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Commentary

Safeguarding biodiversity requires understanding how to manage protected areas cost effectively

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Protected and conserved areas are one of the most important conservation tools, with international targets aiming to protect 30% of Earth by 2030. However, for this extraordinary commitment to effectively safeguard biodiversity, we need to better understand when and why protected and conserved areas are effective.

We are in a biodiversity crisis with human actions having significantly altered 75% of the terrestrial surface of Earth and leading to more species threatened with extinction now than ever before.[1] Conserving and/or restoring nature through the designation of protected areas and other effective areas-based conservation measures (hereafter: protected and conserved areas) is one of the main tools proposed to reverse this trend and safeguard biodiversity. This has led to an expansion of area under some reported form of protection, covering at least 16% of all land and ca. 8% of the oceans, almost achieving international ambitions to protect 17% of land and 10% of the oceans by 2020, an ambition that has now been surpassed in the Kunming-Montreal Global Biodiversity Framework, where 195 countries agreed to protect 30% of the land and the oceans by 2030 (also known as '30 by 30').[2] However, despite the prominence of protected areas and OECM as tools in the international policy arena, many fail to deliver improvements for biodiversity. For example, in a systematic review, we showed that while protected areas on average are better compared to no protection, this is most often through slowing declines rather than stopping them.[3] Likewise, in a recent study of over 1,500 protected areas globally, Wauchope et al.[4] showed that only about 30% of more than 10,000 monitored water bird populations experienced a positive impact from protection with management being a strong predictor of being among those 30%.

For more than two decades, there have been calls to move beyond focusing solely on area under protection and increasing focus on their management.[5] However, operationalizing this has proven difficult in practice.[6] Similarly, the scientific community has struggled with providing robust assessments of the effectiveness of the existing protected area estate and providing science-based advice and "best practices" to inform effective protected-area management. This is perhaps not surprising, as protected areas suffer from major funding shortfalls,[7] suggested to be at least $44 billion per year, which is predicted to increase to at least $80 billion and maybe as much as $150 billion per year under a '30 by 30' scenario.[8] While we can hope that policy makers will increase funding concomitant with their increased area ambitions, the question of how we best and most cost effectively use the limited (and likely insufficient) funding for protected and conserved areas is therefore of critical importance and will be one of the major practical and academic questions of this decade. To move this forward, I see three inter-linked challenges that will be important for answering this question. These relate to (1) how to define success, (2) how to assess the impacts, and (3) how to best utilize data.

Challenge 1: Defining success

To be successful, protected and conserved areas need to target areas of importance for biodiversity, manage threats, and ensure healthy ecosystems that support biodiversity.[9,10] Increasingly, there is also a recognition of the importance of not jeopardizing the livelihood of people and potential synergies between the socio-economic and ecological outcomes.[10] However, the multidimensional nature of the outcomes that protected and conserved areas need to succeed on, presents challenges. While there certainly can be synergies between different conservation priorities, as often seen in the case of areas managed by Indigenous and local communities,[11] there will also be trade-offs. Such trade-offs can occur where a narrow focus on biodiversity can threaten the rights and livelihoods of local communities.[12] In contrast, giving priority to human activities, even at very low and supposedly sustainable intensities can change and jeopardize biodiversity values.[13] But trade-offs can also occur with different ecological or socio-economic outcomes. For example, prioritizing one set of species might negatively impact another[14] or where prioritizing preservation of the services to people provided by more natural habitats might benefit very different community members compared to those "services" associated with more intensified land conversions.[15]

Navigating the many aims of protection and the potential synergies and trade-offs is, however, only one part of the challenge of defining conservation success. Another challenge is the large heterogeneity in the levels of ambitions set for protection. For example, on average, tree-cover loss inside protected areas is lower than outside.[3] But should we be content with this, or could we expect that no natural tree cover is lost and perhaps even expect that protection result in the re-growth of natural habitats before we talk of success? Our expectations of success also

