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MAKING ECOLOGICAL VALUES MAKE SENSE:

toward more operationalizable ecological legislation

Justin Donhauser

ABSTRACT
Value claims about ecological populations, communities, and systems appear everywhere in literature put out by leading environmental advisory institutions. This essay clarifies the content of such normatively significant value claims in two main steps. In it, I first outline the conception of ecological entities, functionality, and properties, I argue is operative in the background of modern ecology. I then assess the implications of that background theory for how policies and management strategy directives that refer to such entities, functionality, and properties, can be most reasonably interpreted and formulated.

INTRODUCTION

Value claims about ecological entities (e.g. ecosystems), their functionality (e.g. stability), and properties (e.g. biodiversity) take center stage in so-called "ecological" ethical and aesthetic theories. For example, the claim that the biodiversity in an old-growth forest imbues it with "value in and for itself" is an explicit value claim about an ecological property (Curry 2011, 4). And the claim that one can study "the aesthetics of nature, including natural objects […] such as ecosystems" presupposes that natural instances of a type of ecological entity exist and can be regarded as more or less aesthetically valuable (Toadvine 2010, 85). The discussion below will bear wide implications for how claims like these—what I will call 'ecological value claims'—can be most reasonably understood. However, this essay is primarily intended to serve as a resource for making sense of the far more abundant ecological value claims found in scientific literature and literature put out by leading environmental advisory institutions.

One finds such claims made implicitly in directives to maintain and restore "ecosystem properties," like those appearing in excess of ninety pieces of federal legislation in the U.S. (McFadden & Barnes 2009). Implicit ecological value claims are also made via the U.S. Environmental Protection Agency's (EPA), European Union's, National Resources Canada's, and the United Nations Framework Convention on Climate Change's (UNFCCC) expressed commitments to emphasizing 'long-term sustainability of ecosystem's structure and functioning' as an overarching guide for environmental policy and management strategy decision-making (Apitz et al 2006; McAfee and Malouin ed. 2008). Explicit ecological value claims are also abundant in the advisory literature. For instance, the South East Queensland Ecosystem Services Framework recognizes nineteen "ecosystem functions," or 'biological, geochemical, and physical processes occurring within ecosystems,' as "important for maintaining ecosystems and biodiversity (the diversity of genes, species and ecosystems) for their own sake. [And important because] they may provide contributions to goods and services (ecosystem services) that people value" (SEQESF 2015). One also finds explicit ecological value claims throughout the ever-expanding literature on mitigating losses of economic goods (e.g., species with agricultural value) and noneconomic goods (e.g., human health) due to climate change (see UNFCCC 2013a, 3).

For instance, the UNFCCC 2013 analysis of non-economic losses due to climate change lists losses of "ecosystems," "ecosystem services" (goods dependent on the ecosystem functionality), and "biodiversity" (an ecosystem property), as being among the "main types of non-economic losses" that will be experienced due to climate change (4). The UNFCCC working group also notes that although "damage to natural ecosystems is primarily a non-economic loss, since ecosystem services are rarely traded on the market" climate change may significantly impact the economic value of ecosystems "if the services [an] ecosystem provides is food or fibre, the provision of which is part of the market economy" (ibid.). Likewise, in the UNFCCC 2010 *Work Programme on Loss and Damage established by the Cancun Adaptation Framework*, it is argued that "enhanced" actions to respond to climate change should: 'consider vulnerable ecosystems' (4); 'aim to maintain the integrity and multiple functions ecosystems' (26); 'conserve biodiversity and ecosystem services' (26–7); and 'promote the resilience of natural ecosystems' (5). So, according to the UNFCCC, ecological entities (i.e. communities and ecosystems), functionality (i.e. the sorts that beget "vulnerability," "integrity," or "resilience"), and properties (i.e. biodiversity) ought to be protected because they can provide economic gains or prevent economic losses and provide or prevent "social and environmental benefits."[1]

Such claims appear straightforward upon first inspection; as it makes perfect sense to say that ecosystems are valuable and should be protected because they provide social and environmental goods. Yet, a closer look reveals that it is difficult to make heads or tails of what the substantive content of many such claims about ecological entities really is. This is because: there are no accepted criteria for what things in nature count as ecological entities and which do not (Sagoff 2003 and 2013; Schizas and Stamous 2010); no received view of what exactly constitutes distinctly *ecological* functionality (Odenbaugh 2010); and no scientifically respectable account of why certain ecological properties are inherently valuable (i.e. somehow beneficial to ecological entities) (Sagoff 2005 and 2009). The absence of a received account of in what ecological entities, functionality, and properties, consist makes it practically impossible to ascertain what particular things in nature value claims about such entities, functionality, and properties, are telling us are more or less valuable. As Mark Sagoff has characterized the problem recently, 'it is difficult to know *what* environmental protection is supposed

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[1] I think it is especially important to develop a reasonable working understanding of ecological entities, functionality, and properties to provide resources for operationalizing the value claims made in the UNFCCC policy framework, as it is rapidly developing in order to realize policies and strategies necessary to adequately respond to now *inevitable and unavoidable* loses and damages; see UNFCCC 2013b, 6-9.

to protect' and hard to know what can or cannot be counted as ecological gains or losses (Sagoff 2013; see also 2003 and 1997).

