’ It sees biological systems and their abiotic environments as deeply causally interlinked—with ecosystems affecting patterns of temperature, wind, precipitation and hydrology, for example—and aims to repair, restore or improve the integrated functioning of Earth systems.

Projects that use the theoretical framework and methods of complex dynamical systems theory, such as Limits to Growth, the work of the Resilience Alliance and the new Planetary Boundaries initiative, are key contributors to this kind of understanding. So too are projects that make explicit the shift in social values and epistemic assumptions that can be part of this approach, such as the array of initiatives brought together under the label of “agroecology.” What these diverse efforts have in common is a broad perspective that sees Earth systems, including human activity, in functional terms and as globally integrated—this is the ‘geofunctional perspective’ (GFP).

As applied to ecosystem functions, the GFP pays attention to the network of causes that give rise to effects at different organizational levels and contribute to the persistence of large-scale causal patterns. Where humans contribute to such effects—or disrupt them—their activities must be included in a geofunctional understanding. Thus, the GFP pays attention to both social and ecological aspects of the functioning of social-ecological systems. Research and planning using this approach expresses diverse values, but tends to seek resilience rather than mechanical control, and questions the goals of traditional industrial development. This approach also has a characteristic epistemic style: it looks for complexity, non-linearity, interdependence, and cross-scale interactions, and as a result expects that much important information has yet to emerge. It expects surprises and recognizes the need to integrate them into its models and management plans (Norton and Steinemann, 2001).

We submit that the GFP is a better guide for dealing with the various challenges of the Anthropocene than the received mechanistic perspective, and should therefore be at the heart of thinking about NEs. As explained in Sections 2 and 3, opposition to NEs and their promotion in ecological management is tied to the worry that NEs provide a license to trash historical natural habitats for economic benefits. The factors that give some teeth to this worry are numerous, many of them relating to the functional reasoning that comes with NEs. Against this background, the worry about NEs can be seen to give rise to a substantial problem about how functional thinking about ecosystems can guide choices in the changing world of the Anthropocene without opening the door to too broad a range of outcomes—the AG Problem. So far, our analysis has shown that the AG Problem depends partly on how the world is (i.e., the fact that ecological functions can often be realized in different ways), but also on how it is represented (i.e., our understanding of what functions and functioning are, and of what interventions could deliver some of them).[5] The GFP is especially relevant for the latter consideration. It acts as a cure for the AG Problem by highlighting the fact that we need to build representations that emphasize how functions and functioning are not simple and isolated properties that can be managed locally.

The valuing of ecosystems with novel functions and functioning should thus include a reflection on the ramifications of functional integration and multiscalar interactions. In the context of ecological compensation, for example, taking a GFP could require developing metrics that offer a more comprehensive view of ecosystem functioning. To reduce the risk of ending up

[5] Ethics and values are also important players in this story, especially short-sighted instrumentalism. But as mentioned earlier, we are not analyzing this aspect of the worry in the present paper.

with ecologically simplified and dysfunctional ecosystems, we suggest that environmental decision-makers and stakeholders should endorse a rich notion of functioning; one that considers how various processes at different scales are integrated together in the creation of dynamical equilibria, and how their activity is linked to other systems as well (Donhauser 2016). Under the GFP, to count as a functionally equivalent place, a restored or protected site will need to have more than a certain productivity, or capacity to store carbon, or the presence of a few selected species. It will also need to be equivalent with respect to decomposition, hydrology, and disturbance regime, to take just a few examples. This entails that the ecological integrity and value of a place must be assessed through complex, multi-dimensional, "functioning indices" rather than through simple proxies.

One of the consequences of adopting such a functional perspective will be that environmental assessment and management become more difficult to achieve because it encourages lumping instead of splitting components (Standish et al. 2013); targeting multiple components requires managers to seek conjunctions (A and B) instead of disjunctions (A or B) of components, which means that the probability of success must be lower. On the other hand, it will result in guiding action toward alternatives that not only are good for a restricted number of isolated ecosystem services, but also take account of the role and persistence of various entities and processes that contribute to the overall performance of social-ecological systems.

To illuminate how shifting to the GFP can impact environmental research and decision-making, consider how the GFP might affect the research on ecosystem functioning, and more particularly the development of a trait-based understanding of ecosystem functions. One of the objectives of this research program is to discover whether the presence of certain organismal traits correlates with a subset of ecosystem functions and services (Lavorel and Garnier 2002;

Sudding et al. 2008). It is proposed that this type of knowledge could help to predict the effect of functional trait diversity change on ecosystem properties. Furthermore, obtaining lists of ecosystem properties and the organismal traits that tend to produce them could assist restoration and conservation biologists who are trying to facilitate the evolution of ecosystems toward a selected set of desired properties. In this context, the GFP would urge the need to see the contingency of these relations and flesh out the conditions enabling the associations between traits and properties in a way that would prevent simplistic representations of these relationships. In exploring these enabling conditions, the GFP would especially insist on uncovering the role of broad social-ecological factors as well as other natural processes, an approach with particular importance for the understanding and management of human-influenced NEs.

