CellPress

Trends in
Ecology & Evolution

Opinion

The mismeasure of conservation

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One of the basic purposes of protected areas and other effective area-based conservation interventions is to achieve conservation impact, the sum of avoided biodiversity loss and promoted recovery relative to outcomes without protection. In the context of the Convention on Biological Diversity's negotiations on the post-2020 Global Biodiversity Framework, we find that targets for area-based interventions are framed overwhelmingly with measures that fail to inform decision-makers about impact and that risk diverting limited resources away from achieving it. We show that predicting impact in space and time is feasible and can provide the basis for global guidance for jurisdictions to develop targets for conservation impact and shift investment priorities to areas where impact can be most effectively achieved.

Highlights

A key role of area-based conservation is saving biodiversity or achieving conservation impact by avoiding loss and/or promoting recovery.

Conservation measures commonly used as policy targets, such as extent of protection and representation of ecosystems and species, are unreliable guides to conservation impact.

Most evaluations of the impact of area-based measures have been retrospective, but with lessons for future decisions.

Recent developments in impact evaluation show the feasibility of predicting conservation impact as a basis for setting targets and priorities, applicable to a wide range of area-based measures.

The post-2020 Global Biodiversity Framework has the potential to guide jurisdictions in achieving quantitative targets for impact instead of targets based on measures that could cause area-based conservation interventions to fail in protecting imperiled biodiversity.

The need for impact targets

The extent of the global protected area estate continues to increase, now covering almost 15% of land and more than 7% of oceans [1]. As well, the world has an extensive, although unquantified, coverage of other effective area-based conservation interventions [2], which we combine with protected areas under the term 'conservation areas' (CAs). According to available data on CA coverage, the world has more conservation than ever, but another measure (the loss and endangerment of species [1,3]) indicates that conservation interventions are failing to stem the attrition of biodiversity. The problem is that neither of these conflicting signals tells us what we need to know about CAs, including how much they have contributed to the conservation of biodiversity and how additional CAs can be established to maximum effect. With CAs at the core of conservation efforts, and the Convention on Biological Diversity's post-2020 Global Biodiversity Framework being negotiated, these are among the most pressing and crucial questions for the future of biodiversity, but we need a different measure to answer them.

CAs are meant to save biodiversity [4], but evidence of how well they do so is scarce. Impact evaluation [5] fills this gap. Impact is the difference that CAs make in avoiding the loss of biodiversity and promoting its recovery relative to the counterfactual of no intervention or a different intervention. The past impact of CAs (*PI* in Figure 1) is widely assumed to be large, but it is seldom estimated and can be surprisingly small. For example, some CA systems would have retained almost their entire extent of native vegetation in the absence of protection [6,7]. Future impact of CAs (*FI* in Figure 1) is generally assumed but rarely considered explicitly in planning new protection. Instead, almost 150 years after the first national park was established, CA policy, science, and practice remain focused mainly on measures that do not reliably reflect impact [8].

Increasing the difference that CAs make for biodiversity (Figure 1), or for ecosystem services and human well-being, requires a wider understanding of the limitations of current measures of progress and the removal of barriers to evaluating and targeting impact. Without these changes, investments in CAs are not accountable and might often be wasted, and adaptive improvement of CA planning and management is hindered.

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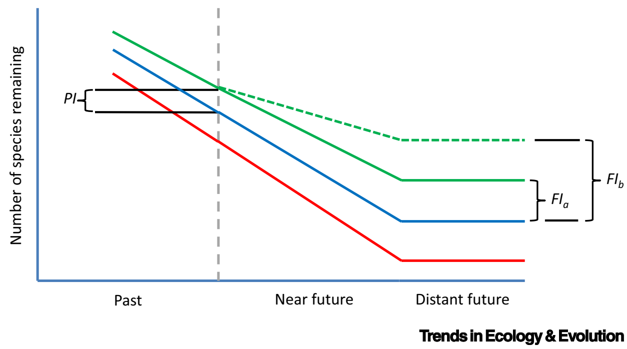

