**Five lessons from teleology-neutrality and metaphor in ecology**:

Bottom-up and top-down all at once

By Justin Donhauser

**Abstract**

This paper illuminates primary epistemic functions of teleological characterizations in ecology through discussion of the historical and conceptual origins of the theoretical branch of ecology (§§1-2). I subsequently defuse enduring confusions about the use of teleological characterizations in ecology; with a focus on recent critical arguments by Sagoff in this journal (2016) and some other places (e.g., his 2013 and 2017) (§3). The paper then culminates by collecting five generalizable novel insights attained through the forgoing discussion and outlining avenues for follow-up work that can build on the arguments laid out in this paper (§4).

**Keywords**

teleology; goal-directedness; top-down causation; philosophy of ecology

As a science of complex biophysical dynamics directly relevant to policy and resource management decision-making, advisory institutions around the world have increasingly emphasized the guiding role ecological research and theory should play in such decision-making. Ecology’s even upheld as an objective guide for “urgent political, ethical, and management decisions about how best to live in an apparently increasingly-fragile environment” (Colyvan et al, 2009, p. 1; see Donhauser 2016b for numerous examples and discussion). Yet, ecology, as a science, is not without its critics. Some have questioned whether the entities described in ecological theory exist in any meaningful sense (see Jordan, 1981; Sagoff, 1997; Shizas & Stamous, 2010; Sterelny, 2001; Wittbecker, 1990).[[1]](#footnote-1) Others have even argued that ecological research is without an empirical foundation, contending that directives advising one to look to it for policy and management decision-making are thus absurd (cf. Hall 1988; Haskell 1940; Peters 1991; Sagoff 2003; Sagoff 2013). And yet, others assiduously defended the science against such criticisms (see, for example, Cooper 2007; Eliot 2011; McIntosh 1985; Odenbaugh 2011b, Reiners & Lockwood 2010).

Through discussion of the historical and conceptual origins of the theoretical branch of the science, this paper focuses on clarifying epistemic functions of teleological metaphors as they are used within ecology (§§1-2). Following that discussion, I engage with, and defuse, certain enduring confusions about the use of teleological language in theoretical ecology by responding to critical arguments regarding uses of such concepts in ecology entertained recently in this journal by Sagoff (2016) and by him in numerous other places (see, e.g., his 2013 and 2017) (§3). The concentration on Sagoff’s arguments is both because they are recent and because they crystalize several historied, though misguided, critiques of work in theoretical ecology. Sagoff also writes in direct response to some of the few very recent works that specifically discuss teleological metaphysics—the main points of which I also discuss. Most importantly, I then reflect on the main discussion of this paper to collect generalizable novel insights to be gleaned from it, and conclude by outlining avenues for follow-up work (§4).

**1. The Metaphysic-neutral Teleology of Modern Ecology**

Let us begin by engaging with a historical and analytic approach to help clarify the conceptual foundations of modern ecology and the role of teleological characterization within it (cf. Donahauser 2014; de Laplante & Picasso 2011; Golley 1993, Odenbaugh 2007; Odenbaugh 2011a; Ulanowicz 1999). Teleological characterizations in ecology include those like common claims that ecological populations, communities, or systems, as exhibiting ‘goal-directed’ behavior or as ‘functioning toward some goal state.’ While true that some ecologists *do* embrace robust teleological metaphysics, the following discussion will establish that such commitments are unnecessary, and certainly not relied on within modern ecology, as some critics would have us believe (e.g., Sagoff 2013, 2016, 2017).

*Modern* ecology began, historically speaking, when well-known ecologists switched away from using “ontologically robust ideas of populations, communities, and ecosystems” to using an ontology-neutral view “according to which ecological entities are contingent causal networks resulting from species-typical interactions between organisms and components of their shared environments” (Donhauser 2016a, 68). Three early quintessential articles show this.[[2]](#footnote-2) Looking at each is important for the purposes of this paper and special issue because they—explicitly in the case of the second and third and by inference in the first case—clearly express numerous metaphysical views regarding teleology, as well as related views on holism and emergence I will not attend to here.

i. The first is Raymond Lindeman’s “The Trophic Dynamic Aspect of Ecology” (1942). Lindeman (1942) was the first to explicitly unpack community and ecosystem-level dynamics as series of “physical-chemical-biological processes” in a popular academic journal (cf. Donhauser 2016a, fn. 2 and Golley, 1993, Chaps. 3 and 4). In so doing, he helped re-envision communities and ecosystems as biophysical, causal, networks (see Donhauser 2016b). He thereby helped develop ecology purely mechanistically, and his work was thus a stepping stone toward the ontology-neutral position adopted by ecologists thereafter.[[3]](#footnote-3) As Donhauser 2016a details, unfortunately, “Lindeman lacked a way of articulating *how* community and ecosystem dynamics can be produced to count the work as having firmly established the network-based view” (68-9).