An example of what we have in mind here is the case of Sudden Oak Death (SOD), a disease affecting many species of oaks that has already killed an estimated 5 - 10 million trees in California and threatens similar damage to forests in eastern NA and the UK. SOD is caused by an (apparently) non-native fungus-like pathogen (*Phytophthora ramorum*), a generalist species that can affect many types of plants, with far-reaching effects for the vertebrate and invertebrate fauna that depend on them. The genus *Phytophthora* is also associated with various plant epidemics throughout America, Europe and Australia. Researchers in California noted over ten years ago that fire suppression might be one of the reasons for the catastrophic spread of *P. ramorum* (Moritz and Odion, 2005), observing that infected trees were very rarely found in areas that had burned after 1950. Yet plant pathologists studying the disease focused their attention—and recommendations for intervention—on the traits of host trees and of the pathogen itself, investigating strategies such as using fungicides to kill the pathogens, cutting down susceptible trees to contain the spread of infection, or breeding disease-resistant seedlings and using them to replace lost populations. Only much more recently have pathologists begun to investigate the role of fire, and the mechanisms by which fire—or a recent history of fire—might enhance trees' resistance to SOD. Moreover, while many North American oaks and a few other species are particularly susceptible to damage caused by *P. ramorum*, and this pathogen is indeed a particularly virulent disease agent for those species, the widespread changes in wildfire patterns and in age and species distributions in forest trees caused by human activity over the past hundred years are likely to be important factors in unexpected epidemic outbreaks of other pathogens and pests as well. One interesting possibility connected with this suggestion is that aboriginal Californians may have practiced extensive management of forest and savanna landscape using fire, so that the structure and distribution of forest ecosystems in this region may have been shaped by the fire regime imposed by human inhabitants. So, in looking for the conditions that promote the existence of diverse and healthy forests, solutions should not be sought merely in associations between organismal traits and ecosystem properties, but also in social-ecological interactions that often act as preconditions. Taking a GFP could thus play a valuable heuristic role here, by encouraging researchers to investigate more broadly the conditions that can bring about an effect. By highlighting the interplay between levels of functional organization, between biotic and abiotic processes, and between social and ecological factors, the GFP thus shows that an enriched functional approach has far more extensive resources for solving the AG Problem than a more reductive and mechanistic functional approach would suggest.

4.2. History matters

This section will provide another factor contributing to the ability of a functional approach to rule out many interventions as harmful or risky, and to pick out relatively few—though including some NEs among this number—as contributing to valuable ecological outcomes. Simply put, this reason is that history matters. The idea that history and historicity matter has received various interpretations in science. In ecology, it is often used to motivate the traditional restoration objective of returning a place to its pre-disturbance state (Higgs 2003). But at least since the 1970s-80s it is also used to emphasize the fact that the order and timing of events in community assembly can make a difference (MacArthur 1972, Sutherland 1974, Chase 2003, Fukami et al. 2015, Kingsland 1995 Afterword). After Desjardins (2015), we distinguish between these two ideas by naming the former "historical fidelity" and the latter "path dependence." Here our focus will be on path dependence.

For present purposes, we define 'path dependence' as a probabilistic causal relation between the history of an ecological system, i.e., the ordered and timed sequence of events leading to its formation, and the structure and/or functioning of that system.[6] To see the ramifications of path dependence, suppose that a certain number of patches in a region are suddenly made available for surrounding species in the region to occupy after some perturbation. The type of perturbation will likely influence what species will do well, but leave this aside for the moment and assume that these "bare" patches all have their origin in the same type of disturbance. Now, further suppose that there is connectivity between local communities such that the group of species composing the regional pool can all visit these patches at some point after the perturbation. But what changes from one local community to another is the order and timing of arrival of these species, or what ecologists call the assembly history. As is illustrated in Figure 1, path dependence would hold in this situation if the assembly history is a difference maker such

[6] Systematic theoretical analyses (MacArthur 1972, Chase 2003) and empirical evidence (Drake 1991, Ehmann and MacMahon 1996, Palmer et al. 2002) of path dependence in ecology have been reported for many types of ecological situations. Most analysis of path dependence have focused on community composition, but not exclusively. Fukami and colleagues (2010, 2015) for example could prove that the order and timing of species arrival can also affect the functioning of community of decomposer.

that the species composition and/or functioning differs from one place to another. If on the other hand all the local communities have the same composition and/or level of functioning despite differences in their respective assembly history, then this convergent outcome is path independent.