What's more, because it is difficult to ascertain to which natural phenomena ecological value claims do or do not apply, it is also difficult to ascertain where to begin in trying to operationalize directives and strategies that are guided by such value claims. It is impossible, in practice, to coherently formulate and implement directives and strategies in order to comply with policies that refer to such entities, functionality, and properties in a non-arbitrary way without a background theory of such things. Indeed, one would be hard pressed to come up with a non-arbitrary resource management plan that would 'sustain ecosystem structure and functioning' without set criteria for locating natural ecosystems or criteria for determining what constitute more or less valuable ecosystem structures and functionality. This is because formulating rational and coherent directives and strategies to protect and assist in the maintenance of ecological entities, functions, and properties, and operationalizing such directives and strategies requires clearly delineating their referents in nature.

In this essay, I take three key steps to help facilitate the operationalization of policies, directives, and strategy recommendations guided by ecological value claims. I first clarify the basic network-based understanding of ecological entities, functionality, and properties I argue is operative "behind the scenes" in modern ecology. I then examine how existing policies, directives, and strategy recommendations about ecological entities, functionality, and properties can be usefully interpreted and operationalized through the lens of that background theory.[2] Subsequently, I discuss a significant implication of the endorsed network-based understanding of ecological entities for how policies and

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[2] I will not attempt to provide an account of why certain ecological entities, processes, or functionality should be valued or why they may be valuable, and will not endorse any particular directives to protect or restore such things. Rather, I focus on providing a conceptual framework for clarifying what in nature ecological value claims are about in order to provide a starting point for making sense of ecological value claims and operationalizing directives and management strategies that are informed by such value claims.

strategy recommendations should *not* be formulated, and then conclude with some brief remarks regarding the more general implications of my arguments in this essay.

ECOLOGY IS THE SCIENCE OF ECOLOGICAL NETWORKS

A survey of the literature in ecology shows that ecologists have always argued about, and continue to argue about, whether populations, communities, and ecosystems, exist in nature or are nothing but abstract theoretical posits. Yet, despite leading ecologist's professed commitments to various conflicting metaphysical stances, careful reading of the substantive claims made in ecological studies shows that there is a conventionally received metaphysic of the entities that are investigated in ecology. Given the frequency with which ecologists claim that they are 'theoretical constructs' or 'semantic constructs,' one might well believe that that metaphysic is antirealist (see, for instance, Gattie *et al* 2006). That is to say, in effect, that ecologists would hold that 'population,' 'community,' and 'ecosystem' haven't any analogues, or referents, in nature. However, ecologists' antirealist affirmations are just plain misguided and only serve to obscure the fact that there is a sense in which modern ecologists presuppose that populations, communities, and ecosystems, *do* exist in nature. This is in the sense that any such individuals are *networks resulting from series of 'ecological interactions' between individual organisms*—not unlike individual social networks (e.g., social-media groups and extended families) exist as networks resultant from series of person-to-person social interactions (cf. Patten 2010, 1636).

In the discussion that follows, I will progress by motivating my claim that this is the received view among modern ecologists and then, after some brief clarificatory remarks, unpacking what exactly this means.

Grounds for Believing the Network-based Metaphysic Undergirds Modern Ecology

The primary reason to believe that modern ecologists assume the entities they study are most basically naturally occurring ecological networks of different sorts is that there is textual support for this conclusion. In literature produced in the last decade, one often finds countless explicit claims that ecological research consists in doing "network analyses" (Allesina and Bondavalli 2004; Scharler et al 2005; Ulanowicz 2011). Accordingly, one finds characterizations of the aim of ecological research as consisting in efforts to better understand the "network properties" of natural populations, communities, or ecosystems, and efforts to understand the "network pathways" that produce such things (see Gattie et al 2006 and works cited therein; cf. Reiners and Lockwood 2010, 140). It is simply undeniable that the idea of 'network analysis' is in vogue in ecology, and in science in general, nowadays. And ecologists shift toward explicitly discussing the subjects of their investigations as different sorts of ecological networks surely indicates that they think this is the most appropriate way to think about them. What's more, even though explicit talk about "ecological networks" is somewhat new, "[n]etwork thinking is by no means new to ecology" (Bascompte 2007, 486; see also Proulx et al 2005).

In historically significant research papers dating as far back as the 1930s at least, ecologist describe the subjects of their investigations as individual networks or in synonymous terms (see Tansley 1935; Peters 1991, 133).[3] Even in the two popular works that are, collectively, regarded as the historical mainspring of modern environmentalism, one finds ecological phenomena discussed in terms synonymous with the idea that they are networks. This is clear enough in Aldo Leopold's conception of "biotic communities" that work like an "energy circuit" (1949). But consider also Rachel Carson's most basic finding in *Silent Spring* (1962): if we spray an area with insecticides and later find

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[3] Tansley argues that communities are 'webs of component-to-component' interactions—where the component parts of such "webs" are supposed to be individual plants and animals. In his extended critique of ecology, Peters, also does not use the term 'network' anywhere, but speaks of ecologists studying "causal webs." I take the idea of 'causal web' to be synonymous with 'causal network,' as they seem to be used interchangeably in the literature in ecology.

that chemical in earthworms and in the bodies of dead and sick birds around that area, it is to be inferred that there is network of causal interactions linking those states. In both works, one finds straightforward accounts of how environmental problems can propagate through *networks* of ecological interactions. Since ecologists' allegiance to the idea that the entities they study are ecological networks is well-precedented in both the contemporary and more historical literature, naturally one should conclude that this is how they conceive of them.