Lindeman (1942) in fact only spotlights correlations between environmental changes (e.g., changes in nutrient levels) and dynamics regarding the relative abundances (i.e., numbers of individual organisms of the biological communities he monitored. He was unable to explain what the “physical-chemical-biological processes” he claims produce network-level dynamics are exactly, or *how* they produce ecological network-level properties, because it would require having “a more complete theory of biochemistry than Lindeman and most ecologists at the time were working with” (Donhauser 2016a, 69). So, he lacked the theoretical and conceptual machinery to explain *how* trophic (food web) interactions, environmental factors, and network-level dynamics are causally related or what the dependence/supervenience relation is between them. The biochemistry one needs to construct these explanations is not seen in the ecological literature until Hutchinson’s work in the 1970s (see Hutchinson, 1979, p. 233).[[4]](#footnote-4) Still, Lindeman’s paper is crucially important because he helped popularize seeing ecological communities and systems as causal networks whose observable dynamics and properties are produced mechanistically through the interactions of their organismal nodes.[[5]](#footnote-5)

ii. The second article that establishes that ecologists presuppose an ontologically-neutral, if not thoroughly antirealist, view of teleological characterizations, is A. B. Novikoff’s “The Concept of Integrative Levels and Biology” (1945). Novikoff’s discussion, like Lindeman’s, lacks any causal account of how exactly ecological network-level properties are produced. Importantly however, Novikoff focuses explicitly on discussing what the right metaphysics and epistemology of ecology should be.

He rebuts “organicist” metaphysics endorsed and argued about by those before him. Organicist ecologists before Novikoff attributed irreducible causal properties to ecological entities. According to proponents of such views, the biological components of ecological populations, communities, and systems are supposed to comprise *unified organic wholes via exhibiting coordinated behaviors* that are directed towards sustaining the vital processes of the whole network of them (see, e.g., Clements, 1916). In contrast, Novikoff argues for a holistic metaphysic that does not commit to irreducible, “emergent,” causal properties. He instead proposes a view that is neutral, or “agnostic,” on that point.

In his view:

Each level of organization possesses unique properties of structure and behavior which, though dependent on the properties of the constituent elements, appear only when these elements are combined [to comprise networks]. Knowledge of the laws of the lower level is necessary for a full understanding of the higher level; yet the unique properties of phenomena at the higher level cannot be predicted a priori from the laws of the lower level. (1945, p. 209)

Novikoff explains that higher-level properties, dynamics, and regular patterns or “ecological laws” are conceptually, and perhaps epistemically, *necessary for* *understanding* ecological networks. And, yet, he denies that they are “irreducible causal properties that are operative in coordinating the behaviors of their component parts” (Donhauser 2016a, 69). He only contends that network-level properties are existentially dependent on the properties of their “constituent elements.” So, Novikoff’s position is ‘theory neutral in that it is compatible with both realism and antirealism about ecological entities’ (ibid.). In his words, the right view: “neither reduces phenomena of a higher level to those of a lower one, as in mechanism, nor describes the higher level in vague non-material terms which are but substitutes for understanding, as in [organicism]” (p., 209).

“Phenomena of a higher level” are not “reduced,” as observable network-level properties exist *but are only found if and when ecological networks are looked at holistically*. Network-level properties are ways of characterizing complex series of component-to-component causal interactions between the organisms within those networks (see Donhauser 2016b). Those “higher level” properties cannot be seen by looking at organism-level interactions but only at more panoramic levels of analysis. This metaphysic-neutral stance Novikoff endorses has been commonplace within modern ecology since the time of his work at least (Donhauser 2016a).