Figure 1. Past and future impact of conservation areas. The vertical axis refers to biodiversity in terms of number of species remaining within and outside conservation areas (CAs), so recovery after loss is possible only over evolutionary timescales. According to other metrics, 'bending the curve' [3] upwards is possible with, for example, improved status or abundance of species [50] or restoration of ecosystems. Existing CAs (past, green) had past impact *PI* relative to the counterfactual of species remaining due to non-spatial interventions (past, blue). Biodiversity has declined even with existing CAs but would have declined further without them. Without CAs and non-spatial interventions, the red line indicates the default number of species that would have remained to the present. Existing CAs and additional CAs similar to them (future, unbroken green line) could have future impact, FI_a. However, future impact can be increased further (FI_b) with new CAs that emulate the past CAs with highest impact (future, broken green line). As for all conservation initiatives, aiming to maximize the impact of CAs in the near future assumes that they can do more than simply delay the decline of biodiversity, whereby downward-sloping lines will converge at the same low level (red) in the distant future, with additional CAs and other interventions only extending the duration of this decline. Whether the number of remaining species in the world is stable above the red line in the distant future will depend on conservation efforts outside CAs [80], including non-spatial interventions, the effectiveness of CAs in relation to their management [67] and security [98], and the size of the extinction debt [99].

Measuring means or ends?

In conservation, a measure (Box 1) quantifies goals and progress towards them. Goals can take the form of policy targets, such as 17% coverage by terrestrial CAs [9], or operational objectives for planning and managing CAs, such as nominated percentages of vegetation types or species ranges (hereafter 'features') to be included [10].

Past successes of CAs and future targets for them are typically measured using attributes of CAs themselves (the means, i.e., inputs, outputs, and outcomes) rather than impacts (the ends). Inputs are enabling, but not necessarily directed to maximizing impacts. Inputs dominate assessment of CA management effectiveness (PAME), a prominent activity globally [8,11]. Inputs can be marginally related to biodiversity outcomes [12,13], but the relationship between PAME and impacts of terrestrial CAs has been elusive [14–16] (but see [17]), although a connection has been demonstrated for inshore marine CAs [18].

For outputs, large numbers or total extents of CAs can conceal small impacts reflected in, for example, small percentages of CA systems that would have been deforested in the absence of protection [6,7]. An important reason is that CAs on land and in the sea are concentrated in residual places, those with least value for extractive activities and in least need of protection from these activities [19–21]. Outputs are therefore necessary but not sufficient to achieve impacts [11,22]. Outputs, in particular, highlight the implications of Goodhart's Law [23]: '…people will tend to affect the statistic in whichever ways can be most readily achieved…and indicator values will become artificially inflated without addressing the underlying problem.' More generally, 'Measurement becomes much less reliable the more its object is human activity, since…people…are capable of reacting to the process of being measured' ([24], see p. 177).

Representation outcomes are the primary focus of systematic conservation planning [10] and are influential in policy, but can be misleading about impacts [8,25] (Box 1). Coarse measurements of representation in CAs, such as coverage of ecoregions, which typically have considerable internal heterogeneity of biodiversity and threats, can fail to capture variability in species composition and endemism [11,26], leaving threatened biodiversity to languish [27]. As well, representation in CAs does not discriminate between features most readily protected and those most urgently in need

