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Who Values What Nature? Constructing Conservation Value with Fungi

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Introduction

Conservation is an applied field with a specific goal: to protect and maintain nature. The politics of conservation are value-based negotiations: what should be conserved, for whom, how, and why? Typically, how people value nature is directly related to their knowledge of and interaction with it. Some are interested in conserving nature because of its *instrumental value*, as something to enjoy and benefit from (Chan et al. 2016). These benefits are often measured economically. By contrast, others argue that nature has *intrinsic value*, its own value independent of people, which is sometimes also articulated as ecological value. Finally, Bryan et al. (2011) suggest that value is created, defined, and changes over time through social practices relating to uses and "non-uses" of nature. They argue that "successful conservation depends not only on identifying ecological and economic priorities for specific areas, but also on how these priorities align with the *social values* assigned these areas by the community" (p. 173, emphasis added). In this chapter, I refer to these three forms of value as economic/instrumental, ecological/intrinsic, and social, respectively.

CPG suggests a distinct position on how to craft and practice new knowledges of nature. As the introduction to this volume suggests, if we have begun to see the world as eco-social, we must adapt how we study and learn to know the world in this new reality. This adaptation must include fundamental shifts

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in value where we allow ourselves to be "transformed by the world in which we find ourselves" (Gibson-Graham and Roelvink 2009: 322) in order to recognize the interdependence of intrinsic, instrumental, and social values of nature. This means going beyond separate claims that biodiversity is primarily a social construction based on instrumental values (Takacs 1996; Lorimer 2012), intrinsically valuable (Hamilton 2005), or that if instrumental and intrinsic values are combined with social values, the total value will finally result in conservation. Indeed, CPG necessitates that we root our social analysis in the material world around us *and* that we consider how our practices of conservation are shaped by the natural world as much as they shape it in return. In other words, it requires new ways to construct value in eco-social futures. The concept of econo-ecologies (Barron 2015) can be useful in this respect.

I have previously introduced the concept of econo-ecologies to "foreground everyday economic practices and choices into not only the social dimensions of natural resource use, but also the ecological dimensions of natural resources themselves" (Barron 2015: 174). Econo-ecologies focus on moments of engagement as forms of work that build and maintain interconnected values between people and nature. This process shows all values are constructed through engagement and therefore open to reinterpretation as eco-social. Although they do not use the term "eco-social," Gibson-Graham and Roelvink's (2009) work on learning to be affected in the Anthropocene sets the stage for econo-ecological conservation values by highlighting humans' interconnectedness with the biota: "recognizing earth others as not-other than ourselves; … acknowledging our co-constituted being as body-world" (p. 324). To ground this exploration of transforming conservation value, I focus on a group of organisms often overlooked in conservation and society: the fungi.

Biologists and policymakers rarely consider fungal conservation (Heilmann-Clausen et al. 2015), and it can be challenging to identify how fungi are valuable economically, ecologically, and socially. With perhaps one notable exception (matsutake), economically valuable fungi are not rare or threatened and most endangered fungi have little or no monetary value (The IUCN Red List of Threatened Species 2015). The vast biodiversity of fungi does not recommend the group broadly for conservation (Blackwell 2011), and for most people, fungi are actually undesirable pests or disease agents (Moore 2001), often targeted for extermination (e.g. *Cryphonectria parasitica* for causing chestnut blight).

Despite the awkward fit, there is a growing discourse around their protection, passionately promoted by fungal conservationists (Heilmann-Clausen et al. 2015; Pringle et al. 2011; Hawksworth 2003; Suryanarayanan et al. 2015). They cite the economic and sociocultural values of fungi for food and medicine and as principle sources of enzymes, antibiotics, and in biotechnology. They highlight the importance of fungi as food sources for other animals, major actors in ecosystem processes of decomposition, and in supporting the vast majority of flowering plants on Earth through mutualisms (Heilmann-Clausen et al. 2015). A CPG stance acknowledges these different values of fungi and pushes us to consider how they shape and are shaped through interaction grounded in the material realities of exchange. Econo-ecologies shifts the focus to human *and* biotic work, both clearly visible and co-constituted in these examples.