While this has generalizable implications for thinking about teleology and the “goal directed” properties of ecological entities, as well as any other higher-level things, it does not itself illuminate the work that teleological characterizations do in ecological research. Historically, that only became clear in the third-mentioned, most well-known, article, which at once more fully establishes the ontologically-neutral view presupposed within modern ecology. This is Hutchinson’s “Circular Causal Systems in Ecology” (1948).

iii. Hutchinson (1948) embraces the neutral network-based view Novikoff (and many others subsequently) articulated, but also employs core “theoretical” methods used in modern ecology (cf. Slack, 2011). ‘Theoretical’ research in ecology is supposed to be that using “theoretical principles, metaphorical analogies, and mathematical models” to examine hypotheses and possible explanations about “the assembly, structure, and emergent properties” of population, community, and ecosystem-level networks (Sagoff, 2003, p. 531). Seminal *theoretical* works before Hutchinson (1948), “were developed in a period of backlash against earlier organicist conceptions of ecological entities” and their authors—including Lotka (1925), Volterra (1926), and Gause (1932)—“adopted a more extreme view than the ontologically-neutral holism” of Novikoff (1945) and Hutchinson (1948) (see Cooper, 2007, Ch. 2.3). As Donhauser (2016a) says:

The authors of these earlier theoretical works bought into a variety of dichotomous thinking that arose in the early 1900s, according to which ecologists had to either embrace organicist teleological metaphysics or altogether deny the existence of ecological entities, and embrace a sort of nihilism, in order to avoid the entailments of organicism […] In these works, ‘population’ is used as a mass term that is elliptical for ‘individuals of a species in a place’ and there is no mention of ‘communities’ accept when referring to “human communities[.” Accordingly…t]here is no mention of investigating natural ‘ecosystems,’ and ‘system’ is used almost exclusively to refer to conceptual systems—as in “abstract systems of description” or “systems of equations[.”] (70)

Hutchinson (1948) greatly advanced thinking about natural ecological networks by remaining neutral on these metaphysical questions, and then demonstrating by example how seeing communities and ecosystems as series of causal interactions between their organismal nodes can help illuminate the underlying mechanics of observable trends in aggregate data on population and nutrient abundances. Because teleological metaphors play epistemic roles in this process, it is instructive to briefly rehearse how that goes in Hutchinson’s paper (§2).

**2. What do Teleological Metaphors *do* in Ecological Research?**

Hutchinson (1948) provides hypotheses (which most would agree are true) about mechanics of correlated dynamic patterns observable in nutrient resource and species abundance data. He uses teleological *metaphors* to aid in the process of coming up with his mechanistic explanatory hypotheses for such correlated dynamics. Figure 1 simulates the sorts of correlations between nutrient and population abundance level changes for which Hutchinson provides these candidate mechanistic explanations.

**Figure 1: Nutrient and Species Abundance Oscillations[[6]](#footnote-6)**

To generate mechanistic explanations of correlated patterns like these, Hutchinson (1948) imagines the patterns resulting from “self-regulatory” processes within ecological networks and then proposes feasible types of component-to-component interactions through which the organisms in such networks could follow the dynamics such processes would produce (1948, p. 237). In this way, he uses teleological metaphors as a heuristic— a sort of “constraining frame”—that shapes the possible candidate accounts of the underlying mechanics of network-level properties(cf. Peters, 1991, pp. 141-2). As is with almost all contemporary scientific literature, unfortunately, Hutchinson does not reflect on his use of these metaphors or explain its role in his reasoning process. Indeed, he says things that one may read literally and that could be the source of many confusions.

For example, he uses the term “teleological mechanisms,” and talks about these as “regulatory”—as working like a thermostat in a heating system in keeping community-level networks from changing too extremely to persist (cf. Odum 1959, p. 45). Yet, upon complete reading, it is obvious Hutchinson is *not* saying that the behaviors of the components of ecological networks are coordinated by a central control. The nodes in the network are supposed to be no more coordinated by a central control than any two people that belong to the same online social network (see Donhauser 2016b, 12). Rather, unlike a thermostat, he maintains that periodic cycles in nutrient and population abundances result from species-typical component-to-component interactions that can be usefully described both “in terms of the transfer of some substance” through such networks and/or “in terms of the variations in the numbers of biological units or individuals” (1948, p. 221). The directionality of his mechanistic explanations is completely bottom-up rather than top-down, as he explains that such “mechanisms” are series of species-typical interactions producing the observable population and resource abundance data patterns and maintaining overall organism-to-resource balances that allow the relevant target biological populations to persist (1948, pp. 222-36).[[7]](#footnote-7)

