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Review

The ethical foundations of biodiversity metrics

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Contemporarily, biodiversity loss is the prominent concern of the conservation movement. In reaction to the escalating depletion of biodiversity, governments and organizations are crafting policies and strategies with a central focus on biodiversity conservation. Assessing the extent of biodiversity loss and its relationship with human society necessitates reliable ecological metrics. However, the tools used to assess biodiversity encompass not only empirical dimensions but also normative values that shape conservation outcomes. This review examines the normative dialog implicit in our conceptualizations and measurements of biodiversity through the chronological framework of four conservation focal areas: Red Listing, species richness, environmental indicators, and the integration of human values. This investigation underscores the imperative to more clearly articulate the values of the conservation movement, a task that is even more pressing with the emergence of novel biodiversity finance tools.

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Introduction

During the past century, ecological assessment has evolved significantly. In the 1960s, the Red List established a conservation framework centered on species rarity and extinction. In the 1980s, the concept of 'biodiversity' gained prominence, shifting the focus toward species richness and ecosystem function. With advances in methodologies and computing power in the early 2000s, attention turned to more targeted indicators of environmental health. This path has laid the groundwork for contemporary biodiversity metrics to increasingly acknowledge normative ideas.

Conservation biology bridges ethical and empirical dimensions to craft principles and tools for biodiversity preservation. Yet, this integration can obscure underlying normative assumptions that shape conservation practices [37]. Such normative assumptions are evident through each focal point of conservation; the emphasis on abundance and rarity raises questions about our focus on species and extinction, while the attention to species richness challenges our consideration of diversity and ecosystem function. More complex ecological indicators answer some of these questions but also introduce new moral dilemmas about concepts like naturalness and historical states.

As the landscape of conservation continues to evolve, the need to examine how ethical values intersect with environmental metrics becomes increasingly urgent. In this review, I contend that the forthcoming phase of conservation will require a more coherent articulation of the values that underpin environmental assessment. Philosophers play a vital role in making explicit the normative stakes for the determination of value in the conservation movement, as conservation efforts can only achieve ethical outcomes through a more deliberate approach that challenges established practices.

Red Listing and the extinction focus (1960s to present)

The conservation movement emerged from global appeals to fulfill a civic duty to protect the natural environment and responsibly manage resources. Momentum about the conservation of biological diversity gained significant traction in the mid-20th century with the advent of pressing concerns about anthropogenic extinction rates. There is scientific consensus that we are presently facing a mass extinction event. This realization is disheartening for many, with a widespread concurrence that knowingly causing or contributing to the extinction of species is morally wrong.

The International Union for Conservation of Nature (IUCN), established in 1948, became an early advocate for species diversity conservation. In 1964, the IUCN developed the renowned Red List of Threatened

Species, an inventory that assesses the global conservation status and extinction risks of species based on abundance and rarity metrics. Today, the Red List is widely used by government agencies, conservation organizations, natural resource planners, academia, and the private sector. However, its application raises significant normative inquiries about our focus on species, the scientific limitations in understanding biological diversity, and broader moral questions regarding the significance of extinction.

First, the focus on 'species' warrants consideration. The concept of species, pivotal in ecology, remains contentious, characterized by a plethora of definitions that encompass diverse criteria considering factors, such as reproductive capabilities, evolutionary lineage, phylogenetic relationships, morphological distinctions, and integrative approaches that combine several of these factors [41]. Shanker et al. [41] emphasize the importance of appropriately defining and identifying species within the conservation framework. Misclassifications can result in misallocated resources and oversight of endangered or hybridizing populations, ultimately leading to increased extinction events.

