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Socio-Ecological Systems

Toward pluralizing ecology: Finding common ground across sociocultural and scientific perspectives

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Abstract

Ecologists increasingly work with people from other fields, in which scholars, practitioners, and activists often pluralize: "ecologies." By contrast, biophysical ecologists use the singular. Specialists beyond ecological science may avoid the singular because it evokes environmental determinism, lack of human agency, and disrespect for ways of knowing beyond science. Some social analysts consider biophysical ecology itself to be but one way of knowing, which embodies social positioning and uneven power relations. For their part, ecologists often ignore discussions featuring the term "ecologies" as unrelated to their work. The authors—one anthropologist and two biophysical ecologists—wish to facilitate social–ecological interaction by evaluating the conceptual content of the plural versus singular contrast. We suggest there are fundamental differences between ecology in the singular and plural. We examine these differences by showing that the singular and the plural within ecological science differ in specificity versus generality. In the view of social critiques, however, the conflict reflects political power differentials and social position of science. We explore whether there are productive parallels between these contrasting implications of the singular versus plural. Social criticisms of singular ecology include lack of system openness, open-ended dynamics, contingent pathways of change, and human agency in ecological processes. We find value in these critiques and have grappled with these issues ourselves. We find that contemporary ecology often employs concepts amenable to those in social critiques. This finding demonstrates why ecologists should not be so quick to dismiss plural ecology as a meaningful phrase. We show that concerns of the social critiques embodied in the plural term parallel ecology's use of (1) multiple models to understand a topic, (2) multifaceted, scalable concepts, and (3) nested dialog between generality and specificity. We conclude that the use of the plural and singular actually share a conceptual foundation that can facilitate interdisciplinary integration and scholarship. Furthermore, the emerging awareness by ecologists of the concerns about the politics of power in science

and its use may improve the ability of ecologists not only to interact with social scientists but also to better engage with social movements and environmental justice.

KEYWORDS
concept, ecologies, hierarchy theory, integration, interdisciplinary, social critique, social–ecological system

THE PLURAL IN ECOLOGY

This perspective piece explores the idea of pluralization of the term ecology. Our goal is to promote interdisciplinary collaboration. We need to understand the substantive implications of the plural for the discipline of ecology and to clarify how pluralization can facilitate working at the intersection of social and ecological fields. Many of the social, humanistic, and practical disciplines and professions that ecologists interact with present the term ecology in the plural. For example, urban designers (McGrath, 2013), anthropologists (Rademacher & Sivaramakrishnan, 2017), and environmental activists (Neshime & Hester Williams, 2018) often speak of "ecologies." By contrast, most biophysical ecologists, with the exception of those conversant in social research and justice traditions, rarely if ever speak of "ecologies." Therefore, as an interdisciplinary team that wishes to improve the connections between diverse social sciences and biophysical ecology, we explore the commonalities that may clarify the use of the plural in ecological science. We hope that highlighting those commonalities can improve how ecologists participate in integrated, social–ecological research and practice of sustainability, resilience, and environmental justice.

Our presentation is synthetic, combing existing insights from the fields of interest. We recognize a body of social critiques of ecology. However, these social critiques may be unfamiliar or seem unjustified to biophysical ecologists. We assert that the various social critiques of ecology point to diverse reasons to pluralize ecology, and that the fundamental conversation between generality and specificity within ecology is essentially doing just that. To evaluate this assertion, we use hierarchy theory (Allen & Starr, 2017) to seek consilience (Laudan, 1971; Wilson, 1998) or synthesis among the perspectives represented by the pluralization that emerges from social critique, and from the diversity of scales, entities, and processes ecology usually examines.

Our primary aim was to show that the thinking in social and ecological sciences is already more similar than people often realize. Our interdisciplinary synthesis suggests that there is in fact a deeper, shared conceptual foundation that is hidden by the linguistic difference of speaking of ecology in the singular as compared to the plural. This means that a bridge between ecology and its social critics likely already exists, but to traverse that bridge more effectively, the interdisciplinary community must share a common understanding of the plural in ecology.

We first lay out important aspects of the social critique of ecology to help identify potential points of commonality with ecology. Next, we detail specific dimensions of pluralization that social researchers and activists already use: ecology as lived experience, avoidance of "totalizing abstraction," expression as an ethical system, and as a social movement. Within this enumeration, we note the epistemological features that ecological science shares with some of its critics. We follow with a discussion of how ecology uses hierarchy theory to address its need for both generality and specificity. We explore reasons within the practice of ecological science itself that pluralization may be justified.

SOCIAL-POLITICAL GROUNDS FOR PLURALIZING ECOLOGY

We begin by summarizing seminal concepts from sociology of science, science–technology studies, and philosophy of science that lead to pluralizing the term (Fischer-Lescano, 2012; Goldstein, 1975). We acknowledge that specialists in those fields, and indeed ecologists who interact closely with the experts and literatures of those fields, will find no surprises in this section. However, because many ecologists who practice more familiar disciplinary approaches to biophysical ecology may be less acquainted with these points, appreciating the social nature of ecological science, and the fact that it participates in social power relations, is a necessary foundation for understanding why and how to pluralize ecology.