The chapter proceeds as follows: in the next section, after a short introduction on valuing nature, I explore how conservation values are normatively constructed vis-à-vis economy, ecology, and society. I include a review and critique of the relevant conservation literature that has adapted these values to fungi. Following this, I present the concept of econo-ecologies more fully in relation to fungal conservation. This analysis highlights the interdependency of physical and human systems at the very heart of CPG, results in a new imperative for fungal conservation, and provides an alternative for other conservationists.

Construction of Normative Conservation Values: Background and Challenges

The logic of the scientific method is premised on isolating and testing individual variables in order to identify sources of variability. This method suggests that isolating different forms of value from each other can help identify mechanisms for more effective conservation management. Below I explore economic, ecological, and social values in turn and pay special attention to how they have motivated fungal conservationists to action.

Economic Value

In public discourse, the all too common "environment vs. jobs" rhetoric reduces any discussion of value to an impossible (and problematic) choice between nature's need to exist and humans' need to work (Chan et al. 2016; Mansfield et al. 2015; Burke and Heynen 2014), suggesting that humans' primary relationship with nature is centered on the need to make money in a capitalist economy. This perspective assumes that what is good for the environment is bad for the economy and vice versa. On a deeper level, these effects are premised on one way of knowing the environment—as something separate from people and one way of knowing the economy—as a capitalist marketplace in which people are either workers or owners of businesses that produce goods and services. In this system, the only way to maintain jobs and protect the environment is through a process often called the neoliberalization of nature.

Neoliberalism, simply stated, is "an economic doctrine that favors free markets, the deregulation of national economies, decentralization and the privatization of previously state-owned enterprises (e.g. education, health care)" (Cloke et al. 2013: 608). The neoliberalization of nature refers to the extension of these ideas to natural resource management and conservation. This approach to conservation is based on the belief that market mechanisms are the best way to create value in nature, making things like clean water, clean air, or biodiversity valuable enough to protect them. In other words, laws and regulations to protect water, air, biodiversity, and so on are unnecessary because if capitalism is allowed to operate freely, conservation will happen.

Buscher et al. (2012) assert, "there has been a conflation of what is generally (and simplistically) referred to in conservation discourses as *economics* with the ideological assumptions of neoliberalism" (p. 5, emphasis in original). Neoliberal conservation, they contend, "shifts the focus from how nature is *used* in and through the expansion of capitalism" to "*conserved* in and through the expansion of capitalism" (p. 4, emphasis added). Nature conservation essentially becomes a growth market (Sullivan 2013). This ideological foundation for nature conservation appears self-evident in a world seemingly dominated by capitalism, making it seem quite logical for non-governmental organizations to work with capitalist enterprises to determine the economic value of nature.

A neoliberal conservation approach is evident in the work of organizations like Conservation International and international conservation bodies like the International Union for the Conservation of Nature (IUCN), who are taking on the work of conservation with significant underwriting from global and transnational corporations (Brockington 2009; MacDonald 2010). For fungal conservationists, the most widely recognized and authoritative conservation organization is the IUCN. Most fungal conservationists are professional scientists (biologists who study fungi are called mycologists). They see their scientific colleagues, working on organisms ranging from coral to tigers, shaping conservation discourse at the IUCN and have been working for decades to make inroads there (Barron 2011). Beyond their own professional societies and a few EU agencies, as recently as 2014, the IUCN was the only international conservation forum where mycologists were active. Those mycologists have in turn been very active at international, national, and local levels to educate other members of the mycological community on the IUCN specialist groups and the process of creating Red Lists (Dahlberg and Mueller 2011), the main mechanism through which the IUCN draws attention to threatened and endangered species (IUCN 2012).

While fungal conservationists have put their faith in the IUCN, the IUCN has in many ways put its faith in global capitalism to help save nature. MacDonald (2010) observed this firsthand at the World Conservation Congress of the IUCN in 2008, which he deemed "a site in the neoliberal restructuring of conservation … in which the interests of capital accumulation receive an unparalleled degree of access and consideration in conservation planning and practice" (p. 271).