Let us pause on this point and look more closely at the epistemic roles of teleological metaphor exemplified in Hutchinson (1948) and commonly employed in ecological and all sorts of scientific literature to date. As an illustration, consider the descriptions of “species-typical” interaction between types of particles in chemistry. In chemistry class, we learnt that different types of atoms “attract” and “repel” one another electrostatically. Collections and combinations of different types of atoms act, and “organize,” as they do because they are always “*seeking* energetically favorable” combinations (Donhauser 2016a, 72). Yet, as in Hutchinson (1948), these teleological characterizations are metaphors. Do atoms literally intentionally “seek” and “attract” or “repel” each other? Maybe (I doubt it). But surely most chemists do not actually think that. Rather, “teleologically-charged notions like ‘resistance,’ ‘attraction,’ ‘chasing,’ and ‘organizing’ are useful metaphors because they help characterize the flow of causal processes that are relatively difficult to understand, and thereby aid scientists in generating causal accounts of *how* network-level dynamics occur” (Donhauser 2016a, 72; see also Nissen, 1983, 155).[[8]](#footnote-8)

For instance, look at how salt (a network of Na and Cl atoms) dissolves in water (a network of C and O atoms). Marc Lange explains this nicely, saying that salt is:

…held together by very strong electrostatic attractions between alternating positively charged (sodium) and negative charged (chlorine) ions. In water, crystalline sodium chloride dissolves into individual sodium and chloride ions because the attraction between Na and Cl is greatly exceeded by the electrostatic attraction between Na and the partially negatively charged oxygen atom of a water molecule, and between Cl and one of the positively charged hydrogen atoms of the water molecule[s]. (1994, 115)

By helping one envision *how* the atoms of salt and water reciprocally interact to make dissolving happen, the metaphorical elements constrain what plausible mechanistic explanations of this occurrence are possible. This is just the same as Hutchinson’s “teleological mechanisms” and common descriptions of “organization” in ecology serving as heuristic epistemic roles by cursorily mapping out how the nodes in causal networks could produce observable network-level properties.

Many critics of ecology do not recognize any of this. Mark Sagoff crystalizes the thinking of a large number of historied criticisms that find fault and folly within ecological sciences because they understand teleological characterizations therein as literal, metaphysically-robust, descriptions (de Laplante & Picasso, 2011 provide an overview; see also, for examples, Goldsmith, 2008; Cooper, 2007; Jax et al., 1998; Shrader-Frechette, 1986; Voûte 1968; Worster 1990).

**3. Sagoff on teleology and “ecological forces”**

To be quite clear and fair (I hope), Sagoff’s relationship with attributing robust teleological assumptions to modern ecologists has fluctuated. We see this simply by taking a sampling of assertions from just some of his works on these points. We find him saying:

* Ecological networks, “however one defines them, self-assemble from components shaped by evolution, and self-organize as those components reproduce and express phenotypic plasticity” (2013, 248)—adding that there is not anything “but magical thinking behind the idea” (ibid.).
* In earlier work, he even says, “[a]s ecologists throw teleology out the front door, they smuggle it in by the back” (1997, 830).[[9]](#footnote-9)
* More recently, in responding to work in which I myself “den[y] that theoretical ecology must have teleological foundations,” Sagoff confusingly says that “those critical of it do not assume it does” (2017). He also retools some of his previous arguments in which he does claim that ecologists “smuggle in teleology” so that their focus is on empirical confirmation and other elements of the metaphysics of ecology (see especially Sagoff 2016).

Continuing the narrative of this paper from there, we can see that shifting to these other considerations regarding the metaphysics of ecology, and indeed science in general, still holds lessons for how we would best think about teleological characterizations within ecology. How so? By giving us a candidate answer to the question of what irreducible top-down causes of teleological network-level properties like “self-organization” and “seeking balance” could be like if they were found in nature. What could they be like? They could be like what Sagoff (2016) calls “ecological forces.” Such “forces” would fit the bill if any such forces in fact exist in nature, as Sagoff (2016) contends modern ecologists assume.

