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Editorial

The Integration of Conservation, Biodiversity, and Sustainability

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Abstract: Our understanding of conservation biology and sustainability have been independently developing for a long time. Evidence suggests that biodiversity is critical for ecosystem function and services on which humans depend, and is directly linked to the economic, social, and environmental components of sustainability. Because of this, the integration of research from each of these areas should and is becoming a priority. In this article, the development of each of these fields and, ultimately, their integration are reviewed. From this, a number of research priorities that allow for the transition from conflict to mutual compatibility between conservation and sustainability objectives are explored. These priorities include research that will improve our understanding of (1) ecosystem services and function provided by biodiversity that benefit humans; (2) the connection between biodiversity and poverty reduction; (3) biodiverse agriculture; (4) issues surrounding indigenous knowledge; and (5) the development of indicators that allow for the integrative assessment of biodiversity conservation and sustainability objectives.

Keywords: agriculture; biodiversity; conservation; ecosystem function; ecosystem service; indigenous knowledge; indicators; poverty reduction

1. Introduction

The relationship between sustainability and the conservation of biodiversity has been slowly evolving and until recently has not been well established, particularly from a research perspective. In some cases, sustainability objectives have been viewed as incompatible with the priority of conserving of biodiversity. However, there is now a growing body of evidence that the diversity of life is critical for ecosystem function and services on which humans depend, and is directly linked to the economic, social, and environmental spheres of sustainability. However, this diversity is increasingly threatened by human activities such as urbanization, global deforestation, agricultural expansion, and climate change such that it is estimated that we are currently losing species at up to 1000 times the background rate of extinction [1]. This is further viewed as a crisis because of the recognition that biodiversity loss and associated reduced capacity in the provision of ecosystem services directly impact the human condition. As such, the UN has come to prioritize the conservation of biodiversity in the UN Rio + 20 outcome document, "The Future We Want", and in its Sustainable Development Goals (SDGs) [2,3]. Since then more concrete efforts to link biodiversity, conservation, and sustainability have been made, and research on integrating them has been accelerating. In this paper, I offer a historical perspective on the integration of sustainability and the conservation of biodiversity. I then identify priorities for research in this area, and while doing so briefly introduce the diverse research articles in this special issue on conservation, biodiversity, and sustainability.

2. Conservation, Biodiversity, and Sustainability: A Historical Perspective

2.1. Early Preservationist and Conservation Movements

Early preservationist and conservation movements pre-date the emergence of the notion of sustainability. Both movements valued biodiversity, but for different reasons [4,5]. Central to the preservationist movement which originated in the late 19th century from transcendentalism, a religious and philosophical movement, was the spiritual connection with nature as a path to self-knowledge. Members of this movement saw opportunities for self-awareness, reflection, and liberation by connecting to their environment. Some viewed nature as a teacher while others understood the spiritual connection to nature as a direct link to God. Still others viewed nature as an awe-inspiring force that should be incorporated into a way of life in which one can express their individuality and self-reliance [4]. These preservationists made strong spiritual and ethical arguments that nature was to be protected, not to meet our pragmatic need for resources but, rather, for its fundamental intrinsic value. Nature and all its diversity were viewed as sacred and humans as intruders. This led to a dominant approach to conservation that established protected areas from which people were excluded or displaced [6].

As early as the 1600s, a more pragmatic approach to conservation was beginning to develop. First in Europe, then later in the US, the initial goal of conservation was to develop and promote forest timber management. Although inspired by the transcendentalists who exalted the inherent value of nature, the conservationists moved beyond the spiritual connection to the natural world and preservationist objectives to recognize other ways in which humans depend on their environment. This led to the development of national forests, parks, and monuments with the goal of not just protecting these areas; but to conserve resources through planned use and renewal. Thus, with the conservationist movement, a new land ethic was developed that valued nature, but not as something sacred that should be set apart from humans. Instead, nature was viewed as something that should be valued for the variety of ways that it could meet the needs of humans and should be managed accordingly. This later evolved into the multiple use approach to conservation that encouraged environmental management to maximize potential for outdoor recreation including hunting and fishing; watershed protection; and the production of timber. However, the immediate needs of local communities in or near conservation areas were still often neglected.