By focusing their efforts at the IUCN, mycologists' arguments about the economic value of fungal conservation have been enrolled into neoliberal conservation strategies where they must demonstrate the value of fungi in neoliberal terms. In this arena, the fate of fungi becomes linked to their ability to prove their worth in the new marketplaces of conservation. For rare, threatened, and endangered fungal species, this is a hard argument to make since only one (*Pleurotus nebrodensis*) of the 35 fungal species Red Listed at the IUCN has any commercial market (The IUCN Red List of Threatened Species 2015).

Ecological Value

Biodiversity is the cornerstone of building ecological value. Since the publication of the Millennium Ecosystem Assessment (MA) in 2005, the value of the environment has increasingly been discussed in terms of the many "services" and benefits it provides to humans (i.e. instrumental values). These services are broken down into four categories: provisioning (e.g. food, water), regulating (e.g. climate, decomposition), cultural (e.g. aesthetics, religious connections), and supporting (e.g. nutrient cycling, soil formation) (Millennium Ecosystem Assessment 2005). Importantly, as specified in a key figure in the MA (Fig. A on p. vi), biodiversity, or simply the diversity of life on Earth, is not considered an ecosystem service but rather is foundational to all services. This distinguishes biodiversity as intrinsically/ecologically valuable, outside of the service framework based on instrumental/economic valuation.

The concept of biodiversity emerged in the 1980s in political debate and was rapidly picked up and used by scientists to secure research funding to demonstrate the applied value of their work (Hamilton 2005; Ghilarov 1996). Biodiversity is an especially interesting concept in relation to ecological value, because it is both from abundance and scarcity that its scientific and public worth is generated (Stuart et al. 2010). One may simply recall the amazing images from the recent Planet Earth 2 trailer, from the massive flocks of penguins covering the Antarctic tundra to the lone cheetah on the African savanna, to recognize this odd paradox (BBC Earth 2016).

As the MA suggests, biodiversity is foundational to all Earth processes and therefore at the heart of conservation. This is also evidenced in the Convention on Biological Diversity (CBD), written at the United Nations Conference on the Environment and Development (the "Earth Summit") in Rio de Janeiro in 1992, which codified the connections among conservation, biodiversity, and development in international environmental law.

For ecologists, however, the definition and scope of biodiversity is more constrained. Simply put, it is difference at varying scales: genetically within species, among species (species richness, species diversity), and among ecosystems at all trophic levels (Hamilton 2005). Ecologists are interested in diversity because they interpret it as a predictor of community stability and hypothesize that higher numbers of species protect an ecosystem from various forms of disturbance (Hamilton 2005). The role of biodiversity in ecosystem function may make the case for conservation, but that is not the scientific goal in documenting it (Ghilarov 2000).

While ecologists and policymakers strive to protect overall biodiversity, emphasis is often placed on the special values of rare species, such as their rare genetics, their unique role in an ecosystem, or their value as an indicator species of some kind. Recognizing specific species as ecologically valuable because of their rarity, and also vulnerability, leads to their placement on lists: IUCN Red Lists (discussed in the previous section), lists of species recognized under the Endangered Species Act, and/or appendices in the Convention on International Trade in Endangered Species (CITES: an international treaty to ensure that trade does not threaten the survival of endangered species). Legal status generates ecological value and makes these species legible and eligible for attention, funding, and special treatment (Burke and Heynen 2014).

Studying relationships among species is the work of ecologists; studying individual species populations, like those placed on lists, is the work of biologists, mycologists in the case of fungi. Prior to 2014 there were only three species of fungi (one macro-fungus and two lichenized fungi) on the global Red List (Dahlberg and Mueller 2011); as of 2015, there are 35 (The IUCN Red List of Threatened Species). This >1100% increase represents a significant achievement for mycologists. By contrast, no macro- or micro-fungi are listed on the USA Endangered Species Act. Two lichenized fungi (*Cladonia perforate* and *Gymnoderma lineare*) are listed as endangered in the "non-flowering plants" category (a problematic listing by the US Fish & Wildlife Service [USFWS] since fungi are a different taxonomic group than plants) (US Fish & Wildlife Service 2016). As of March 2016, no fungi were listed in the appendices to CITES, not even the highly valuable caterpillar fungus (*Ophiocordyceps sinensis*), a rare fungus internationally traded as a medicinal product in traditional and Western medicine (Stewart 2014). Clearly, despite inroads at the IUCN, the conservation status of fungi in the USA (via the ESA) and internationally (via CITES) is low. Conservation mycologists argue that this is because people are unaware of the need for fungal conservation, despite the many ecological values of fungi (Heilmann-Clausen et al. 2015; Griffith 2012). I suggest that the problem also stems from challenges in fungal biology.