According to Sagoff, we are to believe that ecologist routinely presuppose that such forces are: “internal” to ecological populations (2016, 2734) and that they are a kind of “general” forces in that they are universally causally dominant in the production of observable population and community-level dynamics like ‘self-organizing toward balance’ (2016, 2734). He also says that ecologists routinely presuppose such “forces” to be causally powerful from the top down, and claims that they are supposed by ecologists to be forces like gravity (Sagoff 2016, 30130). In particular, he says they are presupposed to be causally operative in theoretical ecological models (the same sorts of models Hutchinson 1948 is using) like gravity is supposed to be causally operative in models in classical physics (Sagoff 2016, 3010).[[10]](#footnote-10)

In direct response, I have already argued in print that no ecologists actually seem to say that such forces are causally operative top-down in ecological networks. And, more importantly, I have shown that no such forces actually appear in the sorts of ecological models Sagoff says they do (see Donhauser 2020; see also Donhauser & Shaw 2019). Here I will add a more general point: even if such forces do exist in nature and even if some ecologists do believe in such things, this is certainly not a stance that any ecologist must adopt. Indeed, we have seen above that, even as early as Hutchinson 1948, we are provided with sensible mechanistic accounts of the bottom-up causes of observable ecological network level dynamics. So, although Sagoff criticizes ecology on the contention that “ecological forces” do not exist in nature,[[11]](#footnote-11) his criticism on this point is simply moot since ecologists needn’t standardly presuppose that they do for any apparent reason. Indeed, they do not need to (and I think clearly do not).

**4. Five Lessons**

For further response to relevant criticisms of ecology, there is already recent research showing in detail what is wrong with the many different variations and predecessors of arguments like those posed by Sagoff (see especially Donhauser 2017 and 2020). Here I wish only to have done some quick work to show that literalist critiques of use of teleological characterization in ecology are misguided at best. What is more fruitful for the purposes of this paper and special issue, I think, is looking for positive lessons. So, I will now finish out the discussion herein by collecting five big lessons to be gleaned from uses of teleology in mainstream ecology.

*Lesson I: Teleology is epistemically-necessary but can be metaphysic-neutral*

The first is already laid out above. Section 2 showed that teleological characterizations are, *at least*, metaphors (though I admit they may be unknowingly literal characterizations sometimes). And they play epistemic roles in reasoning in ecology (whether literal or not). What exactly are these “epistemic” roles? I submit that there are at least two generalizable roles teleological characterizations can and do play by being used as metaphors in scientific reasoning. To crystalize them here, the first is primarily what I think of as being a heuristic role.

*a. Teleological metaphors play heuristic roles*

Recall, Hutchinson (1948) generates mechanistic explanations of observable correlated patterns in aggregate data by imagining them resulting from “self-regulating” within ecological networks. As I said, the metaphor served as a “constraining frame” that limited possible candidate accounts of the underlying mechanics in this case. This is not unlike any heuristic concept; they limit the options to streamline and assist in generating candidate answers. As a simpler, I think non-teleological example, just consider choosing a place to stop and eat on a road trip. If you imagine that you decided that restaurant-type-x generally upsets your stomach and restaurant-type-y generally upsets your travel partner’s stomach, this is a heuristic device that limits the options for what will be a logical solution to your hunger. It shapes the outcomes you will consider as reasonable, whether or not it is true that any particular restaurants of type x or y under consideration would upset anyone’s stomach.

b. *Teleological metaphors can play essential pedagogical roles*

A second, epistemic role of teleological metaphors is also constraining and therefore heuristic. Yet, I think it is also well-characterized as being essentially pedagogical, in that it helps one learn something new. And this is, as I have said above, “by helping one envision *how*” some type of causal event unfolds; what its shape and directionality of occurrence are. If we revisit the example of chemical compounds dissolving in water (§2 above), we can see that teleological metaphors reveal explanatory causal features than are then built-in to more specific candidate mechanistic causal explanations of the same causal process.

The manner in which salt and sugar both dissolve has to do with some of their constitutive parts [Na+ on the one hand and a positively charged portion of an -OH group on the other] being “attracted” to partially negatively charges oxygen atoms. It is the context, the call for an explanation, that determines which features are salient and if more salient details are needed to produce a satisfying mechanistic explanation. If the question is a very general one, like ‘Why do chunks of salt appear to vanish when placed in water?’ then an equally general explanation suffices—that dissolution consists in the crystals de-aggregating and dispersing throughout water. A more specific question demands explaining that the de-aggregations of salt and sugar result from oxygen atoms “inserting themselves” between their own constitutive atoms. However, even at this level of specificity salt and sugar remain type-identical with regard to the sufficient explanation of each their respective dissolutions in water. As Lange (1994) point out, sugar’s dissolution is explained the same way. The occurrence of hydrogen bonding, in the case of sugar but not in the case of salt, becomes salient only once our question can only be sufficiently met by calling attention to those details. However, even then type-identical disposition to “be attracted to” some types of atoms and not others plays the important role of usefully simplifying the world so that we may comprehend it.