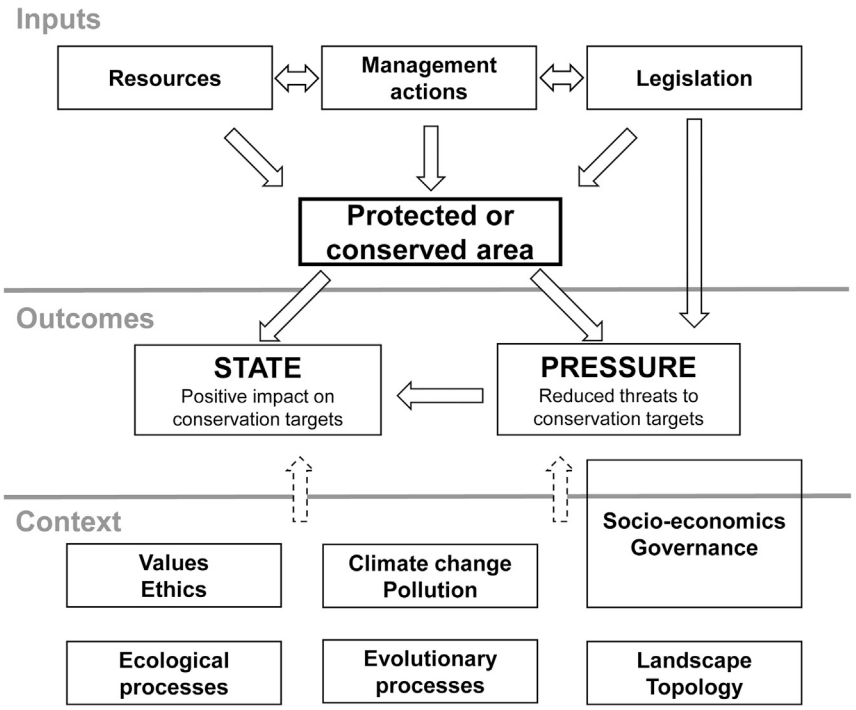

Figure 1. Framework for understanding protected area effectiveness through seeing protected areas as a "treatment" to deliver "outcomes" in the form of improved the state of biodiversity and decreased pressures

The "treatment" can be viewed as a series of "inputs" and is imbedded in a complex socio-economic and bio-physical "context." This context can both shape how inputs work and how outcomes change. In addition, some contextual elements can be seen as outcomes or objectives in their own right.

relate to our perception of what baseline for a natural state is being used and how this might shift over time and generations. Here, expectations vary greatly across the world. For example, in Europe, a long history of intense human pressure has led to dramatic alterations of most of the continent and conversion into production or urban landscapes. Conversely, many parts of the tropics still harbor relatively undisturbed areas of high biodiversity value. Such differences might affect whether managers and other stakeholders view success as even modest biodiversity-gains through restoring heavily degraded land or whether the aim is to reduce losses of near-natural landscapes. Being clear on both the objectives and the ambitions of individual sites and networks of sites is necessary for understanding what to expect from protected and conserved areas as well as for ensuring like-for-like comparisons.

Challenge 2: Assessing impacts

Besides identifying what to conserve, we also need to assess whether protected and conserved areas are actually having an impact on these conservation outcomes. Measuring impacts require isolating the effect of protection on the desired outcomes from those effects that relate to implications of the decision of where to locate a protected or conserved area. However, isolating that effect is not trivial. Protected and conserved areas are ultimately policy tools, implemented by state, local, private, and community actors, or a combination of those, who often do so with differing sets of intentions, histories, and ambitions. In addition, the socio-economic, cultural, and ecological context in which these sites are embedded varies wildly both within and between countries. Early studies of protected area effectiveness often ignored the role of context by simply looking at changes to biodiversity inside protected areas or comparing changes inside to the immediate surroundings.[3] However, an understanding is emerging of the need for more robust approaches that compare the changes inside protected and conserved areas to a credible control that shares the contextual properties of the protected or conserved areas (i.e., a counterfactual).[16] Much of the inspiration for this comes from looking to other fields like education and development studies and particularly the health sciences. This is perhaps not surprising, as protected and conserved areas in many ways are analogous to a treatment administered to a patient (Figure 1). And as in medicine, the treatment is dependent on the specific "inputs" associated with that treatment, which, here, are the available resources, the specific management actions implemented, and the associated legislations. These treatment "inputs" work to solicit a response in the desired "outcomes"—in the case of protected and conserved areas a positive impact on biodiversity and a reduction in human pressures. All of this is taking place in a complex socio-economic and bio-physical "context" that can influence the effectiveness of the treatment and which may in some cases be considered outcomes in their own right. Explicitly identifying what outcomes protected and conserved areas are set up to conserve, what inputs are expected to provide an impact on these outcomes, and how the context of the site or sites can influence this impact is, thus, an essential first step in developing a theory-of-change that can help to test the causal links between inputs and outcomes. However, in many cases, lack of data will likely mean that many important aspects needed to fully assess the impact of protection cannot be considered.