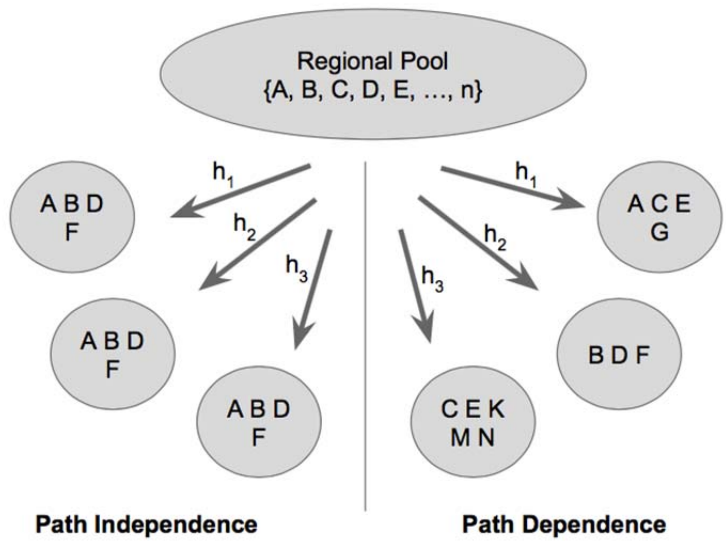

Figure 1. Difference between path independence (left side) and path dependence (right side) in the formation of local ecological communities. Capital letters stand for different life forms. Small grey circles represent local communities. Each h_n represents a particular assembly history. Representation based on Chase (2003).

The impact of path dependence on how we conceive of ecological systems and our ability to intervene on them is profound. First, due to the stochastic nature of the causal factors at play (i.e., order and timing of events), and the fact that things could have been otherwise, path dependence implies that ecological systems are to a certain extent unpredictable. Second, and perhaps more importantly for the present analysis, path dependence implies that interventions to produce a certain effect can be importantly constrained by history. If ecological systems were path independent, then ecological restoration or management could be much simpler. Returning to past composition or bringing about some type of function would be a matter of making sure that the right set of species or traits are present in the region under management. However, if the sought composition or function depends on the order and timing of biotic and abiotic events, then interventions acquire a whole new degree of complexity. Without careful attention to the history of the formation of an ecosystem, and management of the ongoing processes of change in light of the constraints imposed by its earlier history, the feasibility of a desired goal might be very low. The upshot is that *not anything goes* when history matters: a functional approach to valuing processes and states in a path-dependent ecosystem has resources for ruling out many interventions as leading to paths that cannot eventuate in desired (or desirable) outcomes. This conclusion can be further specified by acknowledging that path dependence comes in degree (Desjardins 2011), which means that there are different ranges of sensitivity to the trajectory of a system. This implies that very few things “go” when history matters a lot, whereas greater latitude is available when a sought outcome can be reached by various trajectories.

Finally, a third implication of path dependence is that ecosystems often acquire a kind of historical depth. For example, the presence of a given function or degree of functioning cannot be reduced to a neat set of proxy species, properties, or traits. Path dependence in the context of ecosystem functions entails that certain properties would not manifest themselves unless certain extended series of events, occurring in given order and timing, had already taken place. Again, degrees of path dependence will result in different historical depths. But this type of counterfactual could not be captured by purely proxy-based approach that presume convergent trajectories.

Combined with the GFP (Section 4.1), this fact about historical depth immediately suggests that the history of human societies and the history of the rest of nature are closely related.[7] Appreciating this (seemingly obvious) fact can profoundly influence how we value the rest of nature, for one cannot value a certain function without also considering the (possibly irreproducible) historical processes that brought it into being. If NEs are conceived as mere sets of functions procured by the presence of organismal traits, then it becomes more plausible to look at them as resource pools available for businesses to exploit and transform at will, or as mere collections of artifacts put together without historical connection with the people who happen to live with them. If this is the metaphysical picture that comes with NEs, then it is not surprising that they draw so much criticism. But if the promotion of NEs necessarily involves caring about *how* they come to be, because we understand that their state and value is inseparable from where they come from, the picture changes in important ways. First, it gives a reason to value historical fidelity to existing social-ecological configurations. Second, it implies that good management of NEs requires attention to the ways in which people contribute to the development and maintenance of NEs over time, a shift with potentially far-reaching implications. Taking the historical social-ecological trajectory of NEs seriously in choosing goals for management might, for example, motivate the adoption of management scenarios that include various stakeholders early and throughout the management process, fostering stakeholders' sense of responsibility and identity with the social-ecological system they occupy.