Social specialists conclude that science embodies social processes and contexts, and thus is a sociocultural product

(Jasanoff, 1992, 2004; Longino, 1990). It is sociocultural because it is conducted by a community of researchers who create knowledge together according to a shared epistemological orientation (Franklin, 1995; Latour, 1987; Latour & Woolgar, 2013). In fact, the social nature of science is key because, as we will expand below, the presence or absence of diversity among those who practice science affects both its creative and critical capacities (Callon, 1984; Collins & Evans, 2007; Cook et al., 2013; Jasanoff, 2004; Pickett et al., 2007; Schell et al., 2020). Furthermore, all scientists are themselves socially positioned, working from their own specific sociocultural and structural contexts. Therefore, scientific knowledge is never neutral, nor independent of the individuals and communities of researchers who produce it. Unlike the dry lessons of middle school science class, science is not a soulless following of the rules of "the scientific method" to ensure rationality and objectivity. That sketch of science ignores its sociocultural dimensions, and therefore fails as a comprehensive explanation of how science works.

Philosophers and social scholars who study science itself provide very different explanations of the process. Among those who practice science, a core idea is that it functions in part because it is answerable to a material world. Science therefore often uses conditional statements as a tool for answerability (Pickett et al., 2007): "If *this* happens or holds, then we should observe *that*." The "this" and the "that" are decided based on discussions, arguments, revealing and critiquing different social biases, and insights from the lived experiences of the practitioners of science. Scientific communities ideally, to use the phrase of philosopher of science Helen Longino (1990), engage in "transformative interrogation." Transformative interrogation is the dialog within an open community that generates creativity and innovation in identifying the hypotheses to test. It determines how to represent each phenomenon, proposes how to examine the validity of "if-then" hypotheses, and expresses the meaning of the data collected. To give a different phrasing, philosopher Naomi Oreskes (2019) argues that "science is not the realm of any one individual but an open society built on consensus and self-awareness whose strength is mirrored by its diversity." The venerable motto of the Royal Society of London (n.d.), "Nullius in verba," no one's word is final, can be put into service to reflect the communal, social nature of science. In fact, this motto emphasizes a second point. Scientific understanding is, ideally, an open-ended process.

Yet, the power relations and networks within which scientists operate, and the social biases they hold, influence what places they study, what questions they ask, and what data they value (e.g., Cook et al., 2013; Jasanoff, 1992; Latour, 1987; Wyborn, 2015). This is a characteristic of science as social process, and therefore a diverse reality that motivates casting ecology in the plural. Yet studies of science as a process that makes, and sanctions, a specific form of knowledge also demonstrate that knowledge and social orders coproduce one another (Jasanoff, 2004; Peet & Watts, 1996; Peluso & Watts, 2001). They show that privileging certain knowledge forms to the exclusion, silencing, or discredit of others can create or reinforce social structures of depravation, oppression, and racism. There are myriad examples of scientists serving exclusionary and oppressive social agendas; these include evolution being used to justify racism, data supporting eugenics, and patriarchal neglect of the perspectives of women (Baker, 2021; Marks, 2017; Saini, 2019; Schell et al., 2020). Indeed, the European colonial project itself was tightly linked with the development of Western science (Crosby, 2004; Grove, 1996).

Just as damaging to some peoples, cultures, and places is more recent analysis that is employed to enact conservation policies that result in removing people from, or limiting their access to, culturally significant land and resources, for example. Such policies emerge from science-empowered institutions and elites (Blaikie, 1985; Blaikie & Brookfield, 2015; Callicott, 2000; Chapin, 2004; Chaudhury & Colla, 2021; Commission for Racial Justice, 1987; Forsyth, 2003; Saberwal, 1999; Simmons et al., 2016; Taylor, 2016). Part of what can help to compensate or correct for these problems within science is to include the greatest diversity possible of backgrounds, experiences, social stations, racialized identities, and gender identities in the community of scientists. Diversity should never be a simple decoration in science. It should be the soul of the process, from innovation to criticism. Diversity of practitioners and forms of knowledge about environments begin to explain why we argue for a plurality of ecologies, even within science. Dueling ecologies—that is, different and perhaps conflicting models of places and processes—can only exist in open acknowledgment of multiple valid ways of knowing and multiply positioned "knowers" of environmental change. Incorporating multiple ways of knowing is only possible when we endeavor to understand social diversity and the networks of power relationships that influence who is at the ecological table, and who has a voice in this important transformative interrogation. While always complex and never perfect, our understanding of ecology is richer and more complete through conscious inclusive efforts to understand plural ecologies (Collins & Evans, 2007; Leach et al., 2010).

BOX 1 Interpretations of ecology or an ecology based on chapter 1 of *Racial Ecologies* by Nishime and Hester Williams (2018).