Ecologist do not Completely Agree about the Metaphysical Foundation of Ecology

To be clear, my saying that ecologists assume that the entities they investigate in nature are ecological networks is *not* to say that they agree about whether population, communities, and ecosystems, exist in a metaphysically robust sense—or even that they've come to any general consensus about what that may mean. As I have said, a survey of the literature shows that ecologists continue to argue about these things. Still, the idea that the entities that they study are ecological networks is a *basic* metaphysical thesis about which they can, and apparently do, agree. It is "basic" in the sense that maintaining that some collections of biotic and abiotic things can be usefully identified as ecological networks leaves open the big questions about the metaphysical status of any such things. Accepting as much does not settle the matter of whether any such individuals are merely artifacts of viewing natural phenomena in a certain way or are themselves causally relevant individuals in nature. It also leaves open the question of whether there is any objective basis for claiming that there exist *typical* ecological networks. And so, the network-based view of the entities of ecology leaves room for all of the substantive disagreement in ecology, whilst providing enough common ground for avowed realist and antirealist ecologists to together push forward ecological theory and acquire new ecological knowledge.[4] Accordingly, while disputes about the existential status ("reducibility" or metaphysical "emergence") of the entities of ecology rage on in discussions about the philosophical foundations of ecology, within the field self-proclaimed realists and antirealists can agree that *any actual populations, communities, and ecosystems, are individual ecological networks* of different sorts.

Of course, just establishing that ecologists purport to investigate ecological networks of different sorts is not to provide one a clear idea of what in nature may count as a population, community, or ecosystem. It also does not suffice just to say that the entities ecologists study are 'networks of ecological interactions,' because one needs some idea of what sorts of interactions count as *ecological* ones to make sense of this. Hence, I will now provide a more detailed account of in what ecological entities are supposed to consist by clarifying what the nodes in ecological networks are and clarifying what sorts of interactions count as ecological causal ones according to convention in ecology.

The Nature of Natural Ecological Networks

Although no definition can encompass what every ecologist takes to be essential to the entities they investigate, as I understand things, convention has it that they investigate: contingent causal networks resulting from organism-to-organism and organism-to-environment interactions that influence the behaviors and survival of organisms and thereby bear on natural selection. In other words, populations, communities, and ecosystems, *are networks resulting from contingent organism-level interactions* that are causally relevant to organisms and the species of which they are members, as they constitute contexts in which organisms bump about as they eat, reproduce, and die. This view of the

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[4] Notably, seminal ecologists Sven Jørgensen, Bernard Patten, and Milan Strakraba have co-authored a number of illuminating papers on the workings of ecosystems (the "Ecosystems Emerging" series) in which they conceive of ecosystems as ecological networks, while Patten reports that they each hold different, and conflicting, metaphysical views (2010, 1637).

entities of ecology as organism-to-organism networks that bear on natural selection, is consonant with the first, and enduring, definition of 'ecology,' provided by Ernst Haeckel in 1869. Haeckel says:

> [Ecology is t]he investigation of the total relations of the animal both to its inorganic and to its organic environment; including, above all, its friendly and inimical relations with those animals and plants with which it comes directly or indirectly into contact—in a word, ecology is the study of all those complex interrelations referred to by Darwin as the conditions of the struggle for existence. (as cited in Cooper 2007, 4–5)

In accordance with Haeckel's definition, I submit that ecology is the branch of biology that investigates how species-typical organism-level interactions produce network-level composition(s) (or "structures") and dynamics and how those dynamics influence survival and the course of evolution (cf. Peters 1991, xi).

Since what makes the networks ecologists study *ecological* is that they result from ecological causal interactions between organisms, I need to unpack what 'ecological causal interactions' are to adequately articulate the background theory of ecological entities I've outlined. Although it is circular as a definition, it is nonetheless correct to say that what makes ecological causal interactions distinctly ecological is that they are those causal interactions that produce individual instances of the types of networks that ecologists study. More specifically, they are *direct and indirect stochastic interactions* via which organisms become nodes in such networks—i.e., they connect them to a network—by influencing their ability to survive and reproduce. Allow me to explain what I mean by this.

I here use 'stochastic' in a sense that is, to my knowledge, consistent with its usage in biology. That is, to denote contingent interactions in which individual organisms behave in species-typical ways (cf. Cooper 2007, 88; Shrader-Frechette and McCoy 1993, 42). For example, if a wolf happens upon a rabbit, the wolf will pursue the rabbit, and the rabbit will exhibit the flight tactics characteristic of rabbits. In this way, stochastic interactions are contingent but produce predictable local outcomes. I then take the notions of 'direct' and 'indirect' interaction directly from the technical literature in ecology (see, for example, Patten 1990 and 1991). In accordance with their usage in that literature, 'direct' stochastic interactions are simply those that occur directly between organisms. For instance, a wolf eating a rabbit is a direct interaction. 'Indirect' stochastic interactions are then causal influences of organisms on each other's survival and reproductive capacity via their mutual use of, or "competition" for, resources.[5] Such interactions are thus indirect in the sense that they are mitigated by something that comes between two or more organisms. For example, wolves and foxes indirectly influence each other's survival by excluding each other's access to rabbits and different species of plants can influence each other's survival by excluding each other's access to light and water.[6]