Both functional integration and path dependence thus imply that the degree of multiple-realizability of ecosystem functions and functioning is much less than is usually presumed, and as such contribute to solving the AG Problem (cf. Hobbs et al. 2014). Effective policies and

[7] This point was also one of the founding principles of the environmental history movement (Worster 1988). Turner 2014 provides robust examples.

management strategies must attend to both functional integration and path dependence. Yet, even the fullest understanding of these aspects of ecological functioning cannot solve the AG Problem. To do that, constraints are needed to guide policy and management strategy planning—to pick out some ecological functions as good, and bar others as insufficiently so. These constraints must thus take the form of values. Direct consideration of the values that properly guide ecological management in a changing world, and the ethical principles that underpin them, is thus essential to solving the AG Problem.

5. Ethical Strategies Must Consider Functional Integration and Historicity

We thus turn last to an explicit consideration of an aspect of ecological management that has been present implicitly in this discussion from the beginning: the question of values. Values have played a paradoxical role in the NE debate—a role that is central, but often cryptic. Historical goals hide the values that motivate them. |Once we agree to value historical states, for whatever reason, no further value judgments are needed except in choosing strategies or tradeoffs: the comprehensive nature of historical goals takes care of all decisions. Values are thus hidden in the background—their role is to motivate the historical approach, not to guide its interpretation.

The situation is very different for the functional approach. Here, once we agree to value ecological functions, the evaluative work is almost all still to do. We need to agree further on an interpretation of this approach: on which functions are valuable, and why. The AG Problem arises because some of the interpretations that are accommodated most easily within the context of the traditional reductive approach to ecological functions fail to capture what many people value in their relationships to natural ecosystems, and thus are overly permissive and open to abuse by self-interested actors. These interpretations are rooted in the broader assumptions of the reductive approach: in the sharp divide it sees between human "consumers" of natural goods and services and the ecosystems that provide them, in its atomistic perspective both on ecological functions and on human agents, and in its supposition that the properties that matter are context-insensitive and can be treated quantitatively. Against this background, it is natural to turn to an anthropocentric utilitarian ethical framework as the source of principles capable of guiding our choice of valuable functions, with the results that critics have noted: that despite the possibility of developing a more far-sighted anthropocentrism, the reductive functional approach is especially conducive to a shallow understanding of ecosystems as storehouses for human use, and of valuable ecological functions as those that serve current human preferences as expressed by market behavior. Here again the hard work of determining what is valuable is hidden in the background: individual preferences or market patterns make the choices for us, and the important values are those that motivate the choice of the preference-utilitarian principles as fundamental.

If the functional approach to ecological management is to overcome the AG Problem, it must do so by an explicit consideration of the value principles that are needed to rule out most possible novel ecological configurations as undesirable. Many environmental ethicists have argued recently that traditional utilitarian principles are ill-equipped to comprehend the complex interplays—between humans and non-humans, social and natural processes, intrinsic and instrumental goods, sentient and non-sentient life forms, and functional wholes at many levels—that characterize ecological systems. We agree, for the reasons noted above. Though a far more sophisticated utilitarianism could surely be combined with a richer understanding of ecological function to capture many of the values in play in ecological contexts, the utilitarian lens with its focus on interchangeable individual pleasures and pains is not the most revealing one to use in examining this issue. For similar reasons, we agree with environmental ethicists who have argued that deontological frameworks—with their emphasis on individual autonomy, rights, and duties—are also unhelpful for guiding the management of ecosystems in which interdependency, interpenetration, and causal entanglement between organisms and their environments are the norm.

Environmental ethicists have recently turned to other ethical frameworks, such as virtue ethics and ethics of care, as possible sources of insight and principles to guide ecological management in the changing world of the Anthropocene (Thompson and Benedik-Keymer 2012). We agree that both of these approaches have important insights to offer; both also align in useful ways with the richer understanding of ecological functions defended above. Our focus in this paper will be on virtue ethics.

Contemporary virtue ethics offers a way of thinking about human well-being that aligns interestingly with considerations about the functional values of NEs. One of the core concepts here is that of "external goods" needed for human flourishing. These are the sorts of goods that we might think of as background conditions for human psychological well-being and self-actualization. External goods, in general, are those goods outside of oneself that provide a basis for actualizing good human character. We need these goods to be moral humans and to realize our potentials *qua* human beings. For example, because we are social animals, having friends is an external good for us. But they cannot just be any friends—in friendship, not anything goes. To flourish we must have good friends who possess certain personal and social qualities (Stern-Gillett 1995; Cooper 1977).

Our environments, and thus the ecosystems in which we are embedded, can also confer a variety of external goods; inasmuch as they provide background conditions needed for "a good life"—a life in which someone is able to flourish. Just like friends, these cannot be just any environmental conditions. They also cannot just be conditions that enable us to live, or even to live well by biomedical standards or to satisfy our moment-to-moment preferences. Thinking about functional integration and historicity can help to uncover what makes social-ecological systems best able to confer the external goods that are needed for human flourishing. Among the key features of a "good environment" in this sense are the properties that enable it to support us in maintaining a certain degree of historical continuity in our own lives and in our social-ecological relationships, and in finding harmonious ways to integrate our lives with the rest of nature. The latter aspect also show the importance of putting human living into the ecological picture, and thus recognizing that part of what it is to live a good life is to contribute in the right way to ongoing social-ecological functioning of the systems to which we belong.