This primarily Eurocentric or northern concept of conservation has been problematic for a number of reasons. First, it neglects the value and extraordinary knowledge of biodiversity by global indigenous societies that embraced these ideas long before their modern conceptions. Second, these principles were ignored as the goals of northern colonialism and imperialism were the exploitation of resources from less developed countries with minimal regard for resource management or human rights. It neglected the fundamental interdependency between the environment and the human condition, and opportunities for equitable development as resources were extracted and people were exploited for economic gain. With the realization of the vast indigenous knowledge about land management, agriculture, and the many uses of biodiversity came further exploitation as that knowledge was extracted without any recognition or compensation from the people that held it.

2.2. Prioritizing Biodiversity

Given the scientific documentation of accelerating rates of extinction particularly due to increasing habitat loss, the conservation of biodiversity emerged as a global priority initially with the establishment the International Union for Conservation of Nature (IUCN) in 1948. During the first decade of its existence, IUCN's main focus was to examine the impact of human activities on natural habitats. It recognized the damaging effects of pesticides and other chemicals on biodiversity and promoted the use of environmental impact assessments for various activities. Much of IUCN's subsequent work in the 1960s and 1970s was devoted to the protection of species and the habitats necessary for their survival. In 1964, IUCN established their "Red List of Threatened Species" [7], which has since evolved into the world's most comprehensive data source on the global extinction risk of species and

the most comprehensive information source on the global conservation status of animal, fungi, and plant species.

The IUCN Red List reports measures of the pressures acting on species, which guides and informs conservation actions to help prevent extinctions, and for this reason it is often referred to as the "Barometer of Life". The Red List shows us where and what actions need to be taken to prevent extinction. It provides a straightforward way to factor biodiversity needs into decision-making processes by providing a wealth of useful information on species. The IUCN also drafted a multilateral treaty known as *The Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) [8] to prevent species from becoming endangered or extinct because of international trade. Entered into force in 1975, this treaty requires that countries work together to regulate the international trade of animal and plant species and ensure that this trade is not detrimental to the survival of wild populations. The goal of protecting endangered species was emerging with national policy as well. To carry out the provisions of CITES legislation to protect biodiversity policy began to be adopted at the national level including the US Endangered Species Act in 1973 and similar laws in most countries throughout the world all [9].

2.3. The Emergence of Sustainability

As efforts to study and protect biodiversity were being made, the world also began to focus on the connection between the preservation and conservation principles, and the global enhancement of the human environment and quality of life. At the 1972 UN Conference on the Human Environment in Stockholm, Sweden there was for the first time a real emphasis on the environment as it relates to the human condition, and the integration of environmental protection, equitable development and social well-being. The Stockholm conference declaration recognized the difference between renewable and non-renewable resources and also the need to manage them. It encouraged policy that reduced pollution and promoted environmental research, education, and planning to reconcile the conflict between the need for development and the resultant decline of environmental quality. The declaration also recognized that many environmental issues are global in nature and can only be addressed through multilateral cooperation among nations.

The further integration of development with environmental management led to the origin of our contemporary concept of sustainability linking environmental, social, and economic spheres in 1983 when the UN formed the World Commission on Environment and Development. Gro Harlem Brundtland, then Prime Minister of Norway, was appointed to chair the commission, which became widely referred to as the Brundtland Commission. The publication that was generated by the Commission, "Our Common Future" or "The Brundtland Report", as it is commonly known, addressed the conflict between the promotion of globalized economic growth and the accelerating ecological degradation that was occurring on a global scale. It made the case for a more sustainable development, which it defined as "the kind of development which meets the needs of the present without compromising the ability of future generations to meet their own needs" [10]. "The Brundtland Report" prioritized meeting the basic and essential needs of the world's poorest people, such as access to clean air and water, nutritious food, education, and recognizing that those needs are best met through economic growth that offers opportunity for all people. It also conveyed an understanding of the limits on the environment's ability to meet both present and future needs, and it recommended that if development is to be sustainable, these limitations must be addressed in order to preserve intergenerational equity.

Twenty years after the first global environment conference held in Stockholm, the UN sought to help governments rethink economic development and find ways to halt the depletion and destruction of natural resources and pollution of the planet. This occurred at the UN Conference on Environment and Development (UNCED), or Earth Summit held in Rio de Janeiro, Brazil, in June 1992. It brought together leaders from 172 countries, 2400 representatives from international NGOs, and more than 17,000 broader participants. The summit agreements included: "Agenda 21" a comprehensive program

for global action in all areas of sustainable development [11]; and "The Statement of Forest Principles" a set of standards to guide the sustainable management of forests worldwide. It was also the first convention to specifically address global climate change and the protection of biological diversity through legal conventions [12].