Because they are so various and diverse, it is difficult to formulate a definition that conveys what sorts of causal interactions will count as ecological ones. Characterizing ecological causal interactions is also somewhat contrary to the nature ecology itself, as it is the science of *network-level* phenomena resulting from such interactions rather than a science of those interactions. Hence, rather than trying to formulate a precise catch-all definition, I will now clarify what sorts of interactions count as ecological ones by providing examples of some general sorts of ecological interactions that can be seen as connecting organisms to ecological networks of each major level of analysis in ecology.

Beginning at the population level, I propose that stochastic interactions including interbreeding and socially structured competition for food, habitat, and mates, between members *of the same species* are among the ecological interactions that causally connect members of ecological populations (Odenbaugh 2010, 241). Hence, as a useful working definition, we can say that any "natural population" (any natural target of a population-level meta-analysis) is *an ecological network of organisms of*

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[5] The scare quotes around 'competition' above signal that it is a metaphorical descriptor.

[6] Some argue that there is not sufficient evidence to claim that indirect causal interactions, such as competition, have any general noteworthy network-level impacts; see Cooper 2001. Though I am sympathetic to the alternative view that indirect ecological influences can and often do significantly influence things seen at the network level, here I am not defending this view but simply presenting the idea of indirect ecological interactions as one that is useful for helping make sense of vaguely formulated ecological value claims.

the same species resultant from stochastic ecological interactions like these. More specifically, I submit that populations are usefully conceived as causal networks resulting from direct and indirect species-typical interactions between members of the same species that are distinctively *ecological* in that they are the sorts of interactions that have net, aggregative, impacts on those types of organisms' ability to survive and reproduce.

Then species-typical survival-increasing and survival-decreasing *impacts of one population on another* can be seen as making the organisms within those populations nodes in broader community-level networks. These include, but are not limited to, interspecies competition (mutually detrimental), predator/prey (beneficial/detrimental), mutualistic (mutually beneficial), amensalistic (detrimental/no impact), and commensalistic (beneficial/no impact) interactions (Odenbaugh 2007, 7). Accordingly, I propose that a useful working definition of "natural communities" (the natural targets of community-level studies) has them as *multi-population ecological networks* resulting from interspecies ecological interactions.

Finally, there are stochastic interactions that can be understood as connecting individual organisms, and the populations and communities in which they are nodes, to ecosystem-level networks. For instance, individual organisms can be seen as connected to broader biophysical networks and systems that play roles in the survival of organisms and species evolutions by serving as vectors for energy and resource transport (e.g., means of nutrient resource transport) through such networks. Of course, these interactions can be various and diverse. They can include everything from the conversion of sunlight into biomass by plants, to the breakdown of organic materials by bacteria, to the conversion of biomass into usable energy via consumption by animals. Yet, even though they are various and diverse, they too are *ecological* causal interactions because they connect organisms to networks whose overall composition and dynamics can significantly impact organisms' mortality and the course of species evolutions (cp. Cooper 2007, 277-8). Hence, as a working definition, we can say that any "natural ecosystem" (any natural target of an ecosystem-level study) is a network of *multiple populations and components of their members' abiotic environment* that are, in a sense, interconnected via their members' ecological interactions.

General Affordances of Networkism

The network picture of ecological entities that I have outlined (henceforth, 'networkism') provides basic conceptual resources with which one can formulate the causal picture of nature that ecologists apparently work with—and a causal picture I will argue provides a basis for operationalizing ecology-guided environmental guidelines, policies, and management strategies. More basically, this picture enables one to make sense of what in nature ecology is about. Indeed, absent a working notion of ecological interactions and of what networks resulting from such interactions are like, it is rather mysterious what ecologists study and unclear exactly how ecological research can usefully inform policy and resource management decision-making.

Without an idea of the nature of natural ecological networks, it is also easy to entertain as plausible enduring, though badly misguided, criticisms of ecology according to which ecological accounts of natural phenomena and ecology-guided environmental guidelines, policies, and strategies are deeply problematic because they rely on empirically baseless "magical thinking" (Sagoff 2013, 248). This is because much unfortunate metaphorical language in the scientific and advisory literature suggests that ecology, and such directives, policies, and strategies, do engage idealistic, "magical," views about the workings of nature. For example, common references to protecting ecosystems' "health," "self-organizing" properties, and "natural balance" all suggest commitments to a broadly organicist view of nature (see McShane 2004). And, although perhaps a bit less "magical," the oft cited claim that ecology shows how "everything is connected to everything else"—the so-called 'first-law of ecology'—is nothing-but heady nonsense, and no help in giving one any idea at all of how particular things in nature are connected, without some notion of ecological causal interactions to help unpack it (Odenbaugh 2010, 240–1).