Biodiversity conservation policy rests strongly on the ability of biologists to measure and assess a number of characteristics about the diversity of life. The core concept in this formulation is the species concept, which is premised on the ability to identify, define, and differentiate living organisms from each other. Once identified, a suite of characteristics, including population size, abundance, range, habitat, and how these characteristics are changing over time, may be assessed. Species may be compared and contrasted using these metrics and valued accordingly. Species are literally the currency of ecological value in conservation.

Species are difficult to identify and assess in mycology and thus to value ecologically. The total estimated number of fungal species ranges from 250,000 to 5.1 million (Hawksworth 2001; Blackwell 2011). Because of changing species concepts and changes in fungal taxonomy, previously identified species are regularly reclassified. There is an abundance of examples: based on genetic analysis, the morphological species *Armillaria mellea*, a popular wild edible species in different parts of the world previously identified based on its structure, was broken up into 15 "genetic" species (Coetzee et al. 2000). The morphological species *Boletus regius*, a species listed under the UK Biodiversity Action Plan (Fleming 2001), was recently split into two species. The new species, *B. pseudoregius*, is now also listed as a priority species, simply because of its relationship to *B. regius* (Joint Nature Conservation Committee 2010). Beyond species identification, mycologists also regularly deal with high levels of uncertainty regarding several population biology metrics that form the foundation for the inventory and monitoring assessments that establish ecological value, such as identifying population size and location, mature individuals, and generation length (i.e. average lifespan) (Dahlberg and Mueller 2011).

Conservation mycologists, then, face many challenges in constructing ecological value for fungi. Fungal conservation is still in its infancy and thus is often discussed in relation to the entire kingdom because few people are conversant in individual fungal species of conservation interest. As a kingdom, fungi are wildly abundant and more diverse than the plant and animal kingdoms. Their biology, however, is complicated and not as well understood as flora and fauna. When making a case for fungal conservation, in fact, it is the value of fungi as drivers of many ecosystem services, including nutrient cycling, soil formation, decomposition, disease regulation, and waste mitigation, that gives fungi significant ecological value. However, these ecosystem services are considered separately from biodiversity. This suggests that in regard to ecological valuing, it is problematic to discuss the conservation of fungi solely in terms of biodiversity, since their ecological value is mostly derived in relation to non-biotic-based ecosystem services.

Social Value

The rise of the ecosystem services discourse highlights that for many people, the intrinsic values of nature are not sufficient to change behaviors on a large scale. Economic values represented through ecosystem services create some additional value, but the combination of instrumental and intrinsic values does not go far enough; both of these mechanisms are based on rational, logical valuations. They do not account for the social, emotional, and spiritual connections many people feel with the world around them, which at the individual and communal level are often the most valuable premises for conservation.

For the public, concepts of biodiversity often hinge on a few key species or special landmarks which are consistent with individuals' perspectives on health, balance, wellness, and other personal and social values (Fischer and Young 2007). Bennett (2016) showed that conservation programs were more successful and supported by local communities when people felt positively about them, rather than when they were based on objective scientific evidence. Studies like this one suggest that public perception, including peoples' feelings toward different organisms and landscapes, plays a more significant role in conservation than scientific data and ecological value. For example, visiting Cape Cod National Seashore every summer to breathe in and be renewed by the sea air or traveling to Yellowstone National Park to see wolves in the wild are iconic American experiences of high emotional value that result in stewardship of national parks and may produce "trickle-down" environmental stewardship at the local level.