1. Ecological struggle: how marginalized groups attempt to redress environmental inequities.
2. Ecological crisis: the recognition that social and material harms result from ecological hazards or environmental degradation.
3. Embodied ecologies: how traditions, lifestyles, intersubjective aspects of identity, rituals, or response to environmental cycles are internalized (e.g., those of Indigenous peoples).
4. Slave ecologies: how oppression into hereditary servitude was met with devices for survival, resistance, and self-expression (e.g., African American plantation and industrial).
5. "Racialization shapes a group's relation to ecology": how racial categories constructed and reinforced by legal or extralegal means, including segregation by residence, education, or access to nature, affect environmental attitudes and behaviors.
6. Each group's response is unique: how the specific combination of opportunities, resources, cultural patterns, and expectations for civic participation influence environmental relations.
7. Complaints about the "universalizing impulse" of the founding males of environmental studies, which generates one-size-fits all environmental planning, conservation strategies, and nature education tactics.
8. To combat the universalizing impulse, a view of "small ecologies" can compensate by recognizing multiple ways of being, socially differentiated environmental perspectives, and multiple scales of conceptualizing the ecological.
9. Recognize dialectic landscapes, with race, gender, and ecology in dialog.

SOCIAL DIMENSIONS OF PLURALIZATION

What are the social factors that generate different ecologies? The social critics and humanities have an extraordinary richness of different ways in which they view ecology (e.g., Guattari, 2000; Roane & Hosbey, 2019; Scoones, 1999). Good examples of the plural use of ecology appear in a recent book, *Racial Ecologies*, edited by Nishime and Hester Williams (2018). "Ecologies" is used quite variously in the book (Box 1). We cannot describe all of these ecologies here but can point to some general categories of ecology that are very rich: (1) peoples' lived experience in particular places and social circumstances; (2) a totalizing, fixed worldview of environment; (3) an epistemology distinctive to particular sociocultural groups; (4) an ethical system; and (5) a social movement. This variety of categories helps explore the rationale for pluralizing "ecologies."

Lived experience in specific environments

If ecology is about relationships and transformations in which organisms engage (e.g., Weathers et al., 2021), there should be a clear link between the concerns of people and those who study humans. People, of course, relate with each other and their physical environments, and they transform materials, energy, information, and meanings through those relationships. Lived experience and embodied experience thus become key parts of understanding the human world (Field-Springer & Margavio Striley, 2018; King, 2018). Hence, where and how people live, work, and play, in addition to how they construct meaning as parts of households, communities, groups, and polities, are key parts of various social–ecological worlds as well (cf. Blaser & de la Cadena, 2018). Among many social researchers, a meaningful way to understand these processes involves discerning specific ontologies, or ways of knowing that arise according to the conditions under which humans experience or represent the world. Attention to ontologies not only allows researchers to appreciate the many ways that human social groups might differently conceptualize and relate to the non-human world, it can also broaden our understanding of meaningful and consequential links between human and non-human processes and changes (cf. Kohn, 2015). Put another way, perhaps, a researcher cannot discern ways of knowing the environment without also understanding the cultural context and power relations within which those ways of knowing are made over time, and in lived life (cf. Callon et al., 1986; Latour, 1987). Distinctive ways of being in the world—ontology—beget distinctive forms of knowing the human and non-human world—in other words, distinctive epistemologies.

Human experiences or ways of being are particular—perhaps even literally unique—to each individual. That means that material hazard and comfort, social hazard and security, and the events that individuals have witnessed and participated in over time in particular places have deep significance to them. To the extent

that these experiences reflect a network of many transformations, they may appropriately be said to be an ecology. And there are as many such ecologies as there are people with distinct lived experiences. People, as individuals, as social groups, and institutions, therefore have many different ecologies. This, surely, is one of the principal readings of ecologies as encountered in social writings. It is equally common in the discourse of activists, who emphasize that no group's experience or value is more worthy than that of another.

We use several chapters from the Nishime and Hester Williams (2018) book, *Racial Ecologies*, to exemplify the variety of different social ecologies based on lived experience. Before we distill several ecologies from that book, we must note that we do not imply a biological or genetic origin of the racialized groups discussed. Categories such as Black, White, Asian, or the other terms familiar from the US census, and across the nearly 300 years since Linnaeus first asserted that humans fit into four so-called distinct races, are now understood to not reflect definitive genetic groupings. Rather, the categories reflect networks of power relations, norms, and social control (Graves, 2003; Saini, 2019; Wade, 2014; Yudell, 2014). With this caveat of racialization as a process of "social construction" in mind, we can explore with Nishime and Hester Williams how ecologies in the plural relate to diverse socioculturally assigned or claimed identities. These examples do not exhaust the perspectives of different social groups that might motivate pluralizing ecology. The collection illustrates some of the many environmental–social relationships—ecologies—that might exist. For example, a variety of worldviews point to diverse ontological perspectives among Indigenous peoples (Marez, 2018; Million, 2018). Similarly, there are African American ecologies (Haymes, 2018; King, 2018), reflecting aspects of African traditions and new adaptations hybridized during slavery. The different strands brought together in that hybrid ecology are (1) the interactions among Africans from different religious traditions, languages, and lineages; (2) from coerced interactions with different European cultures in Africa and via the Middle Passage; and (3) interactions with American Whites. African American ecologies can be said to exhibit themes of resistance to slavery and post-Reconstruction oppression as well (Hacker, 2018; Roane & Hosbey, 2019). Gardening is one form of resistance that spans from the days of slavery, through the sharecropping era, to urban agriculture in vacant lots. These are cases of African Americans making ecologies (Quizar, 2018). Indigenous peoples and other racialized and marginalized peoples in the United States have their own ecologies emerging from their diverse experiences, environmental linkages, and spatial contexts (Barry & Agyeman, 2020; Gilio-Whitaker, 2020; Marez, 2018). Communities of diverse heritages in America might create different meanings and interpretations of environmental change. Such varied interpretations may derive from diverse histories, ontological perspectives, and experiences that beget ecological knowledge, and so these, too, can be called ecologies. Various individuals among immigrant groups, for example, can be said to create various ecologies, but it may help biophysical ecologists to see these as "social-ecologies" for that is what they are: coproduced social and biophysical networks of interaction that reflect the specifics of time and place (Rademacher et al., 2019).