Box 1. Types of measures for CA targets and progress towards them

Placing measures into broad categories [8] helps to understand their roles in decision-making and their relationships to one another (Figure I). Inputs are the resources invested in CAs, usually counted as staff, equipment, consumables, and money. Outputs are the material or legal products of inputs, such as numbers or total km^2 of CAs, kilometers of fence to exclude introduced grazing animals, or numbers of boats to patrol for illegal fishing. Outcomes refer to the content and state of protected areas. We distinguish three subcategories. The most immediate and easily measured are representation outcomes, reflecting the presence in CAs of species, ecosystems, or other elements of biodiversity. Threat outcomes measure levels of threats, such as illegal harvesting, expected to result from management inputs and representation of features in CAs. Notably, however, threat outcomes, positive or negative, might lack a causal link to representation [100]. Biodiversity outcomes measure amounts or conditions of biodiversity, such as abundances of vulnerable species, expected to result from changes in threats. However, changed conditions for biodiversity might lack a causal link to threat outcomes [100]. The ambiguity around threat and biodiversity outcomes arises from their estimation only within CAs or systems of CAs [25] and the typical lack of theories of change to establish causal links between types of measures after accounting for confounding factors [44,95]. Widely used approaches to monitoring and evaluation typically do not address impact as defined here, instead assessing performance without comparisons to counterfactual conditions [101].

Conservation impacts tell us what other measures cannot, namely, the difference made by CAs relative to what would likely have occurred, or likely will occur, without their establishment (Figure I). Most impact evaluations of CAs have been retrospective, yielding lessons for future decisions, but predicting impact [50] is essential to guide investments that avoid as much future loss of biodiversity as possible (see Figure 1 in main text).

We analyzed the types of measures considered by a sample of influential strategies and funding programs related to CAs (Table I). Our analyses focused on quantitative statements because qualitative ones are subject to widely differing interpretations, provide no reliable basis for monitoring progress, and can be ignored or interpreted in ways that are inconsistent and/or expedient.

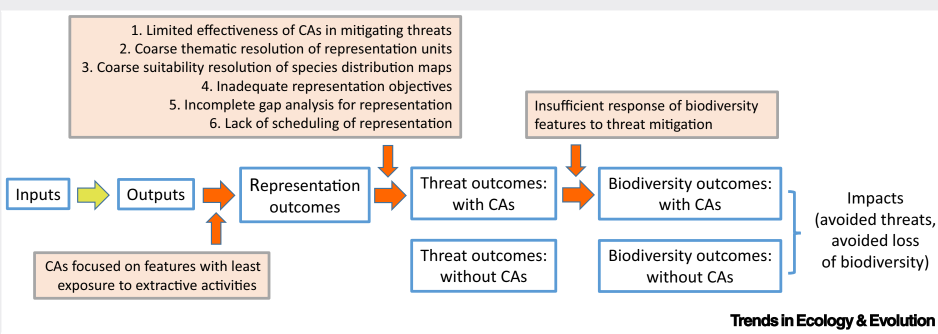

Figure I. The uncertain path from inputs to impacts. The outcomes of most interest to conservation planners will generally relate to representation, threat, and biodiversity. Impact is a selected outcome within one or more CAs (existing or proposed) compared with the same outcome estimated in the absence of CAs. The connection between outputs and representation outcomes can be weakened if representation is biased by placing CAs in areas of least value for extractive activities. The connection between representation and threat outcomes can be weakened in several ways (i) CAs might not be effective in avoiding threats to some species, even with good management and compliance; (ii) very extensive and heterogeneous representation units, such as ecoregions, can be included within CAs while failing to protect many species; (iii) species distributions that lack fine-resolution data on relative suitability and information on areas important for key life history stages can be covered partly by CAs while failing to promote species persistence; (iv) objectives for representation of features, especially objectives not scaled according to relative need for spatial protection, might be insufficient to avoid threats to the extent required; (v) the contributions of some types of existing CAs to representation objectives might be overestimated, thereby underestimating the need for additional CAs; and (vi) without a robust strategy for scheduling incremental establishment of CAs, early protection might not be given to the most imminently threatened features, leading to their loss. The connection between threat and biodiversity outcomes can be weakened if the wrong threats or insufficient levels of threats are mitigated within CAs. Adapted from [8].

Table I. Types of quantitative measures identified by CA strategies and funding programs (colored cells). Strategies are listed chronologically, and funding programs are listed alphabetically. Detailed analyses of measures for each strategy and program are in the supplemental information online. An asterisk (*) indicates impacts recognized in principle but not reported quantitatively. Abbreviations: MPA, marine protected area; PA, protected area.