Popular conservation outlets strongly rely on peoples' emotional and psychological connections to nature rather than the public's ability to process scientific evidence and reasoning (Fischer and Young 2007). In mainstream conservation culture, social values are grounded in what is beautiful, majestic, and invokes emotions. For the biota, "cute and cuddly" or "charismatic" species are at the top of the list. The logo and homepage of the World Wildlife Fund make this point very clearly. The panda logo is surrounded by panels featuring elephants, sea turtles, and a "donate" arrow pointing at a photo of a young boy at a candlelight vigil holding a handmade sign that reads "I love this planet!" (World Wildlife Fund 2016).

Fungal conservationists share an interest in building social value, but fungi tend to trigger associations with rotting food, infections, and poison; mycologists have little scope to invoke positive perceptions or warm and comforting moments. Instead, they emphasize the significant use values (yeast makes bread and beer possible), the major ecosystem functioning values (decomposition makes nutrients available for plants), and the novelty values of fungi (many are used to make natural dyes) (Moore 2001; Money 2012; Heilmann-Clausen et al. 2015). They host events ranging from "mycoblitzes" at national parks (a 24-hour citizen science event) to mycological forays sponsored by specialty grocers, to draw in the public and expose them to the unique and interesting world waiting just below their feet (Barron 2010).

There are also distinct subcultures of people who are deeply passionate about fungi and ascribe significant social value to them. Fungal bodies are turned into many kinds of art (mykoweb.com accessed 7/14/16), fungi have been worshipped as symbols of the Gods (Feinberg 2003), and there is a long history of association between specific fungi and magic, both for medicinal, spiritual, and recreational uses (Letcher 2006). Like with many subcultures, fungal enthusiasm has blossomed on the internet, where amateur and professional mycologists maintain active webpages (e.g. mushroomexpert.com), blogs, and discussion boards for everything from mushroom identification to club organization to tracking the fruiting of different species through mycological association websites and email list serves.

Within the academic community, there is increasing interest in assessing, quantifying, and incorporating social values into conservation planning and management. Ostrom (2007, 2009) outlines a social-ecological-systems framework where she examines human choices and their effects on ecological systems. Bryan et al. (2011) base their assessment of social values on research participants' connection to specific landscapes and specific ecosystem services that they value. Bennett (2016) explores the role of perception in the affectivity of conservation management. This research suggests greater understanding and inclusion of social concerns will improve and enhance wilderness protection and ecosystem management.

Chan et al. (2016) use the concept of relational values to explore a range of social values including forms of identity, stewardship, and responsibility toward nature. They emphasize the value of these human-nature relationships to individual and community well-being. They suggest that seeing conservation through relational values opens up possibilities for more collective negotiation, local knowledge traditions, and local practices. Leveraging social and place-based relationships in conservation, they argue, can then be extended to other places as we build and expand the scope of social relations.

The focus on relational values draws attention to often-neglected dimensions of environmental management but maintains a fundamental separation between humans/society and nature which itself has distinct effects on how nature and people are valued. When people and the environment are conceptualized separately, the underlying premise is a distinct, external nature with essential, intrinsic qualities like biodiversity and clean water. People use and appreciate these qualities as part of social relations, but nature remains outside the social. As a result, the value of nature also continues to exist outside of human and community well-being.

In eco-social futures, being "transformed by the world in which we find ourselves" (Gibson-Graham and Roelvink 2009: 322) means that conservation of nature becomes about self-recognition—that we must know nature differently because to know ourselves we must look to nature and to know nature we must look to ourselves. As organisms that exist within and all around us, fungi provide a unique group of organisms with which to begin this work.

Alternative Value Systems and How They Work for Fungi

The concept of econo-ecologies is based on two geographical literatures: social nature and diverse economies. Geographers (and others) have been working with the concept of social nature for some time now (Castree and Braun 2001; Puig de la Bellacasa 2010) and many take the conceptual (re)unification of nature and society as axiomatic in their writing on environmental management. For example, Burke and Heynen (2014) examine the "valuing and devaluing of natures, knowledges, and peoples" (p. 8) by linking three common systems of valuation (private, public, and household) to particular ways of knowing nature, which they categorize as (1) science based and market friendly, (2) publicly engaged, or (3) outside of science. They identify an expert-only neoliberal knowledge, which they argue dominates what they refer to as socioecological discourses, with negative consequences leading to and maintaining social inequalities. Like "much scholarship on environmental conflict [that] re-externalizes nature by treating it as an abstraction over which people struggle both materially and discursively" (Mansfield et al. 2015: 285), Burke and Heynen's argument about what is valued and what is devalued centers on socioeconomic practices and power relationships in environmental decision-making and therefore maintains, analytically and conceptually, a separation between humans and an external nature.