Each of these multiple social ecologies, or ways of being in the world, can be said to generate an epistemology, or a way of knowing the world. Such ecologies reflect the social–ecological theory. The immense variety of social–ecological systems, appearing in virtually all the Earth's biomes, suggests that pluralizing ecology is not only appropriate but necessary. The global and regional heterogeneity of societies, cultures, and economies is key to the social–ecological worldviews (e.g., Folke et al., 2002; McDonnell & Pickett, 1993).

Concern with sustainability and resilience, given that they apply to the joint social and ecological constraints and opportunities of diverse places, also argues for the pluralization of ecology. Ecosystem services, as a related set of ideas applying a lens of human outcomes of supporting, regulating, and cultural benefits (Millennium Ecosystem Assessment, 2005), is another reason to acknowledge the plurality of social ecologies. To call again on hierarchy theory (Allen & Starr, 2017), the general concepts of sustainability, resilience, and ecosystem services may lack local specificity. However, those important concepts must be locally contextualized (e.g., Ernstson, 2013) to address questions such as resilient to what, for whom, and at what cost across social power differentials? Not only must avoidance of hazards and costs for racialized, marginalized, or disempowered communities be considered, but access to benefits must be assessed (e.g., Boone, 2002; Bryant, 2003; Bullard, 2007) in the pluralization of ecology to support justice in ecosystem services delivery.

Aspects of these epistemologies can be informed by data, but they also involve worldviews about human agency, the agency of other-than-human creatures and entities, and often the agency of the non-material world. Whether taken symbolically or literally, these components of epistemology must be treated with humility and respect by those outside of them. The epistemologies of science are not the only operative ones at the intersection of the human and the natural. Indeed, different social groups or societies inhabit different worlds, which is a much more fundamental assertion than acknowledging

BOX 2 Key points of a contemporary ecological paradigm (after Pickett et al., 1992; Simberloff, 1980, 2014).

1. Ecological entities are open to energy, material, and information exchange. This counters the predominant view of the first half of the 20th century, which still persists in some quarters, that ecological systems are materially closed.
2. Ecological entities may be regulated by processes that arise outside their boundaries. If systems are open not only to energy flow, but to materials, organisms, and information, system regulation may result from external connections.
3. Ecological dynamics are probabilistic and can follow multiple pathways. Early or idealized emphasis on deterministic successions, the invisibility of historical disturbances and their legacies, and emphasis on deterministic models have been replaced by statistical thinking, recognition of the role of non-stationarity, and of historical contingency.
4. A single equilibrium point may be lacking. Teleological explanation has been replaced and the need for an equilibrium goal in complex systems is no longer a dominant modeling strategy.
5. Disturbance or disruption is an important ecological process. For roughly half its history, ecology avoided studying systems that were obviously disturbed and neglected to examine sites or records for past events that might have affected the system prior to the time of a research project.
6. Humans and their artifacts are components of ecosystems. Again, early ecologists, right up through the latter third of the 20th century in the United States, avoided places in which people lived or worked, except when negative impact was the topic. The embeddedness of humans in ecological systems and their often nuanced or lagged effects were largely ignored in ecology.

that they have different views of "the" world (Blaser & de la Cadena, 2018). Rather than the blind interpreting an elephant by examining its different parts, the idea of different worlds suggests there is no single "elephant."

A totalizing abstraction

One reason that social critics so readily pluralize ecology is that they see the term ecology, or related terms like ecological system, as restrictive, and implying a singular, universal, exhaustive explanation of events or structures (Rademacher & Sivaramakrishnan, 2017). Furthermore, they may be troubled by the organismal roots of ecology that may connote deterministic explanations. In the early days of biophysical ecology, species were assumed to reflect stable essences (Mayr, 1982). The probabilistic, population thinking that replaced taxonomic essentialism was one that challenged totalizing abstraction. Furthermore, environmental determinism, which excluded human presence, difference, agency, and decision-making from earlier systems thinking, is often dismissed as "the ecological fallacy" (Lavrakas, 2008). This label might have been fair in the early 20th century, when sociologists borrowed from an earlier and admittedly more deterministic version of ecology (Light, 2009). Such determinism does not mirror the thinking in ecology today, as shown by a summary of the major points of ecology's contemporary paradigm (Box 2). That paradigm is the most general set of background assumptions—a sort of meta-theory of all kinds of ecology. These are the deep assumptions that structure and constrain the more focused theories and models of ecology (Pickett et al., 1992; Simberloff, 1980, 2014).