Challenge 3: Data

Recent decades have seen a surge of invaluable data relevant for assessing the effectiveness of protected and conserved areas. This has emerged from new and economically feasible field-based techniques such as camera traps, audio recorders, and eDNA, from citizen science projects and platforms, from a growing number of satellites with improved both spectral and spatial resolution, and from an increased recognition of the value of knowledge held by Indigenous and local communities. However, while the amount of data is undoubtedly growing, and growing fast, much of this data is not fit-for-purpose for assessing protected and conserved area effectiveness.[17] One key element is the need for time-series data. To identify the most important places to protect, data on

where species and ecosystems are found might suffice. But to understand impacts, we need to understand how things change and how these changes relate to our interventions. Second, we need not only data on the desired outcomes but also on the inputs and socio-economic and bio-physical contexts in which the interventions are embedded. Third, time-series data provides a measure of change, but where these changes are not related to the objectives and expectations of protection or where they are analyzed using insufficient experimental designs—they cannot satisfactorily unpack questions related to impact and effectiveness.[18] Thus, the present data deluge might provide important opportunities for assessing general patterns related to whether protected and conserved areas on average have slowed the decline of biodiversity and what factors correlate with these patterns. But this is not good enough. Identifying how existing data from the field and large-scale data collations can help assess impacts and how these data sources can be augmented by additional data will be important steps to improve our understanding of how and when protected and conserved areas deliver conservation outcomes.

Back to the "laboratory"

To deliver the necessary answers on what makes protected and conserved areas effective in maintaining and improving biodiversity as well as how these objectives are most equitably and cost-effectively achieved, we need to fully accept the scale of this challenge. Currently, studies of the effectiveness and impact of protected and conserved areas are based either on case studies that don't scale up or on large-scale studies using the best available data—data that are rarely good enough. Continuing on that path will not provide us the answers we need. Instead, we again need to look to other fields that have met grand challenges with grander yet ambitions. The annual budget to run the CERN Large Hadron Collider is ca. US $1.25 billion. And while I do not dare to suggest that anything in that magnitude is realistic or perhaps needed for assessing the effectiveness of protected and conserved areas; it is imperative that we move beyond post-hoc evaluations of existing protected and conserved areas based on the data at hand. This requires embracing an experimental approach that starts not with what is available but with how to best answer the main questions on the effectiveness of protected and conserved areas and extrapolate from there, to what data we need. Examples like the Biological Dynamics of Forest Fragments Project,[19] initiated among others by Thomas E. Lovejoy in the Brazilian Amazon in 1979 to study fragmentation processes at scale, might serve as a useful and more realistic example of what is possible when people dare to dream big. An experimental approach would depend on study sites where the types and magnitude of inputs can be controlled and quantified against changes in key conservation outcomes for both the target sites and in an appropriate counterfactual—that last part is critical. In addition, these sites will need to stratify different contextual settings. Given the real-world challenges of allocating new land for protection, selecting sites should build on existing protected and conserved areas and be done in partnership with those already responsible for the management. This also means that a large-scale approach might in reality be a collation of smaller studies but using a unified theory-of-change and similar approaches to identify conservation objectives, measure impacts, and track inputs. Besides ensuring coordination and knowledge exchange across these experiments, it will also be important to link the setup of file-based studies to global data sources and reporting.[17]

The newly agreed Target 3 of the Kunming-Montreal Global Biodiversity Framework (i.e., '30 by 30') should lead to the establishment of many new protected and conserved areas over the coming decade. Additionally, learning from the failure of past strategic plans, the Kunming-Montreal Global Biodiversity Framework has increased focus on effective mechanisms for planning, monitoring, reporting, and reviewing countries' contributions toward the agreed-upon targets. This provides new and important opportunities as well as incentives for scaling up focus on assessing the impact of our protected and conserved areas, which should give us hope that we can be more ambitious about understanding what makes protected and conserved areas effective. However, for the Kunming-Montreal Global Biodiversity Framework to be a lever for improving the effectiveness of protected and conserved areas, focus needs to shift from primarily documenting the actions of countries and other actors (e.g., local and Indigenous communities, the private sector, and NGOs) to assessing the impact and cost-effectiveness of these actions. Doing so will not only require funding but will also require diverse skillsets from across scientific disciplines as well as thinking in large-scale collaborations and coordination that leverages the knowledge and resources of academia, NGOs, and of those people currently managing land and sea for the protection of biodiversity. Indeed, many of the lessons to be learned are already being implemented in countless protected areas across the globe. But understanding when they work and how to transfer best practices to different contexts will require systematic, large-scale, and experimentally based impact assessments that uses standardized metrics and measured under different contextual settings to quantify protected and conserved area impacts.

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DECLARATION OF INTERESTS

The author declares no competing interests.

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