Claims that ecological theory and ecology-guided environmental policies and management strategies engage "magical thinking" are sapped of their rhetorical force once one has a working understanding of the straightforward, and in no way mysterious or magical, network-based view. Understanding the basic causal network-thinking of ecologists also helps one see that commonly employed metaphors, like "health" and "natural balance," *are metaphors*. This is because it provides resources to interpret such descriptions as *ways of describing* series of species-typical ecological interactions that tend to enable the net survival of organisms that are nodes within ecological networks—such that a network may be *described as* "healthier" or "in balance" to the extent that survival-increasing species-typical interactions occur more frequently within it. And by enabling one to get some basic idea of how particular things in nature may be ecologically connected (i.e. connected via direct and indirect ecological interactions) in ways that impact things we, humans, value, the relevant understanding permits one to begin to make sense of vague slogans to the effect that 'everything is connected to everything else' as well. Further still, networkism provides conceptual machinery to make sense of how ecological research (qua research on ecological networks) can both show light on possible avenues for the propagation of environmental problems and provide models of types of ecological networks with heuristic value for decision-making about possible environmental interventions (see Donhauser 2014; Golley 1993, 61–3).

HOW TO (RE)FORMULATE ECOLOGICAL VALUE CLAIMS

In addition to providing resources for making ecology and ecology-guided environmentalism make sense in general terms, networkism bears implications for how existing claims about ecological entities, functions, and properties, can (and cannot) be usefully interpreted, as well as implications for how directives and strategies to protect and maintain such things can be best formulated and implemented. Again, networkism sees ecological populations, communities, and systems as networks resultant from direct and indirect stochastic organism-level ecological interactions. More basically, they are contingent causal networks whose nodes are individual organisms; in the sense that their organismal nodes are ecologically connected via contingent ecological interactions. In line with this understanding, one is to interpret claims about ecological entities and their functionality and properties as claims about organism-to-organism and organism-to-environment interactions. Through the lens of networkism, ecological value claims are then most reasonably interpreted as claims that certain statistically regular species-typical interactions produce what can be usefully conceived, in the abstract, as ecological network-level dynamics and compositional properties that tend to maintain some (actually or ideally) valuable resource.[7]

Upon first inspection, one may think this view implies that there is not a sense in which ecological entities and their (network-level) functionality and properties could be valuable themselves, since they are effectively just *abstract ways of conceiving* of series of statistically regular organisms-level interactions and the net results of those interactions (Jordan 1981). Accordingly, one may think the view suggests the most reasonable way to unpack ecological value claims is to eliminate references to ecological entities altogether. Notably however, even if one believes that networkism ultimately

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[7] I make no commitment whatsoever here to what sorts of resources *ought* to be valued. My point is just that claims about whatever ecological entities, properties, or functionality have been said are valuable, or said should be valued (on whatever grounds), can be usefully interpreted and reformulated as claims about species typical organism-to-organism and organism-to-environment interactions and their aggregated impacts.

commits one to an eliminitivist metaphysics of ecological entities, he or she must admit that there is a straightforward sense in which ecological networks and network-level functionality and properties may be valuable and are actually valued. This is insofar as ecological network's natural analogues (i.e., collections of ecologically interacting organisms) exhibit causal profiles such that they have an appreciable net impact on actually or ideally valuable resources. Because of this, one must refer to collective functionality and impacts, and thus cannot completely eliminate references to ecological entities.

Networkism does *not* suggest that claims to protect or restore ecological populations, communities, or systems, or any such thing's functionality or properties, are to be interpreted as vacuous. Nor does it suggest that such claims are to be taken literally—as claims to protect ecological entities and *their* functionality. As I said above, the view is theory neutral regarding matters of brass tacks metaphysics. And, in my view, it suggests only that such claims are usefully understood as claims to protect or restore *particular organisms and environmental conditions at particular times* in order to enable the occurrence of species-typical ecological interactions *that collectively produce overall network-level dynamics and compositional properties necessary for the maintenance of some valued resource(s)* (cf. Colyvan et al 2009). In other words, the view is holistic in that it takes account of ecological network-level properties, but does not entail treating network-level properties as causal properties that are ontologically irreducible to series of interactions between their constituent parts (see Novikoff 1945, 209). Of more significance to how to most reasonably formulate policies and strategies, the view suggests that, whether or not ecological entities enjoy a robust existence, one can impact the functionality and properties of such things *by impacting their constituent nodes.* Accordingly, I submit that, strategies and policies pertaining to ecological entities *must be designed to impact the behaviors of individual organisms* either by directly impacting individual organisms or their environmental conditions at a time. At least, they must be designed this way if they are to be effective and operationalizable.

One can see that effective policies and strategies must be operative on individual nodes in a network as a general point by considering other, more familiar, sorts of contingently actualized networks and how they might be most effectively policed. For example, consider an internet-based social network. This sort of network is obviously much different than any ecological network, because the members of such social networks presumably have more freedom to voluntarily join or leave such a network and because the social interactions connecting the members (the nodes) are not typically life or death interactions. Such a network is nevertheless similar to an ecological network in that the nodes in such a network are contingently (in this case socially) interconnected individuals that can collectively instantiate network-level functionality and properties.