2.4. The Integration of Sustainability and Biodiversity

Until Rio, much of the environmental component of sustainability was focused on renewable resource management and did not specifically recognize biodiversity as a fundamental resource as biodiversity issues were being considered separately by IUCN. After the Earth Summit in Rio, much of the focus by the UN on sustainable development was within the context of the Millennium Development Project, which got its start at the 2000 Millennium Summit. The declaration produced at this summit stated that every effort must be made to counter the irreparable damage caused by human activities that threaten our planet and our people. The basis of this effort to this was drawn from The Millennium Development Goals (MDGs). The MDGs did not specifically address the need to conserve biodiversity, but more generally emphasized sustainable management of the natural resource base and ecosystems [13]. However, as the international community started to embrace the idea of sustainability, the conservation of biodiversity was beginning to be included as a priority. Even before the MDGs in 1992, the Convention on Biological Diversity (CBD) was signed by 157 countries. The CBD represented a historic commitment to conserve biological diversity, its sustainable use, and equitable sharing of benefits arising from that use. It also recognized that biodiversity is at the heart of sustainable agricultural systems and plays a major role in the provision of ecosystem services, and the insurance of life itself [14]. The further integration of biodiversity and sustainability is reflected in the 2015 Sustainable Development Goals (SDGs) where the protection and value of biodiversity are specifically addressed in two of the SDGs: Goal 14—Life below Water, and Goal 15—Life on Land [15].

3. Research Priorities for Integrating Biodiversity Conservation and Sustainability

Biodiversity is the variability among all organisms in a particular ecological structure such as a habitat, community, landscape, or ecosystem. This includes the number of species as well as the diversity within a species, e.g., genetic variation or differences among populations. Scale matters when considering biodiversity. For example, one can consider the diversity at a specific site (alpha diversity), the differences in species composition among sites (beta diversity), or the diversity of the entire landscape, i.e., the regional species pool and can account for the turnover of species from site to site (gamma diversity). Much of the early research on biodiversity was in the area of taxonomy which is the discovery, cataloging, classification, and naming of organisms; and systematics which is the determination of evolutionary relationships of organisms. The field of systematics has a seen rapid expansion with the development of molecular genetic techniques.

The field of ecology has been very much focused on the distribution and abundance of species as determined by both abiotic and biotic factors including those associated with biogeography [16,17]. With the advancement of the field of Conservation Biology much work has be done on documenting both the rates and the causes of extinction, the influence of habitat fragmentation and alien species on diversity, and on the decline of genetic diversity within species and its consequences. Also, there has been much work on the optimal design of conservation areas for the maintenance of high levels of diversity. This has included the use of ecological corridors or greenways to link conservation areas [18].

As conservation began to be integrated with sustainability, research agendas focused on maintaining diversity in connection with the economic and social components of sustainability began to emerge. One early area of focus was the development sustainable forestry with the goal to provide equitable income while maintaining biodiversity by eliminating monocultures and implementing techniques such as age-specific harvest, the polycyclic felling system; and the sustainable harvest of non-timber forest products. Rather than displacing people, these models offer local stakeholders' economic opportunities through community-based sustainable forestry. Also, an understanding of

biocultural conservation that emphasizes the conservation of culture and heritage as an essential aspect of habitat and species conservation emerged [19]. This approach to conservation recognizes that indigenous cultures typically already value biodiversity, and that they can serve as allies in its protection if their heritage and culture including folklore, language, and indigenous knowledge are also protected. Research in these areas led to the development of conservation projects that consider the habitat and its biodiversity as well as meeting the social and economic needs of human communities that live in or near these areas. In some cases, locals who once exploited forest resources were hired to protect conserved areas or help document the biodiversity as "parataxonomists" such as the case of Area de Conservación Guanacaste World Heritage Site in Costa Rica [20]. The realization that without improving the lives of people in or near conservation areas, conservation objectives would most likely not be met, led to the development of programs such as the Man and the Biosphere (MAB) program by UNESCO. Through MAB, globally nearly 700 reserves that integrate human economic activity, scientific investigation, and preservation have been created [21]. This early work linking sustainability and conservation has led to some success in the preservation of biodiversity while enhancing the human condition. However, given the ever-increasing recognition that conservation, biodiversity, and sustainability objectives are inextricably connected, a number of new research priorities have emerged. In the following sections some of them are highlighted, and the articles in this issue of *Sustainability* that address them are indicated.