The implications of a view of flourishing that pays attention to ecological integration and historicity become apparent in light of two qualifications or caveats regarding how we must think about ecological external goods in the context of NEs. First, given that our thinking here is intended to aid us in finding adaptive responses to our changing world, it is vital that our conceptions of ecological good and human well-being too must be adaptive. Second—and more in line both with Aristotle's original view and with newer 'capability approach' framings of these considerations—"virtuous" management choices must be guided by a serious commitment to *facilitating access* to ecological goods.

On the first point, Thompson explains that: "any genuine virtue is a substantive manifestation of the good. Thus, genuinely new forms of human goodness entail new virtues, just as genuinely new virtues implicate new forms of the good life" (2012:214). Thompson argues, we think rightly, that a commitment to doing good in ecosystem management means recognizing, and valuing, novel ecological goods and novel forms of human flourishing that will arise as the natural world continues to change in the Anthropocene. In less technical terms, this is to say that doing what is best for human life will require realizing ecological conditions that will allow people to flourish, and to contribute to the flourishing of the social-ecological systems in which they are embedded, in the ways that they can in the climate-changed world. Taking such actions is supported by virtuous recognition of past failures and ongoing inadequacies in providing ecological means for living well, virtuous openness to new possibilities, and virtuous tenacity in the face of difficulty. Appreciating novel ecological features and learning how to harness their benefits is really nothing new, but our commitment to doing these things must be seriously strengthened given the extent to which environmental conditions are now changing and will continue to change (Light, Thompson, and Higgs 2013:257). As Sandler (2012) argues, climate change thus: "raises the salience of virtues related to openness and accommodation" associated with restoration, "weakens the justification for historical fidelity," and "raises the salience of reconciliation as a virtue" associated with climate change response and restoration.

The second consideration, that virtuous management strategies should facilitate access to ecological goods, derives from the simple Aristotelean idea that flourishing, or realizing human good, requires having both the inherent capacity to function excellently, and practical ability to do so *in situ* given the particularities of one's current environment (1098a6-13). Accordingly, if ecosystems offer certain environmental goods, but you don't have access to them, those inaccessible goods cannot play a role in allowing you to flourish to the extent possible (see Shockley 2014:209-10). We pause to bring this up because it also means that, inasmuch as ecological interventions are geared toward protecting and promoting human goods, *not anything goes*. Ecosystem management strategies, no matter how they incorporate historical and novel ecological features, will be better or worse for humans on the score of how efficiently they provide ecosystem services needed for human flourishing in each particular context. For example, “the good life” in Kau Hawaii, the Great Lakes, and Chandigarh at any given time will all be very different. Only those living in the second may harness the benefits of the calm quiet of a winter hike and only those in the last may harness the benefits of the biodiversity around Sukhna Lake.[8] This view of external goods as inherently local and contextual contrasts with the utilitarian perspective that sees goods as interchangeable and additive.

In this section, we have shown how the enriched functional perspective that we have articulated, and the ideas of virtue ethics, can work together to solve the AG Problem. Recognizing ecological functions as integrative and path-dependent constrains the space of possibilities for ecological interventions and NEs. The values drawn from virtue theory are amenable to development in ways that take account of human lives’ embeddedness in social-ecological systems, and provide the constraints needed to determine which ecological configurations “go” and which do not. The virtue-ethical perspective that we sketched shows that ethical adaptive responses to climate change should include managing ecosystems such that they provide external goods needed to flourish. Doing this will require realizing ecological conditions that will allow people to flourish in the ways that they actually can in the climate-changed world; it will also require taking account of changing context-dependent features and how to provide access to their benefits. Not anything goes in ecosystem management because context and history matter to realizing ethical management strategies, and ethics matters to the valuing of context and history.

In view of these considerations, we thus echo Higgs in embracing the notion of the “tempering virtue of history” (2012:84), and extend this vision with the idea of the “tempering virtue of functional integration.” We must embrace ecological novelty as “ecosystems pass over

[8] It is also clear that ecological history matters to people because people self-actualize, in part, by identifying themselves as belonging to (being-from) a place and integrating that into their identity.

the threshold where return to history is no longer practicable" (ibid.). Yet, we still have substantive practical and moral bases for maintaining historical ecological features and employing the tools and knowledge that conservationists and restorationists have spent decades developing. So, virtue ethics provides practical and moral bases that help to solve the AG Problem and suggest a more sophisticated position on NEs, policy, and management practices (see also Light et al. 2013, 265-267). Path dependence and the geofunctional perspective in the context of ecological management tell us that the history and the functional integration of each place presents constraints and potentials that should "anchor the choices we make regarding its future" (Hourdequin 2003:125). Though it may not be possible, and is sometimes unwise, to try to replicate historical ecological conditions, it is nevertheless wise to consider maintaining the fidelity of certain historical ecological features and to go forward trying to maintain ecological functioning in a way that is optimal in our human-changed, climate-changed, world (cf. Holland and O'Neill 2003:221).