*Lesson II: Scientific practice shows teleological characterizations are assumed to be non-literal*

A second lesson to be gleaned from uses of teleology within ecology comes from taking a glance at practice, historically, from the Novikoff and Hutchinson era of work going forward. There one finds textual evidence showing that, “in general, ecologists have stayed on board with the idea that teleological characterizations of ecological phenomena are non-literal” (Donhauser 2016a, 71). In fact, contemporary ecologists typically only discuss teleological *causes* being operative within, and at the command of, individual organisms. They see such causes playing operative causal roles in bringing about ecological network-level properties, only because *intentional reproductive and survival behaviors of individual organisms* aggregate to produce patterns observable at coarser grained levels of analysis (cf. Richerson 1977, 3).

For instance, a dragonfly arguably has a goal that determines its behavior when it preys upon a bee. And explanations or predictions and retrodictions that account for individual or collective dragonfly-behavior-impacts may therefore in some sense take account of this sort of teleological causality. However, this is only because the basic causal nodes in the networks that ecologists study are organisms, and it’s not clear that we even need to commit to saying that intentionally coordinated organism-level behaviors are legitimately teleological (see Donhauser 2016b). I am only saying that *if* there is any robust teleology being appealed to within ecology, it is only found at that level; where it seems to me to be rather uncontentious. Yet, as Peacock 2011 points out, acknowledging that organisms contribute to chains of ecological interactions that influence population, community, or ecosystem-level dynamics via some of their intentional, goal-directed, behaviors does not also imply that the behaviors of individual organisms are coordinated by some greater *telos* belonging to the networks in which they are nodes (235). Moreover, the ecological literature also shows that ecologists have either tended to purposely shy away from committing to any robust metaphysics and explicitly remain agnostic or explicitly defend antirealist positions—with “numerous authors argue that a thoroughgoing antirealism has been the prevailing paradigm within ecology for several decades” (Donhauser 2016a, 73; see also Botkin 1990; Fitzsimmons 1999; Wittbecker 1990).

*Lesson III: Ecology is etiological and mechanistic*

A third lesson to be gleaned from looking at uses of teleology characterizations in ecology is that ecologist apparently generally see such characterizations as elliptical for etiological, mechanistic component-to-component, descriptions of the phenomena they characterize. As shorthand *ways of describing* the component-to-component underlying causes of ecological network-level properties, I submit that any teleological statement can therefore also be recast in functionally mechanistic terms—that is, in terms of the types of functions of the component-to-component parts of any ecological network. One way of doing this, I have argued (in Donhauser 2016a), is to translate teleological characterizations into the following etiological form.

For any instance of some type of ecological network (a population, community, or ecosystem), N: ‘any N has the function of doing P just in case an N is present as a result of causing P’ (cf. Papineau, 1992, pp. 61-7; Wright, 1976, Ch. 3). So, for example, an ecologist might say that ecosystem is ‘an ecological network that tends to maximize energy available for work within its boundaries to the extent permitted by energy inputs’ (Mitsch & Jørgensen, 2004, p. 92; Zhang et al., 2010, p. 695). We *could* interpret this as a robustly teleological statement. However, nothing about it requires that refer to any teleological cause of the dynamics of any such ecological networks.

Rather, the implicit characterization according to which ‘ecosystems function to maximize exergy’ just tells one *what* an ecological network will do if it is an ecosystem. It does not tell one *why or how* it may do it that thing that ecosystems are supposed to do. More to the point, the description can be recast so that we get component-to-component descriptions of ways in which the things within ecological networks would “maximize energy available for work” just by doing the things that those types of things do (i.e., following the typical eating, breeding, and dying patterns of their type). Indeed, it is assumed that it is “processes of natural selection” that produce any and all observable natural changes in the composition and regular dynamics of ecological networks; it is the shape and direction of those dynamics that is then characterized using teleological characterizations.