3.1. Ecosystem Services and Function

One of the more cogent arguments for biodiversity preservation is that the maintenance of biodiversity is crucial for ecosystem function and services that also link biodiversity and sustainability [22]. Types of ecosystem services are often differentiated. Provisioning services refer to the useable materials or energy that people obtain from ecosystems such as food, water, medicines, and other materials including those for income generation. In contrast, supporting services are those that play a role in the maintenance and function of ecosystems that serve both natural processes and human need. These include such things as pollination, beneficial insects that consume plant pests, and soil enrichment. Regulating services refer to those ecosystem functions that control or maintain environmental conditions such as erosion control by plants, climate regulation, flood control, and purification of air and water. Finally, cultural services provide cultural, recreational, educational opportunities. These services are not insignificant. Global loss of ecosystem services due to the changes in land use is $US4.3–20.2 trillion/year, and ecosystem services contribute more than twice as much to human well-being as global GDP. More specifically, in agricultural production the annual estimated value of pollinators is US$400 billion, natural enemies in pest management is US$100–200 billion, and nitrogen fixation is valued at US$50 billion [23].

Despite the recognition of the relationship between biodiversity and these services, there remains an urgent need to more specifically investigate the nature of the relationship among them [22]. There is great need for scientifically validated information on the status, trends, and service of biodiversity, and on identifying priorities and recommendations for biodiversity protection [24]. In recognition of this need, The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) similar to the Intergovernmental Panel on Climate Change (IPCC) was created in 2012. The IPBES is the intergovernmental body which assesses the state of biodiversity and of the ecosystem services it provides to society, in response to requests from decision makers [24]. The role of IPBES is to identify and prioritize needed scientific information and recommend and support policy relevant to biodiversity and ecosystem services [25]. However, in order for progress to be made in this area, this connection between biodiversity and ecosystem function in relation to sustainability also needs to be prioritized by scientists and funding agencies [22]. As an example, in this issue Ficiciyan et al. [26] examine the influence of different crop varieties on ecosystem services specifically among traditional landrace varieties versus modern varieties. They found that although both have merit as each supports different

types of ecosystem services, traditional agricultural systems are more resilient with regard to food security and, thus, it is essential that they be maintained and restored to meet sustainability objectives.

3.2. Poverty Reduction

Globally, people use tens of thousands of species to sustain their lives in some way [27]. As a result, biodiversity conservation must be considered in conjunction with the economic and social components of sustainability. Effective biodiversity conservation, therefore, cannot be separated from the elimination of poverty, women's health, education, and economic enfranchisement [27]. The global centric perspective on conservation led by the north does not always account for the needs among stakeholder groups, but rather, it sees the solution to the biodiversity crises as imposing limits to development and resource use including those harvested for income generation. This approach has been referred to as *bio-imperialism* which is in contrast to sustainability objectives that require *bio-democracy* [28]. Also, we need to recognize that the increasing relationship between biodiversity conservation organizations and the private sector makes biodiversity conservation an organized political act that could favor income generation for larger business over community stakeholders. This could include large development projects which both threaten biodiversity and limit income generation by local stakeholders [29].

Some have viewed the relationships among conservation, human rights, and development needs to be in conflict with each other. As such, more research on how best to combine conservation with poverty reduction is sorely needed [30]. Research priorities should focus on how biodiversity can be used to generate stakeholder income generation within the context of sustainability. One example of this has been the development of non-timber forest products (NFTPs) such as edible products, oils, gums, resins, and floral greens all of which can be harvested without killing the plant. Globally, such harvests can be a significant contributor to rural livelihoods. For example, communities in Nigeria's Cross River National Park generate 13% of their annual income on the sustainable harvest of NFTPs [31]. More research that helps communities find new natural products, and how to sustainably harvest and develop markets for them should thus be a priority.