This approach to conservation poses practical challenges because the description and understanding of species are confined to existing technologies and methodologies. For example, studies such as the widely publicized article by Ocampo-Peñuela et al. [34] spark debate about potential inaccuracies with the Red List system due to outdated data collection methods. Likewise, newly emerging eDNA practices, which gather DNA traces of organisms rather than direct observations of individuals, can reveal further discrepancies with Red List classifications. These methods can unveil an extensive range of previously unknown DNA sequences and reveal potentially undescribed species, thereby challenging conventional notions of species and prompting questions about how to ascribe moral status. Species exist on a spectrum but are often treated as discrete entities in conservation and finance practices.

From an ethical standpoint, focusing solely on species level biodiversity may overlook the moral significance of individuals, communities, and lineages that transcend species boundaries or are categorized at other taxonomic levels, such as subspecies. According to MacLaurin and Sterelny [30], understanding biological diversity through the lens of "species" fosters a useful consensus on the objectivity of the concept. Nevertheless, it is crucial to recognize the role of taxonomic categorization as a human construct developed in a time very different from ours and the potential oversights that may occur within this system.

These challenges raise broader inquiries about the underlying values behind our ethical convictions for the prevention of species extinction. In his foundational work titled 'What is conservation biology?' Michael Soulé posits that species possess intrinsic value, derived from their long evolutionary lineage and potentiality [44]. However, the philosophical justification for preventing extinction remains contentious. Claims about intrinsic value are difficult to justify or implement, though some advocate for a 'weak' conception of intrinsic value for biodiversity [32]. Instrumental arguments also face criticism, particularly in their inability to fully account for the wrongness of species extinction in itself [49]. Notably, there is little instrumental justification behind conserving species that serve no apparent utility or are exceedingly rare or preserving species that would be more instrumental if exploited.

There are several aesthetic arguments that can help justify the conservation of species. However, aesthetic preferences also pose problems by introducing biases into the management of species, scientific research, and public involvement [31]. As outlined by Small [42], most humans present (1) widespread ignorance and indifference toward the majority of species; (2) a tendency toward 'biophobia', manifesting as negative perceptions toward many encountered species; and (3) a strong positive inclination toward specific species valued for their characteristics or perceived significance to the human psyche. This focus on charismatic species has led to the disproportionate allocation of scarce resources toward a few species while neglecting broader conservation concerns [42].

The tension between instrumental and aesthetic values appears to reveal inconsistencies between conservation principles and outcomes. Many organizations claim to support conservation by emphasizing ecosystem function and its benefits to human society. However, if this claim holds true, organizations should prioritize conserving ecologically significant species of fungi, bacteria, and insects, rather than focusing on charismatic species like pandas, which may have a minor ecological role. On the other hand, aesthetic approaches that prioritize charismatic or rare species may better align with normative intuitions about conservation, while neglecting species that may be more useful. Thus, neither approach seems to fully align with the broader goals of conservation.

To resolve this conflict, a more nuanced framework is necessary. One approach could involve prioritizing species diversity from a sentientist perspective, highlighting the broader benefits to sentient beings within ecosystems. However, this method is limited by normative concerns, such as the risk of permitting the extinction of non-sentient species as long as the ecosystem sustains sentient life. Alternatively, the 'option value' of species, which focuses on potential future benefits of conservation, offers another instrumental approach [30,33]. Yet, this utilitarian framework also faces normative criticism, such as the

potential to substitute one species for another. It is crucial to proceed with precaution, acknowledging uncertainties about the potential economic, cultural, epistemic, and aesthetic benefits of various species.

It may also be necessary to move beyond the species level altogether. Many conservation arguments fail to justify species conservation, and ascribing moral standing to such a collective entity as species poses challenges. Wienhues et al. [49] found that most arguments against species extinction are not focused on the species themselves, but rather on the moral significance found elsewhere — such as in the well-being of individuals, human relationships with species and landscapes, or diversity. Stronger moral arguments may be found within these dimensions.