To illustrate, consider how simple natural selection processes change the composition of plant communities over time. For example:

[Any] species, X, suited to growing well given an abundant supply of certain nutrients will do so and will therefore out-compete other species that are less well suited to growing in those same conditions. Accordingly, if relative nutrient resource abundances change substantially, species-X would likely be supplanted by a species, Y, that is better suited to thriving in the new conditions. (Donhauser 2016a, 72)

This regular occurrence is aptly described as a community-scale plant network “maximizing useable energy” within its boundaries. And this happens through selective processes via which the fittest species under the going environmental conditions simply, and predictably, outcompete those that are less well adapted to those conditions. In other words, plant communities can be described as tending toward producing ‘optimal amount of biomass by changing in their overall composition in response to changing network inputs’ (ibid.) This also accounts for any regular, statistically typical, dynamic pattern in a place where there are patterns in environmental changes and nutrient flows (due to seasonal weather conditions, for instance) through any such ecological community (not unlike the “oscillations” as shown in Figure 1 above). In view of all of this, it is undeniable that at least some teleological characterizations are non-literal, and non-causal, *ways of describing* observable network-scale of analysis dynamics that can be re-cast in component-to-component terms.

*Lesson IV: “Bottom up” and “top down” are compatible*

A fourth lesson from the history of ecology is already implicit above in the discussion of Novikoff (1945). This is that “bottom up” and “top down” causal explanations are compatible. Is this to say there is both “bottom up” and “top down” causality occurring within ecological networks? My reader may at this point expect a resounding: No! After all, I have just argued that ecologists see top-down teleological causal characterizations as elliptical, nominal *ways of describing* bottom-up component-to-component processes. However, I submit that the answer is more nuanced and that there is still a sense in which there are legitimate “top down” causes. This is *not* to say that there is any coordinated control from the network-level down. Still, I submit that there are two ways in which there are “top down causes”.

First, emergent network-level properties exist. Second, emergent network-level properties *do* have causal impact on the individual nodes within the network. Or, alternatively, one might say that the collective properties of the entire complex of an ecological network have causal impacts on the individual nodes. As a simple instance, if the populations within a community are within some kind of population density “balance” relative to available resources, then more individual organisms will survive over time than if their population levels are wildly different or the amount and kinds of environmental resources change. I think this is uncontentious. And I submit that one can describe that as something like ‘emergent network properties bearing causal influence on the component parts.’

Then, in the view I have sketched, “top down” causality just has to do with the causal profile of a network being different if it is composed and assembled differently. And notably that in not a linear thing. A pile of random wolves and deer does not have the same causal profile as a community including interacting populations (cf. Sagoff 2013). If we shift away to a simpler physical example, just think of a stone arch bridge (the kind with a keystone at the top). Stone arch bridges are exponentially more stable that other types of relational structures of even the same stones, but any engineering student could give a “non-linear” component-to-component story of the realization of that stability by the stones. Clearly we can reductively explain any arch bridge’s specific stability, the collective foraging behaviors of the members of any bee hive may, in principle, be explained just in terms of the actions and interactions of each individual bee, and so on for the neurophysiology and physics underlying any predators stalking and for the electron physics of any planetary shift. The point is that there are emergent, “top down,” causes in this qualified sense, and “bottom up” and “top down” causal thinking can be seen as consistent and compatible in this qualified sense.

*Lesson V: Metaphysics after instrumentality*

Finally, we might follow modern ecologists in embracing a thoroughgoing ‘instrumentalist’ epistemology on the whole (see Donhauser 2016a, 74). According to such an epistemology, all characterizations of ecological phenomena, and thus teleological characterizations, are essentially conceptual instruments whose value is tied to their instrumentality. So, what matters is whether and how well they serve as aids to understanding(i.e. how well they aid in acquiring *an* *ability to comprehend and explain* some ecological phenomena), as well as how well they aid in making inferences (e.g. by aiding in understanding to help generate more robust predictions or explanations). The question of whether and to what extent any characterizations are true is subordinate to the matter of their instrumental value in this regard. In fact, many ecologists follow the view that the entire endeavor of ecology, and all of science but especially ecology, is an endless pragmatic effort. An effort to “posit new hypotheses that become relevant to public policy and resource management as the environment continually changes; anticipate novel environmental problems; and explore the potential ramifications of alternative responses to potential problems” (Donhauser 2016a, 74; cf. Holling, 1995, p. 4; Mitchell 2009, p. 99; Rist *et al*, 2013). We have seen that teleological characterizations have in fact been epistemically and practically valuable in scientific practice within ecology, since Hutchinson (1948) at least. So, although I won’t argue for or defend the view here, one final lesson is that instrumentalism is a sensible position, and one whose embrace can defuse literalist worries about teleological characterizations in science.