More information on the social impact from the establishment and maintenance of protected areas including the displacement of communities, economic benefits or loss, and associated social and cultural costs is needed. Though the IUCN proposed this in 2004 World Conservation Congress it has not been a priority for research [30]. One recent study demonstrated that in Costa Rica two out of six districts with national parks or reserves were found to have higher levels of poverty than what is the average for all communities [32]. This both demonstrates that the socioeconomic benefits of conservation can vary within a country, and that further research on the relationship between conservation of biodiversity and poverty at finer scales is needed i.e., national averages may be misleading. An article in this issue by Roque et al. make that case that practices such as pasture, forestry and agriculture within protected areas in Brazil increase the income of families within those reserves; and that if properly managed can contribute to reducing pressures on natural resources effectively balancing biodiversity conservation and sustainability [33]. Also, ways to measure the intensity of conflicts between human activity and biodiversity conservation and their reconciliation are greatly needed. For example, various forms of agriculture could have different degrees of conflict with conservation efforts for more effective conflict management and the development of reconciliation strategies, yet this type of monitoring is rare or nonexistent [34]. As an example, in this issue Benitez-Capistros et al. [35] show that the nominal group technique that deliberately engaged stakeholders in the Santa Cruz, Galapagos reduced conservation conflicts. This method can, thus, be used to better balance the needs and interests of the community with those of biodiversity conservation.

3.3. Sustainability, Biodiversity, and Indigenous Knowledge

It has been broadly recognized that indigenous cultures have developed lifestyles more consistent with sustainability objectives, and, in many cases, have a deep understanding of the use and services

that biodiversity provides. Such knowledge could be applied to both sustainability and biodiversity conservation objectives. It can serve as the basis for stakeholder decision making in agriculture, healthcare, natural resource management, income generation, and other activities. Some have argued that you have to know how to use nature and biodiversity in order to save it and that this information exists globally in rural communities [19,36]. However, as development proceeds primarily through the action of outside forces this knowledge can be lost. Research on how best to document, preserve, and integrate this knowledge and empower community stakeholders in sustainable development programs is sorely needed as is consistent with concept of biocultural conservation described above. Working with indigenous communities to help them map historical and contemporary land use and territory in conjunction with documenting their vast historical and cultural knowledge has helped both support those communities and the conservation of biodiversity. One example of such a project is the ethnographic mapping of the traditional lands of the Matawai Maroons in Suriname [37]. Also, in this issue Luzuriaga-Quichimbo et al. studied traditional plant knowledge in Chacras, which are traditionally managed Amazonian agricultural systems. They found that this plant biodiversity knowledge varies by gender concluding that gender perspective must be taken into account in biodiversity conservation programs [38].

There have been a number of problems associated with research on indigenous knowledge that need to be taken into consideration. Knowledge that has been obtained from indigenous communities that has been revealed through research has often led to large profits by corporations in the north without any compensation to the communities from which that knowledge has come. For example, a number of medicines are based on indigenous knowledge of medicinal plants, insects and microorganisms used in these communities. Since only a small fraction of tropical forest species have been examined for their potential benefits, bioprospecting for species with potential medicinal value has been enhanced by working with indigenous healers because their knowledge can help narrow the search. However, typically, local communities receive no portion of the massive profits that these medicines based on their knowledge have yielded [39].

Another problem is that historically major discoveries of this type have led to the over exploitation of the organisms that produce the chemicals, thereby negatively impacting both biodiversity and indigenous communities. One model for addressing this is the agreement between the Costa Rican National Biodiversity Institute (InBio) and Merck & Co where InBio provides Merck with extracts from their forests' organisms for screening, and in return Merck provides funds for research and a percentage of royalties from any profits generated from products based on this knowledge [40]. More research is needed to develop models like this for all possible products offered by biodiversity that have market potential with an effort to preserve all knowledge, conserve natural areas, and existing social structures while providing income generation for communities that provide that knowledge. Finally, we need to rethink the appropriation and conservation of biological diversity from the perspective of social movements [28] and consider that there is a false dichotomy between indigenous and scientific knowledge within the context of power relationships [41].

3.4. Biodiverse Agriculture

Currently, approximately 40% of Earth's surface is under use for food and fiber production and this is anticipated to continue to rise. This trend will have grave consequences for the environment and biodiversity unless traditional agroecosystems like the Amazonian Chacras described in this issue are preserved [38,42,43]. In addition, regenerative sustainable agriculture techniques must be promoted, but in a way that avoids external or government enforcement. Community-based outreach and demonstration that these techniques at the farm level can actually increase yield over the long term are more effective. This requires knowledge that enables an understanding of biodiversity and how it can be managed to attain sustainable development [43]. Also, community and individual value of agricultural biodiversity must be cultivated, as should both measures of biodiversity and agrobiodiversity [42,43]. Gabel et al. in this issue compare methods of assessment to evaluate on-farm

biodiversity finding that each of them exhibit strengths and weaknesses, again a strong argument for further research on quantifying biodiversity [44].