Similarly, from an aesthetic perspective, Mikkonen and Raatikainen [31] propose that aesthetic value may reside not in the visual appeal or charisma of species but in the complexity of healthy ecosystems at the landscape scale. While aesthetic values alone do not fully justify the necessity of conservation, they play a critical role in shaping our engagement with it. Consequently, it is imperative that conservation methodologies are explicitly aligned with the ethical values that underpin them.

Species diversity as ecosystem function (1980s to present)

The term 'biodiversity' gained prominence in the 1980s alongside the rise of international conservation policy, bolstered by pioneering experiments that linked high species diversity to ecosystem function. The concept of biodiversity was further solidified with the publication of the Global Biodiversity Strategy [50] and the Convention on Biological Diversity, signed at the Earth Summit in Rio de Janeiro in 1992. Since then, biodiversity has become a central tenet of the conservation movement, centering the importance of ecosystem function and its instrumental value for human society [12].

The definition of 'biodiversity' has been a topic of extensive debate in philosophical literature due to its vague, grand reference to all scales of life and the interactions between them (see Refs. [1,28,30,38–40]). This ambiguity extends to its scientific study. Since biodiversity cannot be directly measured in its entirety, ecological practice relies on 'surrogate metrics' to approximate it. The most common of these metrics is species richness [14]. Ecologists use these metrics to generate statistical insights into ecological communities, providing conservationists with data to evaluate the conservation value of different landscapes.

To address definitional ambiguity, contemporary ecologists frequently utilize Essential Biodiversity Variables (EBVs).[1] These systematic biodiversity observations encompass standardized data about genes, species, traits, community composition, and ecosystems. Standardization allows scientists to focus on and compare specific levels of biodiversity. While EBVs help reduce scientific inconsistency, they still rely on surrogate metrics to approximate biodiversity.

A drawback of using surrogate metrics such as species richness is that they fall short of capturing the values associated with 'biodiversity' and its broader impact on ecosystems. For example, if species richness was truly the important part of biodiversity, then there should be no opposition to increasing species richness through human genetic modification and breeding or through the introduction of exotic species.[2] Yet, many environmentalists would staunchly oppose these methods. Thus, the concept of biodiversity must encapsulate additional values beyond species richness.

According to Newman et al. [33], the conservation movement tends to prefer a series of eight different values beyond diversity, including (1) preventing extinction, (2) natural over modified habitats, (3) preservation over conservation, (4) wild over domesticated populations, (5) native over introduced species, (6) historical over changed communities, (7) ecological wholes over individual sentient organisms, and (8) *in situ* over *ex situ* conservation. Thus, surrogate metrics do not seem to fully capture the implied normative components of biodiversity [38] nor the complex spatial and temporal interactions associated with biodiversity [27]. While the contemporary development of more sophisticated indicators is narrowing these gaps, there remains a pressing need to examine the underlying values of these metrics.

To illustrate this need, consider the concept of diversity itself. Attempts to measure and preserve biodiversity imply that 'diversity' is what is valuable about nature. Yet, it is questionable from an ethical perspective whether biological diversity has value in and of itself. The deterioration of biodiversity does not itself provide an argument to stop deterioration; rather, biodiversity conservation must be given a normative premise [1]. Scientifically, the premise of the focus on diversity has been its importance for the maintenance of ecosystem function. This assertion is based on a series of pioneering experiments that found higher species diversity to be associated with higher plant productivity and respiration, increasing biomass production, and efficient use of nutrients (e.g. [47]).

[1] https://geobon.org/ebvs/what-are-ebvs/

[2] Some people have argued in favor of such tactics. For example, Lean [26] argues against the idea that invasive species increase the instrumental value of an ecosystem; Lean [25] discusses the introduction of new genetic material into wild populations.