	Types of measures					
	Inputs	Outputs	Representation outcomes	Threat outcomes	Biodiversity outcomes	Impacts
STRATEGIES						
Micronesia Challenge		■	■	■	■	
National and regional networks of MPAs		■	■			
Australia's National Reserve System Strategy		■	■			
China National Biodiversity Strategy		■				
Convention on Biodiversity Aichi PA targets		■			■	
European Union Biodiversity Strategy					■	
Coral Triangle MPA Action Plan		■	■			
Nature Needs Half		■	■			
French Strategy for MPAs		■				
United Nations Sustainable Development Goals		■				
30 X 30 Blueprint for Ocean Protection		■	■			
Global Deal for Nature		■	■			
FUNDING PROGRAMS						
Critical Ecosystem Partnership Fund	■	■	■	■	■	
Darwin Initiative	■	■		■	■	
Debt-for-Nature Swaps	■					
Global Conservation Fund	■	■			■	■
Global Environment Facility	■	■	■	■	■	*
USAID Biodiversity Policy	■	■		■	■	*

of protection [28], so increases in representation can be accompanied by, and conceal, ongoing avoidable loss of biodiversity [29]. This limitation applies particularly to metrics based on evenness [30] or average representation [31] across features. Like outputs, representation outcomes are necessary but not sufficient to achieve impacts.

Because they lack counterfactual comparisons (Box 1), threat and biodiversity outcomes can be uninformative about impacts [25]. Proper estimates of impacts eliminate plausible alternative reasons, other than protection and associated management, for outcomes within CAs [32]. For example, has reduced illegal harvesting within CAs resulted from changes to distant markets rather than from local protection? Are increased populations of harvested species within CAs due to recovery after drought rather than reduced poaching? Outcomes can, however, provide information complementary to impacts [33]. Negative trends within CAs, for example, might alert managers to failure of local protection, even if trends outside are more strongly negative and impact, therefore, is positive. Ideally, a monitoring design would provide insights into both outcomes and impacts [34] while distinguishing between them.

The incipient shift toward evaluating CA impacts [25] will be accelerated if high-level strategies and funding programs for CAs shape aspirations for success in terms of impacts and direct resources accordingly. With the need for this guidance in mind, we examined a sample of influential strategies and programs (Box 1) and categorized the measures they proposed as targets or used them for reporting. We found a pronounced lack of attention to impacts. Only one reviewed funding program, the Global Conservation Fund, reported on impacts related to avoided deforestation, although the method used is likely to overestimate impact (see the supplemental information online). Both the Global Environment Facility and US Agency for International Development have recognized the need for impact evaluation in principle but have yet to implement quantitative reporting. Also concerning is the regression of at least one CA strategy, Australia's National Reserve System. Instead of progression towards recognizing impacts, the quantitative targets for this strategy [35] are ambiguous and weak (see the supplemental information online), resulting from pronounced dilutions of guidelines agreed by Australian governments in 1997, which were themselves dilutions of previous scientific criteria [36].

Impact evaluation

Both retrospective evaluation and prediction of impact (Box 2) are active research fronts with potential for policy traction. The constraints on randomized control trials for CAs [37] mean that estimating conservation impacts retrospectively usually involves quasi-experimental sampling designs, typically matching sites within and outside CAs and tracking their relative conditions through time [38]. Evaluation is applicable to multiple types of protected areas, including those that allow some extractive activities [6], to other area-based conservation interventions [39] that, by definition, provide 'effective *in situ* conservation of biodiversity, regardless of…objectives', and to non-spatial interventions [40].