Other important areas of research include how best to develop product value addition and links to markets, germplasm enhancement, participatory plant breeding, and to increase the diversity of high value products such as coconut and other nut products as way to improve livelihood [43]. With climate change come a number of problems for farmers such as increased drought and longer dry seasons, greater intensity of rain in wet seasons, and overall warmer temperatures [45]. Research on how best to adapt farming practice to these changes must be a priority including crop diversification and the development of new varieties. One example is the work of the Interspecific Rice Diversification Project which has developed drought resistant varieties [46], keeping in mind that crop diversification is also one way to increase biodiversity. Also, The Committee on Sustainability Assessment is a global consortium of development institutions that work collaboratively to advance the systematic and science-based measurement of sustainability in agriculture [47].

3.5. Indicators of Biodiversity and Sustainability

If our goal is to integrate biodiversity conservation and sustainability objectives, we need measurable indicators to determine success. Thus, an important research priority should be to both apply existing and develop new quantifiable indicators of outcomes from efforts that integrate the two. There exists an extensive list of criteria and indicators for biodiversity conservation with regard to forest management [22]. However, most of these indicators require complete and repeated species inventories which are a challenge to conduct. The same is likely true for non-forest systems as demonstrated in this issue [44]. As such, quantifying the presence of indicator species and guilds that reflect greater biodiversity has the potential to estimate biodiversity though this has its limitations. A potentially more powerful approach is to use structural based indicators such as stand complexity or connectivity among forests [22]. Work also needs to be done to improve our ability to compare biodiversity conservation effectiveness among regions such as the reference condition index used to do so among Biodiversity Ecological function Zones in China described in this issue [48]. A research priority should be to further develop ways of quantifying biodiversity in other kinds of ecosystems for which conservation is a priority, and to develop an adaptive approach to managing these systems that allows for research, monitoring, and subsequently adapting the way those systems are managed.

If we are to effectively integrate biodiversity conservation with sustainability objectives, then then we need to simultaneously assess in both areas. In other words, effective conservation efforts need to be considered in conjunction with poverty reduction, equitable economic, and income generation opportunities, and other measure of social progress while also considering whether resource use is regenerative. In this issue, two articles effectively adapt a traditional sustainability assessment tool, Life Cycle Assessment (LCA), to include impact on biodiversity. The LCA examines the environmental effects throughout the lifecycle of a product, from resource extraction and fabrication, to use and ultimately disposal. Maier et al. in this issue adapt this impact assessment measure in a way that allows for quantification of the impact of land-suing production on biodiversity, and develop a hierarchical framework to do this at the scale of global value chains [49]. Also in this issue, Rodríguez-Rodríguez et al. develop quantitative tools to assess local environmental, social, and economic effects of legally designated protected areas located within biodiversity hotspots that are managed for multiple uses [50]. These serve as models for developing assessment tools for both sustainability and conservation objectives by modifying existing indicators from either research communities so that elements from each can be integrated.

4. Conclusions

It is clear that the preservation of biodiversity is important if not essential in allowing humans to sustain their lives in a variety of ways. At the same time biodiversity conservation and human activity and development are often seen in conflict with each other. This conflict can be alleviated

through the integration of biodiversity conservation with the three-pillar model of sustainability and sustainable development [27]. There has been a long history of important biodiversity science, but its development as an interdisciplinary field that can address the scientific, political, and societal challenges that we face has not been advancing at a rate to meet those challenges [27]. Also, a lack of interdisciplinary scholars working on solutions-based research has been a barrier to achieving sustainability objectives [51]. However, as seen in this issue and elsewhere, this is changing. The field of sustainability science including its relation to biodiversity is rapidly expanding. A recent analysis shows that the rate of publication in interdisciplinary sustainability science is growing at 7.6%, almost twice as fast as the mean across all disciplines [52]. In this article, I have addressed some, but not all research priorities that will allow us to better link these disciplines. These examples represent both the dire need and the potential for this sort of integrative research. This integration has been referred to as *reconciliation ecology* which aims to eliminate the conflict between biodiversity conservation and human development by studying the mutually beneficial ways for the coexistence of other species with humans [53]. Continued work in this realm is sorely needed in order to guide both development and conservation policy.

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