Mansfield et al. (2015) address the reunification of society and nature by "conceptualiz[ing] people and their needs, visions, and actions as internal to what nature is and does. [They] reject identifying groups of people that come into conflict over an externalized nature, instead considering the inherently political process through which particular social natures are fostered and contested" (p. 285). They enact their eco-social conceptualization by defining distinct forest types based on social groups, management actions, and ecologies. While specific biotic species are identified, they are never the defining drivers of the typology. Rather, forests are named according to differences in practices and accessibility based on land tenure. For example, instead of an "oak-hickory complex" or "pinion-juniper woodland" subjected to different social values and demands, Mansfield et al.'s forests are named "silvicultural forests" or "livelihood forests."

Although Burke and Heynen (2014) suggest their work is premised on a unified vision of nature and society, by comparing it with the work of Mansfield et al. (2015), it appears less so. Similarly, critical research on conservation is often purported to be about conservation (Neumann 2004) but does not always seem attendant to the biophysical material conditions of rapid widespread population declines and accelerated rates of species extinction (Bauer et al. 2016). Critical Physical Geography is, by design, intended to "go the extra step" that is visible in Mansfield et al.'s work, to construct new styles of research design, conceptualization, and writing to internalize nature's struggles as co-constitutive of human material and discursive struggles.

To construct values for effective conservation practices, ecological and social values must be recognized as interdependent. Ecosystem services and neoliberalization of nature are premised on capitalism, which does not allow for this type of interdependency. Econo-ecologies, by contrast, are premised on the diverse economy and thus provide an economic discourse through which values can be intertwined.

The diverse economy is an idea introduced by Gibson-Graham (1996) to critique the widespread belief that the economy is dominantly capitalist and to show the economy as diverse and always changing. She argues that the world cannot be reduced to a few key determinants (e.g. economic, ecological, social values) and instead can be understood "as shaped by multiple and interacting processes, only some of which we can apprehend. This approach helps us recognize the power and efficacy of things that might seem small and insignificant. It also means that we are open to the unexpected and the unknown" (Gibson-Graham and Community Economies Collective 2016). The diverse economy framework can thus provide theoretical tools for Critical Physical Geography to avoid reductionist analysis.

Econo-ecology, a concept developed based on diverse economic theory, is one such tool (Barron 2015). It encapsulates multiple forms of economic value grounded in social nature relationships. Conservation in this framework involves ongoing processes of learning and "becoming ethical subjects" through negotiations among humans, species, landscapes, that is, organisms and the places we all inhabit together. Conceptualizing those negotiations as moments of work, in which all involved are invested in maintaining and supporting well-being, foregrounds conservation values premised on ethical exchange and for long-term sustainability.

To somewhat mirror the structure above, I discuss fungi in an econo-ecological framework by moving from more economic to more ecological aspects. The entire section is premised in the valuing of social relationships inclusive of fungi. Unlike the sections above, these areas are intentionally not separated out in order to emphasize their interdependence.

In earlier work (Barron 2015), I suggest that considering society, economy, and ecology in isolation, as is often done in capitalist approaches to natural resource management, essentially pits these interests against each other and sets management up for failure. Econo-ecology is an alternative framework focused on engagement and exchange—that is, when value is created and materializes—as moments of ethical interaction among organisms. For example, the act of picking a mushroom in the forest includes an ethical choice: "For me to have this mushroom to eat/share/sell, I may decrease its reproductive success (mushrooms are the fruit of fungi). Is this OK? Yes, under these specific conditions…." Expanding on the economic value of wild edible fungi, I present a range of "transactions, labor practices, and enterprises found in wild product harvesting" (Ibid., p. 182).