It is true that ecology seeks generalization and comparison, but it does so through the assembly of various models that deal with the variety of specific conditions that exist in the material, social–ecological world. So, totalizing abstraction, which applies equally and in detail to all cases independent of the diversity of the world, is not the goal of ecology. Totalizing abstraction, which is the goal in classical mechanics, with its universal gravitational attraction, for example, cannot in fact be the stock in trade of ecology. Totalizing abstraction fails in the face of evolution of biodiversity, probabilistic and non-linear interactions, and historical contingency (e.g., Cadenasso et al., 2006; Levin et al., 2013). Consequently, generalization, comparison, and integration are desired in ecology, but universal theoretical idealization is not.

Rather, ecology embraces diverse, complementary or contrasting models as its explanatory and predictive strategy. Ecology, like the various socially oriented sciences, deals with the particulars and contingencies of real and complex situations beneath its umbrella of general principles. For example, spatial heterogeneity is a universal concern in ecology. Of the eight most general principles of ecology identified by Scheiner and Willig (2011; Box 3), five of them deal

BOX 3 The general principles of ecology, following Scheiner and Willig (2011).

1. Organisms are heterogeneously distributed: Plants, animals, and microbes are differentially located along gradients of environmental resources, stressors, and disturbances, or are arrayed in patch mosaics in response to environmental discontinuities or their growth and social requirements.
2. Abiotic and biotic interactions: Organisms interact with each other, and with material and energetic environmental factors. Ecology is a science of interaction.
3. Organism variation generates heterogeneity: In their growth and interactions in heterogeneous backgrounds, organisms generate additional layers of spatial heterogeneity in three dimensions at many scales.
4. Distribution and interactions are contingent: Accidents of history as they affect the physical environment, the dispersal, arrival, and interactions of organisms, and the occurrence and intensity of disturbance and stress are a part of the explanatory apparatus of ecology—history matters.
5. Environment perceived as heterogeneous: Organisms perceive and respond to temporal and spatial differences in their biological and physical environments.
6. Resources are finite and heterogeneous: Resources are not continuously available in any environment without constraint. The interactions among organisms mediate the availability of resources to other organisms.
7. Environment constrains birth and death rates: The basic drivers of evolution, of community composition, and of the organismal components and processes in ecosystems are the birth, life processes, and death of organisms.
8. Organismal properties result from evolution: The properties of organisms are not fixed over the long term, and change across generations and over time due to the cumulative and interactive effects of evolutionary processes, including mutation and variation, migration, recombination, drift, and isolation, for example.

explicitly or implicitly with heterogeneity. But exactly how much heterogeneity there is in a locale, what the sources of that heterogeneity are, how it affects organisms and environmental processes, and what its outcomes are in specific times and places are matters of local interactions as well as the effects of processes that can arise at a distance.

The features of ecology enumerated above suggest that there must be a plurality of models to deal with those local and temporal specificities. For instance, the spatial heterogeneity of the general phenomenon of community change through time is expressed very differently in places starting from bare rock versus a lake basin, to point to an extreme contrast. So, ecology deals both with general abstraction and with the rich particularities nested within the general, abstract schemes. Hierarchy theory (Allen & Starr, 2017) and the related theory of panarchy (e.g., Gunderson & Holling, 2002) inform this approach to linking the general and specific. Hierarchically nested theories range from the most general and inclusive ones through constituent, more narrowly focused ones. This application of hierarchy theory resonates with the idea of "middle level theories" introduced in social sciences, to relate the general with various degrees of the specific (Cadwallader, 1988; Merton, 1968). Hierarchy here does not imply a rank of prestige or power, but rather a nested conceptual structure subject to modification, improvement, or replacement.

An ethical system

Ecology is sometimes used to denominate an ethical system (e.g., Rozzi et al., 2014). Ecology can represent an ethical stance for stability on the one hand, or for adaptability and change on the other. It can represent contrasting visions of resilient balance, or of fragility (Levin, 1999). It can stand for a place improperly assumed to lack human influence (e.g., Gomez-Pompa & Kaus, 1992). It can be taken to show how the world should be, or just how the world is as the result of evolution—with or without a guiding hand. What ecology represents, in the sense of lessons from "nature," is an immensely broad and contested list. Ethical systems draw on assumed features of nature, or ecosystems, and the contrasts in the roster are sometimes great (Larson, 2011). The stances attributed to ecological entities and processes are myriad. However, ecological systems, as biophysical entities, lack moral content on their own. In other words, moral content is ascribed by researchers or practitioners.