6. Conclusion

Novel ecosystems offer some obvious and important benefits. Some novel ecological conditions enable the continuation of ecosystem services, for example by providing new resources to sustain an otherwise endangered biological population (Hallett et al 2013). Others can provide enhanced services. Take for example "designer ecosystems" including "biofiltration ecosystems designed for effluent treatment" and "green roofs that provide an improved building envelope" (Light, Thompson, and Higgs 2013:258). As another example, emergent NEs can be higher in biodiversity than historic natural systems, and can therefore be more resilient and provide a greater number of evolutionary pathways for certain species (Kowarik 2011; Tratalos et al 2007). NEs have also enhanced conservation capabilities by providing connectivity and ecological buffer zones (see, e.g., Kueffer & Kaiser-Bunbury 2014). Indeed, as Hourdequin effectively argues by looking at case-studies:

> [At many sites] managers recognize that past human uses have in some cases created the conditions for certain species of wildlife to flourish, and it is not clear why the ecological communities that existed two hundred years prior should prevail in importance over those that exist now. (Hourdequin 2013:124)

NEs can also provide a myriad of social benefits (e.g. recreation and education) by giving populations (e.g. underserved urban populations) access to greenspace and "wilderness" that they lack access to otherwise. Of course, emerging hybrid systems also serve as rich sources of information and opportunities for management experiments that can inform efforts going forward in our climate-changed world (Alberti et al. 2003 and Perring et al. 2012).

The promotion of these potential benefits has been met with a critical response, rooted in the worry that if we abandon the goal of historical fidelity in ecosystem management and embrace NEs, we will find ourselves no longer able to provide principled reasons—or effective regulations—to prevent unconstrained ecological exploitation or abuse. This paper has argued that the grounds for a principled solution to this "Anything-Goes" Problem can be found in an enriched conception of ecological functioning that sees social and ecological systems as functionally integrated across scales, and takes account of the path dependence of many ecological processes including the emergence of new ecosystems. Completing the solution of the AG Problem requires an appeal to an ethical framework capable of grounding the values that distinguish the ecological functions that should "go" from those that should not; an adapted virtue-ethics framework aligns well with our conception of ecological functioning to play this role. But this is only an in-principle solution. To ensure that the anything-goes worry is not realized in the practical and political world, enabling us to enjoy the benefits of NEs without giving away the ecological store to rapacious exploitation, requires that the shifts in perspective that we advocate here be taken up into policy and practice—a serious challenge beyond the scope of philosophical solution.

Works Cited

Alberti, Marina, Marzluff, John M, Shulenberger, Eric, Bradley, Gordon, Ryan, Clare, & Zumbrunnen, Craig. (2003). Integrating humans into ecology: opportunities and challenges for studying urban ecosystems. *BioScience, 53*(12), 1169-1179.

Bardgett, Richard D., and Wim H. van der Putten. “Belowground biodiversity and ecosystem functioning.” *Nature* 515, no. 7528 (2014): 505-511.

BBOP Advisory Group (2016). “The Business and Biodiversity Offsets Programme (BBOP): planning policies and projects to achieve a net gain of biodiversity.” http://www.forest-trends.org/documents/files/doc_5091.pdf

Beier, Paul, & Noss, Reed F. (1998). Do habitat corridors provide connectivity? *Conservation biology, 12*(6), 1241-1252.

Bull, Joseph W., K. Blake Suttle, Ascelin Gordon, Navinder J. Singh, and E. J. Milner-Gulland. “Biodiversity offsets in theory and practice.” *Oryx* 47, no. 03 (2013): 369-380.

Chase, Jonathan M. “Community assembly: when should history matter?” *Oecologia* 136, no. 4 (2003): 489-498.

Choi, Young D. “Restoration ecology to the future: a call for new paradigm.” *Restoration Ecology* 15, no. 2 (2007): 351-353.

Clark, E Ray, & Canter, Larry W. (1997). *Environmental policy and NEPA: Past, present, and future*: CRC Press.

Cooper, Gregory. “Must there be a balance of nature?.” *Biology and Philosophy* 16, no. 4 (2001): 481-506.

Cooper, John M. (1977). Aristotle on the Forms of Friendship. *The Review of Metaphysics*, 619-648.