Shifting the scale of engagement from conservation institutions to personal individual exchanges like the one above highlights economic relationships outside of capitalism. As discussed in the previous section, neoliberalism has colonized conservation spaces and discourse. Critical scholarship suggests that everything that happens within neoliberalized spaces, like the IUCN, specifically furthers neoliberalism (MacDonald 2010; Buscher et al. 2014). In other words, neoliberalized spaces are absolute. In econo-ecologies, we can observe economically driven conservation moments outside of these spaces by thinking about biodiversity as a scale. With a diverse economies perspective in mind, this enables us to observe that while perhaps capitalism has colonized conservation at certain scales and in certain spaces, there is much more to conservation. For fungi, the scale of engagement is critical precisely because they are not highly visible in large-scale conservation institutions and likely never will be. Rather, fungi's greatest value, their best chance at contributing to conservation, becomes clearer at different scales.

Species are the currency of biodiversity. Ecologists discuss biodiversity in terms of species richness and overall species diversity. These are intrinsic values. However, biodiversity can also be considered as difference across all trophic levels, meaning that it occurs on a scale and can be studied biogeographically. On a "biodiversity scale," distinct levels may be: genes (micro-level), species (meso-level), and ecosystems (macro-level). Less than 10% of fungal species have been discovered and described, suggesting that meso-level conservation strategies are not ideal for fungi.

Interpreting biodiversity as a scale conceptually "opens up" the "species currency market" beyond species, meaning fungal gene fragments found in soil have conservation value, and fungal functional groups have conservation value as drivers of ecosystem services. Thus, econo-ecological value can be found in the following examples: fundamental aspects of major biogeochemical cycles are influenced by fungi, such as the weathering of Earth's surfaces (Hoffland et al. 2004; Taylor et al. 2009) and decomposition in terrestrial (Hattenschwiler et al. 2005) and freshwater (Nilsson et al. 1992; Hackney et al. 2000) systems. Moreover, the diversity of fungi in a community impacts the diversity of plants in a community, as when mutualist fungi serve as positive drivers of plant diversity (van der Heijden et al. 1998; Dighton 2009) but also when emerging pathogens (chestnut blight or more recently sudden oak death) kill common species (Rizzo et al. 2002). Many of the specific species involved in these processes are not known, and as the discussion of fungal biodiversity above suggests, the number of functionally active species is likely much higher than currently thought. What is increasingly observed, however, is that fungal species do have distinct biogeographies (Griffith 2012) and that failing to recognize this could put dependent plant communities at risk. Ecosystem functioning is affected by biogeography because as species assemblages change, who is completing which activities (physical-chemical-biological processes of energy transformation and nutrient and matter cycling (Ghilarov 2000)) may shift.

Biogeographies are econo-ecological relationships because people have been intentionally and unintentionally moving organisms at great distances for millennia (Barron 2015). They move spores when they collect wild edible mushrooms in the woods of Oregon and ship them to Japan for consumer markets. They intentionally move mycelia when they inoculate trees with truffle spawn and distribute them for sale across the northwest of the USA. More often, people unintentionally move spores and mycelia when they cut down timber, package soil, ship horticultural plants, move food, drive cars, walk through woods, and so on. Based on recent research on the human gut microbiome, when people move, microbes move (Huffnagle and Noverr 2013).

Econo-ecology draws attention to the interconnectedness of microbial biodiversity, ecosystem services, and interpersonal relationships with and among humans, fungi, and other organisms. It shows the micro-level and macro-level of conservation as mediated by human actions and therefore as sites of ethical decision-making and practice. Spatially, the econo-ecology framework advocates for more place-based, context-dependent formulations of value attentive to experiential knowledge. This idea, that ecosystem functioning is co-constitutive with human choices, actions, and values about where to move and how to interact with plants and animals, is an eco-social stance on how to know nature.

Conclusion

The idea that fungi need the same form of conservation as "whales, primates, orchids and albatrosses" (Dahlberg and Mueller 2011: 149) may seem surprising to many, including other scientists and the public at large. Fungi are relatively unknown, not liked, and essentially *undervalued*. Not only is the conservation value of fungi not immediately obvious to most people, for some fungi are anathema to conservation; the idea that people should divert energy and resources to protecting a fungus is akin to the idea that we should protect mosquitoes or leeches. In the face of this widespread undervaluation, the fact that fungal conservation is being championed at all is itself notable.