However, contemporarily, the presumed significance of diversity for ecosystem function or stability lacks scientific consensus [22,38]. The original experiments supporting the connection between diversity and ecosystem function were extremely limited in their focus, examining only one trophic level and a small handful of species [30] and under very limited spatial and temporal scales [33]. Moreover, these experiments did not establish causation, as the changes in ecosystem properties might be attributable to external variables [14,38]. Furthermore, measures of ecosystem function are highly subjective and dependent on contexts and preferences [31,45]. For example, we tend to favor high primary productivity in forests but not in algal blooms [14]. Thus, metrics such as species richness lack grounding and fail to encompass the entirety of our values concerning ecosystem functionality.

Given the lack of scientific consensus, Frank [14] suggests that the conservation movement's strong emphasis on diversity may have been politically driven by researchers aiming to substantiate biodiversity as a concept. Biodiversity is closely connected to the politics of conservation and has become a prominent term shaped by implicit beliefs about the consequences of diversity loss on humanity's resources.

Even so, the historical emphasis on ecosystem function likely offered a more robust and precautionary argument than today's narrower functionalist approach [9]. In the 1981 'rivet popper' metaphor, biological species were likened to rivets in an airplane, where removing too many could lead to cumulative, irreversible damage, ultimately compromising the aircraft's integrity [11]. This pointed to the critical need for precaution in biodiversity preservation, reflecting the considerable uncertainties surrounding ecosystem functions and potential future pressures.

Centering the concept of option value may be a good strategy to realign biodiversity with the movement's foundational intent. Emphasizing the preservation of ecosystems for future, unknown benefits would strengthen the case for conservation. From a financial perspective, this approach better addresses risk and uncertainty while optimizing potential returns. This consideration reiterates the importance of understanding the philosophical foundations of conservation tools in practical contexts like biodiversity finance.

Ecological indicators and human impacts (2000s to present)

The growth of international biodiversity planning, alongside advancements in field methods, DNA sequencing, and computational capabilities, has led to the development of multivariate biodiversity indicators. Contemporary indicators provide stronger policy support, enable comparisons across broader spatial and temporal scales, more explicitly measure the desired outcomes of the conservation movement, and are increasingly employed to inform the emerging field of biodiversity finance (e.g. [16,24,46]).

Today, hundreds of biodiversity indicators are used by conservation organizations to track progress toward targets and to convey the outcomes of evaluation efforts. These metrics utilize diverse data types and may focus directly on the state of species (e.g. species richness/abundance), on biodiversity pressures (e.g. deforestation), or on human responses to biodiversity challenges (e.g. conservation project expenditures) [18]. Indicators vary in reliance on direct ecological measurements, proxy metrics like habitat condition, or model-derived data [18]. Example indicators include the Living Planet Index,[3] the IUCN Species Threat Abatement and Restoration,[4] the Biodiversity Intactness Index (BII),[5] and the use of Life Cycle Assessment (LCA) to assess the impacts of human land use.

Indicators aim to capture a wide array of conservation metrics and values, addressing some of our prior concerns about more simple metrics. However, they also introduce additional normative questions. For example, many common tools like BII and LCA examine how land is altered or occupied for human purposes, hindering its return to a 'natural' state (e.g. [5]). The conditions and assumptions used to define reference states and baselines are highly variable and frequently rely on substantial assumptions regarding environmental pressures and the interactions among these pressures [4]. Ongoing debates in literature revolve around whether 'natural reference states' should be defined by marginal change or should strive for some sort of pre-anthropogenic or pristine state [48]. Indicators lack stable definitions for terms like 'naturalness' or 'pristine', and they often apply these concepts inconsistently [7].

Foundational conservationist Michael Soulé and others argue that human-driven extinction is unacceptable, but that 'natural' extinction is not morally wrong [1]. However, given the planet's continuous evolution and species turnover, how do we define *natural*? The notion of a pristine nature separate from human life is philosophically flawed, as we are a part of the world [15]. Evolution of the genus *Homo* has been intertwined with ecosystems for millions of years, and *Homo sapiens* have influenced the environment for around 200 000 years. In a dynamic world shaped by millennia of mutual influence,

[3] https://www.livingplanetindex.org/
[4] https://www.iucn.org/
[5] See De Palma et al. [8]

how should we determine which environmental events fall under human moral responsibility? How can we define a natural state, and what is our moral justification for pursuing one? Can we truly identify an ideal historical baseline that we ought to revert to?