But harking back to the social aspects of the science of ecology, ethical values do shape what scientists seek to know, and sometimes how they interpret the social meanings or political importance of their findings. A critical eye to the kind and degree of ethical content of the scientific process is an appropriate caveat.

A social movement

Ecology can be taken to refer to a social movement (e.g., Nishime & Hester Williams, 2018; Sze, 2018). If that movement only reflects "mainstream" values of the dominant elite, then that warrants criticism (Haymes, 2018). Such motivation for setting aside land, or excluding people from it in the name of conservation, for example, manifestly ignores and displaces the epistemologies of Indigenous people, or of racialized and excluded or lower cast groups (Million, 2018). Racism may prevent people from recognizing the narrowness of some conservation programs (e.g., Finney, 2014; Taylor, 2016). For example, aspects of the traditional US conservation movement emerge from a White upper class that values the environment as a stage on which to enact masculine prowess (Taylor, 2016), or as a kind of pre-industrial vignette that perpetuates settler-colonial myths of the North American continent as a vast, unpeopled, and apparently unclaimed wilderness (Cronon, 1995; Nash, 2001). Socially and culturally constructing the allegedly unclaimed wilderness was accomplished by genocide, removal, displacement, and historical erasure (e.g., Peluso & Watts, 2001; Taylor, 2016). For example, New York City's Central Park, a paragon of American urban greenspace, was literally constructed in 1858—not found—which required, for one, the removal of Seneca Village, a vibrant, middle, and professional-class, property-owning Black community that had settled north of the crowded city to escape the slights and hazards of racism prevalent there (Miller, 2022). The diverse perspectives through which conservation can be viewed are one way to motivate the pluralization of ecology. The important questions are as follows: What group or coalition's view of ecology governs what land to conserve? Are local people included, and how, and by whom is the conservation estate managed? What other ecologies are excluded by these decisions?

Seeing ecology as a kind of social movement poses the question, "What is the social hierarchy and the power structure against which social movements struggle?" Although the answer varies based on the culture and history of particular places, in the United States, the answer points to racialization and White supremacy (Gates, 2020; Goetz et al., 2020; Pulido, 2015; Van Sant et al., 2021). The United States is constituted and continues to be structured via racialized power, in which those identified or identifying as White are afforded positions of privilege and authority (Bonilla-Silva, 2018; Hare, 1970; Hayes, 2017). Indeed, the country was built on capitalism that depended on the European colonial project, and on the capitalization of indigenous dispossession, African (and Afro-descendent) enslavement, and a violently maintained social order (Fields & Fields, 2014; Mills, 1997; Purifoy & Seamster, 2021). Indeed, even legal and seemingly non-racial devices, like environmental zoning variances (Lord & Norquist, 2010), municipal zoning and home rule (Hackworth, 2019; Trounstine, 2018), assessment of credit-worthiness (Rothstein, 2017), and subprime lending (Rugh et al., 2015) can be deeply discriminatory. Given this hegemony of the White elites in the United States, it is understandable why social critics would enlist the plural term ecologies to call attention to the racialized groups or classes suffering from the country's exclusionary social hierarchy. Ecology as multi-faceted environmental movements is better described in the plural. There are specific movements to reclaim the making of "homeplace" in the African diaspora, for example, whether in rural or urban settings (Anderson & Wilson, 2021; Haymes, 2018; Roane & Hosbey, 2019). There are movements to restore the rights of dispossessed Native Americans to gather foodstuffs or artisan materials or practice rituals in conserved lands (Kimmerer, 2013). There are movements to revive indigenous languages and associated practices in places where they have long been suppressed or unlearned (Ogden, 2021). Thus, ecologies as a plural term honors the displaced or threatened practices and relationships embedded in specific environments.

We present two examples of ecology as a social movement at local scales: One is community science and the other is civic science (Krasny & Tidball, 2012). Many practitioners of community science eschew the previously predominant term, "citizen science," to avoid unintentional anti-immigrant bias and promote inclusion (Cooper et al., 2021; Debs Park Audubon Center, 2018). Community science engages community members in generating scientific data relevant to societally important questions. This approach (1) alerts people to their local environments, (2) engages them in civic dialogs that are relevant to various kinds of governance, (3) provides an entry for laypeople into a policy process, and (4) can be a democratizing process (McHale et al., 2018). Community science is intended to be responsive to people's needs and interests where they live, move about, work, and recreate (Irwin, 1995; Riesch & Potter, 2014). Because of the diversity of perspectives, locales, and issues of interest, plural ecologies is the relevant term for describing the diversity of communities and situations that employ community science.