The monetary values of different fungi, as direct and value-added commodities, go some way toward making the case for fungal conservation because it serves as a tool to educate scientists and the broader public, already steeped in neoliberal conservation, about beneficial "friendly" fungi. However, it is also limiting because it suggests that if fungal bodies or fungal labor cannot be converted into a material or service commodity, they are without worth.

In conservation, economic/instrumental, ecological/intrinsic, and social values are identified and rationalized as separate values with a shared goal: to protect nature from collapse while maintaining society (and nature) as we know it. In econo-ecology, these values are not separated. Instead, species and environments that we personally, spiritually, and emotionally value (social) are sites where we build well-being through moments of exchange and work (economic), leading to conservation of a co-constituted eco-social environment (ecological). Fungi become part of our exchange networks in a diverse economy and therefore must be maintained for our own survival.

For conservation, value is thus constructed through moments of exchange and is only as stable for as long as the moment or specific relationship exists. Change may not be frequent, but the possibility is always present. An approach to conservation that is based on adapting to ongoing change is important if we are to adapt and change conservation to include fungi. Most immediately, an econo-ecological perspective on fungal conservation might bring value to species linked to the need for new fungal-based medicines (Sliva 2003), those foundational to previously disregarded ecosystems now important to combat global change (Wieder 2014), or changing harvesting practices of matsutake in the USA based on their extirpation from Japan, where they are highly culturally valued (Hosford et al. 1997).

Value systems emphasizing specific forms of valuation are not effective for all organisms, and normative valuations can be detrimental to conservation overall because they undervalue organisms that are fundamental to the long-term success of conservation and neglect to recognize the interdependent nature of value. Consider, for example, the noble polypore (*Bridgeoporus nobillissimus*), a critically endangered fungus that only occurs in the Pacific northwest USA. The logging of old growth forests, changes in forest composition, and disturbance regimes have decreased its habitat (old growth Fir (*Abies*) forest), by over 90% in the last 100 years. The known sites of the species are protected, but the tree composition has shifted to a Douglas Fir (*Pseudotsuga*)-dominated forest (The IUCN Red List of Threatened Species 2015). The species is listed as critically endangered by the IUCN, but the Endangered Species Act regulates US management of endangered species, so at the federal level no action is mandated. There is not space here to discuss the complexities of forest management that resulted in this shift in noble polypore habitat. The salient point is despite its global endangered species status, what has happened and continues to happen to this fungus is mostly a series of side effects of the active management of trees.

Employing an econo-ecological perspective shows us that we live in an eco-social world in which our basic needs are coupled with those of other organisms and center on work: we work to eat, to reproduce, to move, and for joy. Other organisms also perform work for most of these same reasons. These are all fundamental to our survival as individuals and together. But for humans, work is more than that. It is not just about material survival or having the resources to meet one's basic needs. We work to maintain social and communal networks and physical health and security (Gibson-Graham et al. 2013). These are all enhanced in environments that are flourishing.

Econo-ecologies highlight relationships that cannot be easily quantified, categorized, or regulated but are real and worthy of nourishment and protection. Using econo-ecologies to reframe biodiversity conservation means reclaiming the concept of value as one that cannot be broken down into composite values and subsequently aggregated for better management. It means recognizing the diverse ways humans work with nature *as a part of it*. For example, ecotourism businesses provide paid employment and are dependent on intact and functioning ecosystems filled with clean air, clean water, and beautiful creatures. Alternative economic sector activities from fair trade coffee to organic cotton rely on humans' ability to work in and with coffee and cotton plants. Unpaid activities like berry and mushroom gathering generate important food products for families in many parts of the world and support close connections with the environment premised on the availability and safety of eating these wild foods.

An econo-ecological framework shifts the focus away from quantification of individual values, and is therefore less stable, but it can still be assessed: is this an exchange that benefits those making it now and does not harm the possibility of those in the future to make their own choices? This sustainability-based approach radically alters value, because exchanges that do not consider the present *and* the future are not valuable. For Critical Physical Geography, this means that value does not rest in the landscape, the biota, or the human systems but in their co-constitution.

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