**4. Conclusion**

I hope in earnest that my arguments above will inspire further work on the philosophy of teleology in scientific practice and history and philosophy of biology more generally. I have sought to push forward the dialogue about teleology in science by attempting to illuminate some epistemic functions of teleological characterizations. I’ve done so through discussion of the historical and conceptual origins of theoretical ecology (§1), briefly defusing some persisting confusions about the use of teleological characterizations within ecology (§2), and collecting five generalizable novel insights regarding uses of teleological characterizations in science (§3). So that others interested the philosophy of teleology may find some inspiration to extend their own investigations, I will now conclude by suggesting five research questions that would set an agenda for fruitful follow-up that can build on the arguments and contentions in this work.

 These five possible research questions are extrapolated from the “five lessons” to be gleaned from uses of teleology in mainstream ecology discussed just above:

* Are there more epistemic functions of teleological characterizations than I have discussed?
* Are there areas of science or scientific practices that presuppose that teleological characterizations are literal? Would it change anything if they were assumed to metaphorical instead?
* Is the way of reducing teleological characterizations to etiological ones rehearsed above tenable? Is there some better, or just alternative, reduction strategy?
* Are “bottom up” and “top down” causal accounts in fact able to be compatible in all cases?
* Is there anything problematic or undesirable about instrumentalism regarding teleological characterizations used in science?

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1. I am sympathetic to the view that many concepts employed in ecology (e.g. ‘ecosystem’ and ‘community’) can, and arguably do, serve as useful and practically valuable theoretical constructs even if they haven’t any naturally delineated analogues; cf. Fitzsimmons, 1999 and O’Neill, 2001. [↑](#footnote-ref-1)
2. Some argue that Karl Möbius introduced this ontologically-neutral understanding of ecological entities in the 1800s, and others argue that this view has even deeper historical roots (see, for example, Shrader-Frechette & McCoy, 1993, p. 19; Egerton, 2012, Ch. 1). I won’t attempt to trace the exact historical origin of this thinking, but will simply contend that this view was clearly popularized and widely-accepted by the 1940s at least. [↑](#footnote-ref-2)
3. Thanks to an anonymous reviewer for clarifying this point. [↑](#footnote-ref-3)
4. George Verdanksy, whose theory Hutchinson uses, had developed the needed biochemical understanding in the 1930s. However, as far as I understand the history of ecology, it was not adopted by ecologists until Hutchinson made the relevant connections. [↑](#footnote-ref-4)
5. Donhauser 2016b unpacks this understanding of ecological networks and nodes. [↑](#footnote-ref-5)
6. Adapted from Donhauser 2016a, Fig. 1. See the discussion around that original figure for further details that are informative but unnecessary for establishing the key points of this paper. [↑](#footnote-ref-6)
7. The latter part of his paper then concentrates on explaining how certain kinds of theoretical population models can be used to predict relative rates of change in the abundances of some common types of interacting populations (1948, pp. 238-42; see Donhauser 2016a for further explanation). [↑](#footnote-ref-7)
8. This is not to say that everyone must go through a phase of understanding such forces using the teleological metaphor. My claim is, rather, that teleological metaphors *can* *and do* serve epistemic functions of helping to understand the shape and realization of some kinds phenomena and dynamics in different sciences. [↑](#footnote-ref-8)
9. In his 1997, Sagoff also includes an entire section, V, in which he discusses how ecologists have presupposed a robust “telos” being operative within ecological networks in his view. [↑](#footnote-ref-9)
10. Sagoff (2019) provides other critical arguments, about alleged Paley-type design-thinking within ecology. However, his arguments in that paper do not explicitly concern teleology or “ecological forces,” and so I will not engage with them in this paper. [↑](#footnote-ref-10)
11. Notably, since it is a negative proposition, it is logically impossible to establish Sagoff’s claim that no such forces exist in nature; that may just be unknowable. [↑](#footnote-ref-11)