Cundy, A. B., Bardos, R. P., Puschenreiter, M., Mench, M., Bert, V., Friesl-Hanl, W., et al. (2016). "Brownfields to green fields: Realising wider benefits from practical contaminant phytomanagement strategies." *Journal of Environmental Management, 184*(Part 1), 67-77.

Desjardins, Eric. “Historicity in biology.” PhD diss., University of British Columbia, 2009. DOI: 10.14288/1.0067848

Desjardins, Eric. “Historicity and ecological restoration.” *Biology & Philosophy* 30, no. 1 (2015): 77-98.

Donhauser, J. (2016). “Making Ecological Values Make Sense: Toward More Operationalizable Ecological Legislation.” *Ethics and the Environment, 21*(2), 1-25.

Duinker, Peter N., and Lorne A. Greig. “The impotence of cumulative effects assessment in Canada: ailments and ideas for redeployment.” *Environmental management* 37, no. 2 (2006): 153-161.

Drake, James A. “Community-assembly mechanics and the structure of an experimental species ensemble.” *American Naturalist* (1991): 1-26.

Egerton, Frank N. “Changing concepts of the balance of nature.” *Quarterly review of biology* (1973): 322-350.

Eliot, Christopher. “The legend of order and chaos: Communities and early community ecology.” *Handbook of the philosophy of ecology* (2011): 49-108.

Fukami, Tadashi, Ian A. Dickie, J. Paula Wilkie, Barbara C. Paulus, Duckchul Park, Andrea Roberts, Peter K. Buchanan, and Robert B. Allen. “Assembly history dictates ecosystem functioning: evidence from wood decomposer communities.” *Ecology Letters* 13, no. 6 (2010): 675-684.

Fukami, Tadashi. “Historical contingency in community assembly: integrating niches, species pools, and priority effects.” *Annual Review of Ecology, Evolution, and Systematics* 46, no. 1 (2015): 1.

Graham, N. A., Cinner, J. E., Norström, A. V., & Nyström, M. (2014). Coral reefs as novel ecosystems: Embracing new futures. *Current Opinion in Environmental Sustainability, 7*(Complete), 9-14. doi:10.1016/j.cosust.2013.11.023

Higgs, Eric. (2012). History, Novelty, and Virtue in Ecological. *Ethical adaptation to climate change: Human virtues of the future*, 81-85.

O’Neill, J., & Holland, A. (2003). Yew trees, butterflies, rotting boots and washing lines'. *Moral and Political Reasoning in Environmental Practice*, 219-236.

Hobbs, Richard J., Lauren M. Hallett, Paul R. Ehrlich, and Harold A. Mooney. “Intervention ecology: applying ecological science in the twenty-first century.” *BioScience* 61, no. 6 (2011): 442-450.

Hobbs, R. J., Higgs, E. S., & Harris, J. A. (2014). "Novel ecosystems: concept or inconvenient reality? A response to Murcia et al." *Trends in ecology & evolution*, *29*(12), 645-646.

Hobbs, Richard J. and Katharine N. Suding (Eds.) (2013). *New models for ecosystem dynamics and restoration*. Washington: Island Press.

Hobbs, Richard J., Eric S. Higgs, and Carol M. Hall. "Defining novel ecosystems." *Novel ecosystems: intervening in the new ecological world order* (2013): 58-60.

Holling, C. S. (1998). Two cultures of ecology. *Conservation ecology*, *2*(2).

Hourdequin, M. (2013). Restoration and history in a changing world: A case study in ethics for the Anthropocene. *Ethics & the Environment*, *18*(2), 115-134.

Kowarik, Ingo. (2011). Novel urban ecosystems, biodiversity, and conservation. *Environmental Pollution, 159*(8), 1974-1983.

Kueffer, Christoph, & Kaiser-Bunbury, Christopher N. (2014). Reconciling conflicting perspectives for biodiversity conservation in the Anthropocene. *Frontiers in Ecology and the Environment, 12*(2), 131-137.

Lavorel, Sandra, and E. Garnier. "Predicting changes in community composition and ecosystem functioning from plant traits: revisiting the Holy Grail." *Functional ecology* 16, no. 5 (2002): 545-556.

Light, Andrew, Thompson, Allen, & Higgs, Eric S. (2013). Valuing novel ecosystems. *Novel ecosystems: intervening in the new ecological world order. Wiley, Chichester*.

MacArthur, Robert H. *Geographical ecology: patterns in the distribution of species*. Princeton: Princeton University Press, 1972.

Maclaurin, James, and Kim Sterelny. *What is biodiversity?*. Chicago: University of Chicago Press, 2008.

Minteer, Ben A, & Miller, Thaddeus R. (2011). The New Conservation Debate: ethical foundations, strategic trade-offs, and policy opportunities. *Biological Conservation, 144*(3), 945-947.