Given humanity's extensive impact on the environment, the human-nature divide appears to be a cultural construct warranting critical reevaluation. In environmental indicators, approximations of a 'human-free' ideal continue to depend on ecological conditions that are affected by human activity [48]. To establish a baseline for what constitutes 'pristine' nature, clearer normative definitions are necessary, alongside stronger justifications for the moral significance of achieving such states. Similar concerns extend to other values and preferences in conservation, such as ideals of 'native', 'disturbed', or 'wild'.[6] This broader consideration of criteria may risk complicating the biodiversity movement's elegant solution to focus on biological diversity itself.

To address uncertainties surrounding reference states, Vrasdonk et al. [48] suggest aligning reference states with conservation goals according to biological needs, current policy recommendations, societal norms, and practical considerations. Subsequently, while indicators aim to capture more complex values than standard ecological metrics, such as concepts of naturalness, they often articulate their findings by revisiting the traditional values of the conservation movement centering on rarity and extinction. Many indicators, such as BII, employ 'mean species abundance' as a focus, while LCA frequently centers on the 'potentially disappeared fraction' of species [7]. Thus, indicators revisit the original concerns with red listing and extinction focus, highlighting the continuing need to reassess how values intersect with conservation outcomes.

Human values in biodiversity conservation (2010s to future)

Recent advances in biodiversity frameworks have increasingly articulated the normative dimension of conservation. As evidenced in the adoption of the Kunming-Montreal Global Biodiversity Framework in 2022, there has been a significant shift in the global approach to biodiversity toward the trend of aligning conservation with human interests.[7] This shift follows the 2012 establishment of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). IPBES operates as an autonomous intergovernmental entity that aims to enhance the connection between science and policy to promote the conservation and sustainable use of biodiversity for the long-term well-being of humanity and sustainable development.[8] The IPBES Global Assessment Report on Biodiversity and Ecosystem Services exemplifies this paradigm shift by espousing a wide array of values and metrics while framing conservation within the context of 'Nature's Contributions to People'[21].

The IPBES Conceptual Framework endorses a pluralistic approach that aims to link nature, ecosystem services, and human well-being [10]. The framework advocates for the recognition and inclusion of diverse societal perspectives on what constitutes importance in conservation efforts. IPBES documentation outlines a range of potential values for biodiversity, including its economic significance, cultural and spiritual importance, and notions of intrinsic value [20,35]. The platform's focus on equitable and participatory decision-making is paramount as the conservation movement grapples not only with biodiversity loss but also with the social issues of power, economic inequalities, and the unequal distribution of environmental benefits and harms.

This 'ethical pluralism' approach has been gaining momentum in international biodiversity policy and presents merit (see e.g. [6]). However, the wide-reaching call to consider all values lacks sufficient precision. Notably, the most recent IPBES publication calls for a better recognition of nonmarket values [35]. Yet, the document primarily equates biodiversity with the services it provides and minimally references biodiversity metrics, only briefly mentioning the metric 'number of fish species' in a graphic. The broad range of values and metrics potentially supported by the IPBES framework could enable political actors to choose methodologies that support their preferred actions, potentially misaligning with the intentions of recommendations. Without well-defined priorities, conservation efforts risk becoming fragmented, or worse, perpetuating the existing practices that exacerbate environmental degradation.