A second cogent example is the origin of environmental justice as a social movement. Emerging from the concerns and activism of indigenous and other communities of color (e.g., Bullard, 1983; Commission on Racial Justice, 1987; Gilio-Whitaker, 2020), environmental justice originally focused on the colocation

of environmental hazards and communities of color. For example, Bullard's (1983) early work showed that solid waste facilities were disproportionately located in Black neighborhoods in Houston. Later work demonstrated that segregated communities of color and low-income communities faced greater health risks than society in general (Bullard & Johnson, 2000; Pulido, 2000). Inequity appears not only in the exposure to hazards, including the so-called "natural" ones such as hurricanes, tornadoes, flooding, or earthquake (Hendricks & Van Zandt, 2021), but also to the recovery from such events. As an example, assistance and support for recovery of Black communities in the Gulf Coast of the United States after Hurricane Katrina (Bullard & Wright, 2009) or of communities in Puerto Rico (Kishore et al., 2018; Lugo, 2018) after a series of recurrent disasters following Hurricane Maria in 2017 (Machlis et al., 2022) have been slower or less complete than wealthier communities or jurisdictions. The same patterns appeared in the wake of Hurricane Harvey in Houston (Smiley, 2020).

Environmental justice activism has expanded to include attention not only to hazards but also to amenities. For example, Boone et al. (2009) documented that Black communities in Baltimore had less access to large or high-quality parks and recreational facilities. Environmental justice has also grown beyond its roots in activism to include a scholarly component (Agyeman et al., 2002; Bryant, 1995; Shrader-Frechette, 2005). This may be driven by a desire to both remain grounded in particular places and communities, recognizing the variety of drivers and pathways to injustice, but at the same time acknowledge the fundamental similarity of power differentials leading to injustice in exposure to hazard or access to environmental benefits (Boone, 2008, 2013; Schlosberg, 2013). Furthermore, concerns of environmental justice extend well beyond the borders of the United States (Agyeman et al., 2012; Simone, 2017). Differential exposure to hazards or denial of amenities exists in other countries that emerged from settler-colonialism (Whyte, 2018), or in former colonies where the legacy of colonial segregation of imperial representatives from indigenous functionaries, or the local population at large (Nightingale, 2012), or even in states where virtually ubiquitous class differences are the principal markers of injustice (Zhu et al., 2019). The variety of practical and theoretical concerns of environmental justice argue for pluralizing ecology, both from ontological and epistemological standpoints.

The examples of social critique of ecology presented above have shown that the dialectic between ecology in the singular and ecology in the plural is a gesture shared with its critics. Scholars of the human and scholars of the ecological both recognize the plurality of contexts in which consequential interactions take place. Each of these contexts is examined through various approaches—a case, a specific model, an ethnography, a narrative, or a history, for example. The pride of place goes to context and specificity in all these disciplines. We conclude that the social and ecological disciplines that may at first seem diametrically opposed in their degree of plurality actually share a great deal.

SCIENTIFIC LENSES ON PLURALIZING ECOLOGY

With this understanding of contemporary social uses of ecology in mind, the question then becomes: What might pluralizing ecology mean within the contemporary science itself?

Science holds two things in dialog, readily linked by hierarchy theory (cf. Marquet et al., 2014; Meyfroidt et al., 2018; Pickett et al., 2007; Scheiner & Willig, 2011): generality and specificity. On the general side of the conversation is ecology as an inclusive body of knowledge. From this generalizing perspective, there is one science of ecology. Yet, this science is fascinated with diversity, difference, contingency, spatial heterogeneity, and multiplicity of change. In fact, the *spirit* of pluralization is central to science. As illustrations, some classic questions in ecology include:

1. Why are there so many different kinds of organisms? That is, why is there so much biotic difference (Hutchinson, 1959)?
2. Why are there different kinds and numbers of organisms in different places (Andrewartha & Birch, 1954)?
3. What causes the changes in rosters and abundances of organisms over various time scales, from seasonal, to yearly, to decades, to millennia (Raup, 1964)?
4. What things and conditions shape the kinds of transformations of chemicals, energy, or information that organisms engage in (Odum, 1953)?

These general questions sound simple on the surface, but in practice they suggest many different answers. For example, Pickett and Cadenasso (2017) emphasized generality and unity in urban ecology by using five meta-principles subdivided into 13 more detailed ones. By contrast, Forman (2016) emphasized the diversity of urban ecosystem types and conditions by articulating 90 principles for the same discipline. Similarly, evolutionary theory can classically be framed as the broad principle of "descent with modification," whereas many specific models could be constructed to deal with mutation, genetic drift, various kinds of selection,

dispersal, or geographic isolation, for example. So, it is clear that even the most general questions in ecology require multiple models to generate an answer. A model, for this purpose, is a representation of the organisms, processes, and their interactions, along with the controls on the interactions. Models can be expressed in verbal, mathematical, graphical, or experimental terms (at least!). Each model might take a different approach to the question. For example, models of change in the identity and mixture of plant species at a place over time—succession—can be tables of formulas, flowcharts of observed transitions, or diagrams of the changing structure of the vegetation in three-dimensional space (e.g., Meiners et al., 2015). New data sets that encompass spatially broad landscapes or transitions in forest communities over long time periods provide fodder for new likelihood-based models of the process of succession (Canham, 2020). Transitioning from the general to the specific side of the dialog, there is no single answer to the question of why plant assemblages change over time.