I submit that they are also like ecological networks in that effectively policing and managing a social network requires developing policies and strategies that directly impact the behaviors of its individual nodes. For example, to prevent a social network from being used to realize a money laundering operation, surely measures would need to be taken to stop individuals from taking the steps to launder money. Hence, even a network-wide policy (e.g. 'this networking platform shall not be used to facilitate money laundering operations') could only be effectively operationalized and implemented by including mechanisms for impacting the behaviors of individual persons. That is, either by impacting individual's behaviors through direct interventions or by impacting their background, environmental, conditions via restricting access to features of the networking platform. Given that ecological entities are also most basically contingent causal networks, it stands to reason that viable policies and strategies pertaining to any such things should also target their nodes, and should therefore consist in directives and strategies that impact individual organism's mortality and abilities to manifest species-typical behaviors.

One can begin to see how this "downshift" to interpreting claims about ecological entities and their properties as claims about typical organism behaviors and interactions is helpful for unpacking normatively significant ecological value claims by considering its implications for claims like those mentioned above. For example, take the UNFCCC's call for "enhanced" actions to mitigate economic and noneconomic climate change losses via 'protecting ecosystem functions' and 'promoting the resilience of ecosystems.' In accordance with the view I've outlined, these are to be unpacked as recommendations to protect ecological networks' functionality and to promote the continuation of such functionality *via protecting and maintaining species-typical organism-level interactions*. In practice, this means fleshing out such normative claims in terms of actions that foster the growth of opportunities or limit opportunities for individual organisms to manifest certain species-typical behaviors.

Accordingly, one could effectively *foster* such opportunities either by directly assisting organisms or by taking measures to ensure that certain environmental conditions obtain. Or one could operationalize such normative claims by taking measures to limit opportunities in either of these general ways in order to *prevent* species-typical interactions that have a decidedly negative impact on some valued resource. Thinking in terms of these two general "ecological hedging" strategies, it is easy to see that there are very many specific ways to effectively implement strategies in order to comply with the abovementioned sorts of ecological value claims (Boyd 2010, 7). For example, assisted relocation, habitat (or refuge) protection, and migratory corridor engineering are just a few existing sorts of operationalizable management strategies for 'protecting ecosystem functionality' and 'promoting resilience' that operate at the organism level—via providing opportunities for individual organism's to exhibit species-typical behaviors, survive, and reproduce.[8] For instance, one could effectively protect valued 'ecosystem functions' and 'promote resilience' of valued network-level functionality by assisting a population in adapting to higher temperatures due to climate change by providing viable habitat in locations with lower temperature (e.g. higher altitude locations) or by providing more migratory pathways for the salient species.

Perhaps obviously, beyond just providing resources to help unpack and operationalize existing policies and strategy recommendations, networkism also suggests ways to better formulate policies and strategy directives. In accordance with how I have just suggested interpreting existing normative claims about ecological entities and properties, the view suggests formulating policies and strategies such that they target *individual organisms* either by directly referring to impacting organisms or their environmental conditions at a time. To be clear, this is not to say that viable policies and directives must refer to particular (token) organisms. It is to say that such normative claims are best formulated such that they clearly indicate how they could be implemented through efforts to impact instances of types of organisms or their environment.

For instance, it would be much easier to determine how to operationalize the many pieces of US legislation that call to protect ecosystems—passed after the Clinton administration's *Interagency Ecosystem Management Task Force* deemed the ecosystem "the basic unit of environmental policy"—if those pieces of legislation made it clear that ecosystems are networks resulting from organism-level interactions; such that the "basic unit of environmental policy" is networks of individual organisms (McGinty *et al* 1995; McFadden & Barnes 2009). Likewise, the US EPA's, European Union's, National Resources Canada's, and the UNFCCC's recommendations to foster 'sustainability of ecosystem's structure and functioning' as an overarching decision-making guide would be better formulated so as

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[8] There is far too much literature on assisted relocation, refuge protection, and migratory corridor engineering to cite. A database search of these terms produces hundreds of helpful articles.

to refer to protecting opportunities for individual organisms to exhibit species-typical behaviors that contribute to the maintenance of some valued resource(s). In sum, my point is simply that rather than formulating normative claims that refer to protecting ecosystems, communities, or populations, and *their* properties, networkism suggests more precise ways of formulating such claims. It suggests formulating policies and directives such that they clearly apply to organisms and such that they indicate how they might be implemented through actions that impact individual organisms either directly or via impacting components of their environment.[9]

HOW *NOT* TO FORMULATE POLICIES AND GUIDELINES

I have just argued that viable environmental policies and directives should not be vaguely formulated by referring directly only to ecological entities, like ecosystems and communities, and their properties. In what follows, I will focus on a more specific way in which viable normative claims should *not* be formulated according to the network-based picture I've endorsed. The relevant constraint on how normative claims should be formulated follows from a variation of what Kim Sterelny has called the "contingency hypothesis," according to which individual ecological networks are sensitive to so many contingent factors that each is very unique (2001, 158–9).