International biodiversity frameworks reinforce the paradigm of sustainable development and ecosystem services, which, without careful philosophical scrutiny, could inadvertently endorse unquestioned economic growth, the commodification of nature, and the continued exploitation of vulnerable people. Mere acknowledgment of pluralistic perspectives falls short of addressing this, especially when value frameworks center on nature's utility. The 'Nature's Contributions to People' framework of IPBES aligns less with Soulé's original postulates and the origins of biodiversity and more closely with the human-dominated approach of

[6] Note the infamous philosophical debate about appeals against exotic species being akin to xenophobia, see e.g. [17]

[7] https://www.unep.org/resources/kunming-montreal-global-biodiversity-framework

[8] https://www.ipbes.net

Kareiva and Marvier [23], with which Soulé himself criticized [43].

Ultimately, modern biodiversity frameworks seek to integrate normative values into metrics more explicitly; however, their broad scope and instrumental emphasis may grant political latitude for a wide range of actions, potentially diluting their effectiveness. Without systemic change, social and environmental inequities can be perpetuated by the conservation movement (see e.g. [2,3,13,19,29,36]). This concern is especially urgent with the advent of financial tools and investment strategies for biodiversity conservation, which currently lack ethical direction. By abstaining from taking a definitive stance, pluralistic frameworks are at risk of implicitly endorsing the continuation of business as usual.

Conclusions

This article reviews the growing recognition of the moral dimensions of measuring biodiversity. Over time, conservation metrics have evolved through the frameworks of the Red List, the focus on species diversity and ecosystem function, and more directed indicators of ecosystem health. These ecological metrics reflect implicit values that shape the policies and outcomes of the conservation movement.

On the horizon, the broadening scale and scope of biodiversity metrics and policies raise new normative questions. Addressing philosophical and social challenges will require more than a mere acknowledgment of diverse values; stakeholders should advocate for and integrate values that are consistent with ethical imperatives. The role of philosophy in clarifying these concepts and articulating the normative stakes is crucial to ensure that value determinations have a meaningful impact.

Normative concepts influence — and are influenced by — environmental metrics. The advent of novel financial tools and investment strategies in conservation underscores the urgent need to articulate the ethical values underpinning conservation methodologies. This may encompass a more precautionary approach that considers the option value for future biodiversity. It may also necessitate moral considerations that extend beyond the species level. Without a concerted effort to reorient conservation toward well-defined ethical values, the economic and power structures driving the biodiversity crisis will remain unchallenged. Only through a deliberate approach can conservation actions transcend the current paradigm and genuinely sustain ethical outcomes.

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Data Availability

No data were used for the research described in the article.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Papers of particular interest, published within the period of review, have been highlighted as:

- • of special interest
- •• of outstanding interest

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This article examines the discourse surrounding the biodiversity–ecosystem function (BEF) debate that has unfolded since the 1990s, the focus of which has been the interpretation of correlations between species richness and ecosystem properties and their implications for conservation policy. The author argues that this scientific debate had significant implications for conservation policy, as it underscored tensions between different ecological factions and highlighted broader ethical considerations within conservation discourse. The author reveals the 'uneasy consensus' on BEF and the role that political and ethical discourses play in ecological science.

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This report, commissioned by the IPBES, serves as a methodological assessment regarding the conceptualizations of nature's multiple values and benefits. It reviews various sources and traditions of knowledge concerning the diverse values of nature while providing practical tools to policymakers for recognizing and incorporating these values into decision-making processes. The report discusses the challenges of value trade-offs across scales and the importance of collaborative efforts among different stakeholders to address these challenges. This represents a significant contribution to the international policy discourse on biodiversity conservation in the framework of ethical pluralism by providing a systematic framework for assessing diverse values.

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This article examines the Debordian concept of spectacle through a case study of Valle Chacabuco's transformation into Patagonia National Park. The authors highlight the tensions between international conservation efforts and local perspectives, arguing that the production of spectacle in conservation processes obscures underlying capitalist logics and reinforces dominant ideologies. The article underscores the role of digital media and consumer actions in perpetuating the spectacle, ultimately limiting alternative visions for sustainability. It calls for a deeper understanding of spectacle in nature conservation and its implications for fostering socially just conservation politics.

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