Furthermore, there is no single answer for any of the other big ecological questions posed above. Each answer is framed as a *specific* model and brings together different representations of the interactions that might be occurring at specific times and places in material worlds. For example, the coarse scale latitudinal diversity patterns have long been known to differ between marine and terrestrial organisms, and have more recently been found at a finer level of detail to differ between trees and herbaceous epiphytes (Spicer et al., 2020). The models to explain these different patterns necessarily assemble the driving mechanisms differently because of the contrasting environments these life forms primarily respond to. Perhaps each of these models might be called "an ecology," but in the field of ecological science, they are just called models. The knowledge base of ecology writ large—in the singular—consists of this collection of disparate, complementary, or contradictory models—ecologies—in the plural—writ small. Generality stands on one side of the dialog, with marvelous particularity on the other.

The same dialog exists in other fields like ethnography, where individual case studies expose the particularities of social relationships and environmental connections of particular peoples and times. A "case" is a basic unit of ethnographic context, and each case is embedded in its own cultural setting. Like the singular term ecology, ethnology is a collective term for studies of people's cultures in general, while ethnography is a study of the culture of a particular group in space and time. Similarly, the singular term religion refers to the aggregate concept of human relationship to the divine, sacred, or absolute, while a religion is a particular system that embodies a specific form of worship or canon of moral teachings. Thus, the contrast between a collective concept and particular cases is common across disciplines and human practices. Ecology, social sciences, and humanities share in plurality. However, ecology's plurality has rarely been articulated as such within the discipline.

This exploration brings us to a waypoint. Ecological science is an approach toward empirical, testable knowledge about a material world that aims for an inclusive understanding of how organisms generate or catalyze myriad transformations. Each time period, each place, or each network of interactions represents a particular collection of organisms, connections among and between them, and with the physical processes and conditions of the place they occupy. Each of these models might be called an ecology. Ecologists just do not usually do that. As a body of knowledge, ecology in general, that is, without a definite article, is a collection of diverse models that aims to explain or predict the transformations in particular circumstances or places. Each specific model constitutes ecology with a definite article—the. Each detailed model is "the ecology" of some situation, or "the ecology" of some forest, field, city, or historical period. Together these models are "ecologies" of the multifaceted, contingent, probabilistic, heterogeneous material world, in which humans play diverse but ubiquitous roles. A key point about contemporary ecological science is that the term "material world" includes people, their cultures, and their activities along with such things as soil, water, or atmosphere.

CONCLUSION

The crux of our argument is that social critics and ecologists think in ways more similar than the two groups often realize, so the bridge between ecology and the social fields is already in place. It is a matter of "seeing" the bridge through the fog of seemingly contradictory language—whether ecology is seen as singular or plural. Pluralization of ecology is an easy step, but important assumptions hide within that simple grammatical operation. If those assumptions remain hidden, they may hinder seeing the bridge of shared thinking, and hence, thwart interdisciplinary interaction that is key to solving contemporary environmental problems of sustainability, resilience, justice, or ecosystem services. This can leave the partners in conversations about research and practice confused or annoyed. Social scientists and biological ecologists both can benefit from this realization. If social scientists do not see any contribution from systems thinking, they may miss the opportunity to learn from its unique forms of

environmental information, and to enrich ecological scientists' awareness of socially multifaceted problems and interventions. A fuller set of "ecologies" stands to build more effective, collaborative coalitions to advocate for social and ecological improvements, adaptations, and equities.

To help lower the barrier to interdisciplinary interaction, participants in the conversation must recognize what ecology in the singular means to each party, and what ecologies in the plural suggests to all participants. These are tactics to advance consilience (Wilson, 1998) between social disciplines, ecological sciences, and those who act to change the world.

Shared understanding of the connotations of pluralizing ecology should facilitate effective cross-disciplinary communication and advance shared purpose. The connotations and meanings of ecology and ecologies can be seen through lenses of ecological science research, various social disciplines, and activism. All these viewpoints have legitimate claims to the power of these terms and have enumerated benefits of using them. But members of each of these communities also have responsibilities in using the terms. Each should be prepared in any cross-disciplinary interactions to explain how they are using the terms. All those participating in the discourse should be willing to say what ecologies refer to.

Explanations of what a disciplinary community or a field of practice means by ecology/ies should avoid a defensive posture. The point of stating a definition is not to force its use on others, but to expose the assumptions and values that each community brings to the dialog. It is these underlying values, perspectives, and worlds that each community inhabits (Blaser & de la Cadena, 2018) that are important, not the terms chosen to stand for them.

Ecology, meaning a field of study, is a science and an approach to complex and diverse social–environmental relationships. Ecologists have long since been displaced as the gatekeepers of the broader use of that term. One milestone on that road was the popularization of the term ecology in the wake of Earth Day more than 50 years ago. However, our experiences as continuing students at the suture of biophysical ecology and various social sciences convince us that many disciplines see the value of ecological perspectives in understanding the relationships of all beings to the material sources of and constraints to their thriving, to the richness and power of their relationships with their fellow beings, and to the places they all inhabit. We are committed to understanding the growing ways in which social scholars and activists use the term ecologies and humbly invite all of us to more often say, "And by an ecology I mean … ."

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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