Some contingency hypothesis proponents argue that its truth implies that there are no network-level structural or behavioral properties repeated across discrete ecological networks, no general patterns in nature, to objectively ground ecologists' delineations of types of ecological networks. I won't endorse this sort of antirealism about ecological types, as the fact the ecological networks are unique does not imply that there are not also general network-level patterns—as is

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[9] To be clear, I am not suggesting that there are not existing policies and directives that already fall in line with this advice; there are in fact many. As just one randomly selected example, the National Forest Management Act of 1976 (16 U.S.C. §1600 et seq.) does so by requiring "that viable populations of all native species of vertebrates be maintained well-distributed through their range"; Lande 1988, 601.

arguably the case (cf. Odenbaugh 2011, 125–6). Still, I must concur that variation, instability, and constant change in biological reality, dictate that ecology must be "a science of the particular" (Norton 2003, 130). Accordingly, I submit that, because natural ecological networks are unique and ever-changing contingent causal networks, no "one size fits all" correlation between certain ecological properties and functionality can hold true of actual ecological networks. Specifically, it occurs to me that at least two sorts of variability within ecological networks make it impossible to establish such generalizable correlations.

The first is the variability in the functional roles that individuals of the same species can play within different ecological networks. Indeed, organisms of the same species (i.e., the same types of nodes) often play *different causal roles* in producing ecological network-level properties even *via the same types of component-to-component interactions*. For example, depending on their respective causal impacts on overall network structure and functioning, distinct populations of the same species and relative size can help sustain relative population abundances in some ecological networks and severely destabilize other ecological networks through manifesting the same species-typical trophic behaviors. For instance, "Asian Carp" (*Cyprinus carpio*) have destabilized ecological networks in the Erie Lake region in North America, to which they are non-native or "alien," by outcompeting native species and overgrazing. Yet, populations of that same species enjoy a sustainable existence in the regions of Europe and Asia to which they are native (see "Asian Carp Overview"). More generally, various other species-typical behaviors like prey selection and predation efficiency can have profoundly different indirect impacts on overall network-level dynamics in different ecological networks.

The other sort of variability that makes it practically impossible to establish generalizable correlations is that individuals of the same species can manifest *different causal profiles in different ecological contexts*. For example, breeding pattern changes resulting from population 'hybridization' can reproductively isolate phylogenetically identical members of the same population, and can thereby lead to the local extinction of that species in some ecological networks. J.C. Greig's (1979) study of *Capra ibex* populations in Czechoslovakia is a classic case-study documenting an instance of this sort of occurrence that is frequently cited in ecology textbooks. In his study, Greig documents what happened when resource managers relocated *Capra ibex* populations from Austria and Turkey to the Tatra Mountains of Czechoslovakia; in efforts to mitigate the ecological impacts of the extinction of the Czech population due to hunting. Greig reports that in initial efforts a population relocated from a region in Austria with a similar climate to the Tatra region successfully bred with the remaining Tatra Mountain herds for multiple generations. However, in a later effort an Ibex population relocated from a region in Turkey that is warmer and has different seasonal successions than the Tatra region failed to successfully reproduce after one generation. More specifically, the population relocated from Turkey succeeded in breeding with the existing Tatra population, but the resulting hybrid generation rutted in the Fall like the Turkish population rather than in the Winter like the Austrian and Czechoslovakian populations. Consequently, the offspring of the Turkish/Czech hybrids' were born in the coldest part of February and the population went extinct within a generation.[10]

Variability in both 'the causal roles of the same types of nodes within different ecological networks' and 'the possible range of properties that the same types of organisms can manifest within different ecological contexts' are just two of many contingent factors that can significantly impact the overall structure and functionality of population, community, and ecosystem level networks. And contingency hypothesis proponents are right that such contingent factors make it so that there are no broadly applicable, "one size fits all," correlations between general sorts of ecological properties and functionality. Hence, we should conclude that environmental policies and directives should not be

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[10] There is a lot of recent work on hybridization suggesting that anthropogenic displacement of many species threatens to cause many such extinctions; see, for example, Edmands 2007.

formulated such that they assume that stable correlations between ecological properties and certain, desirable, sorts of ecological functionality obtain. To illustrate how such normative claims go awry by example, consider the idea that promoting biodiversity serves to maintain and promote valued resources by "stabilizing" ecological functionality—a presupposed correlation that in fact underlies many existing environmental policies and directives.

This ideas long history began with ecologist Charles Elton's (1927) 'biodiversity-stability hypothesis.' According to Elton's overall view, 'stability' is a relatively low level of variation in the abundances of the populations comprising a community. Elton's 'biodiversity-stability hypothesis' then states that ecological network stability, specifically community stability, increases concomitantly with increased biodiversity (an increased number of distinct species ecologically interacting within a community-level network). On this view, higher biodiversity is supposed to beget greater stability by providing a greater number of possible series of ecological interactions, more life paths, via which individuals within a community may be able to survive (see Sterelny and Griffiths 1999, Ch. 11).[11] According to the Eltonian view, more highly diverse communities are also supposed to have a higher density of causal pathways connecting the constitutive populations, and this higher degree of "connectance" is also supposed to render them more stable than comparatively less diverse networks. As this idea has intuitive appeal, it is not surprising that it is a widely received assumption that there is in fact a positive correlation between biodiversity and stability.