Murcia, Carolina, James Aronson, Gustavo H. Kattan, David Moreno-Mateos, Kingsley Dixon, and Daniel Simberloff. “A critique of the ‘novel ecosystem’concept.” *Trends in ecology & evolution* 29, no. 10 (2014): 548-553.

Norton, Bryan G. “Environmental ethics and weak anthropocentrism.” *Environmental Ethics* 6, no. 2 (1984): 131-148.

Norton, Bryan G., and Anne C. Steinemann. "Environmental values and adaptive management." *Environmental Values* 10, no. 4 (2001): 473-506.

Odenbaugh, Jay. “On the very idea of an ecosystem.” In *New waves in metaphysics*, pp. 240-258. Palgrave Macmillan UK, 2010.

Palmer, Todd M., Truman P. Young, and Maureen L. Stanton. “Burning bridges: priority effects and the persistence of a competitively subordinate acacia-ant in Laikipia, Kenya.” *Oecologia* 133, no. 3 (2002): 372-379.

Perring, Michael P, Standish, Rachel J, Hulvey, Kristin B, Lach, Lori, Morald, Tim K, Parsons, Rebecca, . . . Hobbs, Richard J. (2012). The Ridgefield Multiple Ecosystem Services Experiment: Can restoration of former agricultural land achieve multiple outcomes? *Agriculture, ecosystems & environment, 163,* 14-27.

Perring, Michael P., and Erle C. Ellis. The extent of novel ecosystems: long in time and broad in space. *Novel ecosystems: intervening in the new ecological world order* (2013): 66-80.

Poulton, David W. “Biodiversity and conservation offsets: a guide for Albertans.” (2015). *Canadian Institute of Resource Law*, Occasional paper 48. www.cirl.ca

Pulliam, H. R., and B. R. Johnson. 2002. Ecology's new paradigm: What does it offer designers and planners? Pages 51-84 *in* B. R. Johnson and K. Hill, editors. *Ecology and Design: Frameworks for Learning*. Island Press, Washington, DC.

Quétier, Fabien, and Sandra Lavorel. “Assessing ecological equivalence in biodiversity offset schemes: key issues and solutions.” *Biological Conservation* 144, no. 12 (2011): 2991-2999.

Ruiz-Mirazo, K., J. Pereto, and A. Moreno. 2004. A universal definition of life: Autonomy and open-ended evolution. *Origins of Life and Evolution of the Biosphere* 34:323-346.

Sagoff, M. (2013). “What does environmental protection protect?.” *Ethics, Policy, and Environment, 16*(3), 239-257.

Sandler, Ronald. (2012). Global Warming and Virtues of Ecological. *Ethical adaptation to climate change: Human virtues of the future*, 63.

Sarkar, Sahotra. *Biodiversity and environmental philosophy: An introduction*. Cambridge University Press, 2005.

Scott, Dane. “Geoengineering and environmental ethics.” *Nature Education Knowledge* 3, no. 10 (2012): 10.

Shockley, K. (2014). Sourcing Sustainability in a Time of Climate Change. *Environmental Values, 23*(2), 199-217.

Stern-Gillet, Suzanne. (1995). *Aristotle's philosophy of friendship*: SUNY Press.

Standish, Rachel J., Allen Thompson, Eric S. Higgs, and Stephen D. Murphy. "Concerns about novel ecosystems." *Novel ecosystems: intervening in the new ecological world order* (2013): 296-309.

Suding, Katharine N., Sandra Lavorel, F. S. Chapin, Johannes HC Cornelissen, Sandra DIAz, Eric Garnier, Deborah Goldberg, David U. Hooper, Stephen T. Jackson, and MARIE-LAURE NAVAS. “Scaling environmental change through the community-level: a trait-based response-and-effect framework for plants.” *Global Change Biology* 14, no. 5 (2008): 1125-1140.

Sutherland, John P. “Multiple stable points in natural communities.” *American Naturalist* (1974): 859-873.

Thompson, Allen. (2012). The virtue of responsibility for the global climate. *Ethical adaptation to climate change: Human virtues of the future*, 203-222.

Thompson, Allen, and Jeremy Bendik-Keymer, eds. *Ethical adaptation to climate change: Human virtues of the future*. MIT press, 2012.

Tratalos, Jamie, Fuller, Richard A, Warren, Philip H, Davies, Richard G, & Gaston, Kevin J. (2007). Urban form, biodiversity potential and ecosystem services. *Landscape and urban planning, 83*(4), 308-317.

Turner, N. (2014). *Ancient Pathways, Ancestral Knowledge: Ethnobotany and Ecological Wisdom of Indigenous Peoples of Northwestern North America* (Vol. 74): McGill-Queen's Press-MQUP.

UNFCCC. (2015). Paris Agreement. from http://unfccc.int/paris_agreement/items/9485.php

Walker, Brian, and David Salt. *Resilience thinking: sustaining ecosystems and people in a changing world*. Island Press, 2006.