In fact, this Eltonian view is not only still widely received in popular discussions of ecology and environmental policy and management, but there are also very many directives and pieces of national and international legislation, "biodiversity legislation," that presuppose a positive correlation between biodiversity and ecological network stability (see Medaglia et al 2014). For instance, as I mentioned

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[11] I cite Sterelny & Griffith's discussion of Elton because it is much clearer than Elton's original discussion.

above, the UNFCCC 2013 analysis of non-economic losses due to climate change lists loss or "reduction" of biodiversity as one of the "main types of non-economic losses" that will be experienced due to climate change impacts (4; 12). Through the lens of networkism, such value claims appear problematic, since variability in the causal roles and manifest properties of the same species within different ecological contexts implies that there will likely not always be a positive correlation between biodiversity and stability. More troubling still, ecologists have established that there *is not* always a positive correlation between biodiversity and network stability, and the idea that there is a correlation more generally is therefore not usefully informative for policy and resource management decision-making.

Well-known studies show that biodiversity and ecological network stability can vary either independently, proportionally, or inversely. Perhaps most notably, in theoretical studies discussed in his 1972 paper, "Will a Large Complex Systems be Stable?," and 1973 book, *Stability and Complexity in Model Ecosystems*, Robert May directly challenged the biodiversity/stability hypothesis by showing that more highly diverse and highly "connected" networks can be far less stable than comparatively less diverse and connected ones (see Donhauser 2014; McCaan 2005; Odenbaugh 2005). For instance, he found that simulated communities of only four or five species tended to remain stable with a connectivity magnitude of around twenty percent while a community with upwards of ten species would exhibit chaotic and unsustainable changes in species abundances at similar levels of connectivity (May 1972, 414). By showing such things, May demonstrated that stability does not necessarily increase concomitantly with biodiversity, and so provided reasons to seriously question whether Elton's diversity-stability hypothesis holds in nature.

Numerous follow-up theoretical and empirical studies have since showed that under some constraints increased diversity and overall trophic connectivity tend to facilitate stability while under other constraints they do not (see Jeffries 1974; Allesina and Tang 2012). In light of these results, a weakened variation of the biodiversity-stability hypothesis has been received among ecologists since the 1970s. Ecologists do not agree that the biodiversity-stability principle is altogether wrong, but have found it best to interpret it so as to accommodate variations in constraints on stability. According to the more moderate interpretation that has been long received: 'species diversity mediates ecological network stability through compensating interactions to environmental fluctuations among co-occurring species' (McNaughton 1977, 523).

This weak variation of the hypothesis is consonant with May's findings, the findings of follow-up works, and the fact that there are types of natural ecological networks that are low in diversity but highly stable, as well as types that are highly unstable though highly biodiverse.[12] However, this formulation of the hypothesis is so weak that it does not imply anything about whether there is, even if not always, at least a generally stable positive correlation between biodiversity and stability. Because counterexamples abound, many ecologists and philosophers continue to argue that there is not a generally positive correlation (e.g. Maier 2012; May 1973; Pimm 1991; Sterelny 2006). While others still defend the Eltonian view and argue that there is a generalizable positive correlation (e.g. Hautier et al 2015; Lehman and Tillman 2000; Sarkar 2005). My own view is that while the weak correlations that have been established can be usefully informative, they are not useful for making policy and resource management decisions *in general.*

Although counterexamples to a general positive correlation between biodiversity and stability abound, ecologists have established genuine relationships between greater or lesser biodiversity and certain structural and dynamic properties in *some* types of ecological networks. Accordingly, I submit that the view on the positive correlation between biodiversity and stability one can justifiably embrace

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[12] For instance, salt marshes often host exceptionally stable communities that lack biodiversity while intertidal aquatic zones often host unstable but highly biodiverse communities; see Shrader-Frechette & McCoy 1993, 4.

is this: f*or some networks, some sorts of changes to biodiversity can positively impact stability*. Though very weak, this claim is not altogether without substance, and can be usefully informative for decision-making about some types of natural ecological networks—especially if the relevant networks are very well understood and there is relatively little uncertainty in what factors may change within those particular networks. Still, as uncertainty and constant change are the norm in nature, it appears there is no broadly generalizable trend in how biodiversity and stability vary relative to each other.

Whatever the drivers, sometimes impacting biodiversity in either direction makes an ecological network more adaptive or otherwise stable and sometimes the opposite occurs. So, although it is undeniable that changes in biodiversity often impact stability, the correlation is nearly vacuous for practical purposes; and is not a generally useful guide for policy and resource management decision-making. The correlation between biodiversity and stability thus serves to illustrate my more general point. Because many contingent factors impact the overall structure and functionality of natural ecological networks, there are no generally applicable "one size fits all" correlations between general sorts of ecological properties and functionality. Ergo, environmental policies and directives should not be formulated such that they assume that generalizable correlations between ecological properties and desirable ecological functionality obtain.

CONCLUSION

Eugene Odum once said that ecology must be "reductionist in the sense of seeking to understand phenomena by detailed study of smaller and smaller components, but also synthetic and holistic in the sense of seeking to understand larger components as functional wholes" (1977, 1289). In essence, I have argued that the network-based background theory of ecological entities operative within modern ecology implies that normatively significant ecological value claims should be interpreted and formulated in line with Odum's moral. Given that ecological entities are contingent networks of individual organisms, ecologically connected through species-typical stochastic interactions, it appears that policies and management strategy directives referring to ecological entities, properties, and functionality can be most reasonably formulated so as to be operative at the level of individual organisms while at once taking account of aggregative network-level ramifications.

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