The most rigorous retrospective evaluations explore uncertainties in estimates of impact arising from plausible variations in model specifications and unobserved variables [7,41]. Methodological challenges remain, including the inability of remotely sensed forest cover to indicate disturbance beneath the canopy [42], time lags in manifestation of impacts, accounting for spatial autocorrelation [43], and limited attention to the mechanisms by which interventions make a difference, which help to explain reasons for successes or failures and to generalize findings [44]. Notably, however, these limitations and many others apply also to outputs and outcomes. Moreover, outputs and representation outcomes are incapable of reflecting impact reliably [25], and outcomes for threats and biodiversity might reflect impact only accidentally and come with their own uncertainties in estimates [25]. Consequently, scientists and practitioners have a clear choice. One option is to continue only with measures that are familiar and convenient to estimate but address the means, not the ends, of conservation. The other is to embrace the uncertainty inherent in estimating impact to understand whether CAs are, in fact, delivering on their basic purpose.

Maximizing future impact (Figure 1) will require improving the management and security of some existing CAs [45], placing new ones strategically, and managing those effectively. Guidance for doing so requires not only lessons from retrospective evaluations but also predictions about priorities for minimizing further loss of biodiversity and promoting recovery. One basis for predictions is systematic review or meta-analysis of retrospective evaluation studies to identify rules of thumb about likely future impacts. Given the varied, and often interdependent, pathways and mechanisms by which CAs affect biodiversity [44], these syntheses [46,47] can move beyond the idiosyncrasies of individual studies to assemble data that support generalizations about achieving future impact.

A second, essential and complementary, basis for maximizing the future impact of CAs involves estimating alternative futures with and without CAs and their effective management (Box 2). Ideally, the foundations of this approach are spatiotemporal models and scenarios of change [48–50]. At least some of the parameters for these models would preferably be informed by evidence syntheses. The feasibility of impact prediction is demonstrated by the widespread development of sophisticated models of future conditions, including changes to climate and extractive uses of the land and sea. A few of these models have been applied already to estimate conservation impact in terms of avoided loss and/or potential recovery [51–58].

Uncertainty is inherent in predicting impact [59], requiring attention to risks of misidentifying priorities. These risks are typically neglected in conservation measures and priorities generally but can be managed [48]. Because uncertainty increases with prediction further into the future [60], models will need to be rerun periodically with updated parameters, and conservation priorities will need to be modified accordingly. Periodic updating is accepted by many practitioners as a

Box 2. Spatially explicit approaches to evaluating the impact of conservation areas

Four approaches can be distinguished (Figure I) by whether they consider existing or potential CAs and whether impact is analyzed *ex post* (past performance) or *ex ante* (future performance). *Ex post* analyses are based on estimated changes in outcomes over past time series. *Ex ante* analyses are based on simulated future changes in outcomes. Approaches 2–4 are predictive in considering potential CAs and/or future outcomes. A major goal of all approaches is to draw lessons for achieving high impact with existing and future CAs [84,102].

For ready availability of examples, the descriptions later mainly concern impact estimated as avoided loss of vegetation. All four approaches could be applied to any biodiversity features, any realms [34,103], the management as well as designation of CAs, multiple types of CAs, restoration and recovery [50], and interventions outside CAs, including policies and legislation.

Approach 1. Factual: what happened to protected sites over the past time series? Counterfactual: (i) what happened to matched, unprotected sites over the past time series, as an indicator of what would have happened to protected sites in the absence of protection [7,34]? Or (ii) by simulating past expansion of development or extractive activities in existing CAs, what would have happened to protected sites in the absence of protection [104]?

Approach 2. Factual: what will happen to sites in existing CAs over the future simulation period if they are secure from extractive activities or if resources are insufficient to make them fully secure? Counterfactual: (i) what will happen to sites in existing CAs over the future simulation period if protection were removed altogether? Or (ii) what will happen to matched, unprotected sites over the future simulation period as an indicator of what will happen to protected sites in the absence of protection [105]?

Approach 3. Factual [29]: what would have happened to sites that were unprotected at the start of the past time series if they had been protected during the past time series? Counterfactual: what happened to sites over the past time series in the absence of protection?

Approach 4. Factual [57,58]: what will happen to currently unprotected sites over the future simulation period if they are protected? Counterfactual: what will happen to currently unprotected sites over the future simulation period in the absence of protection?

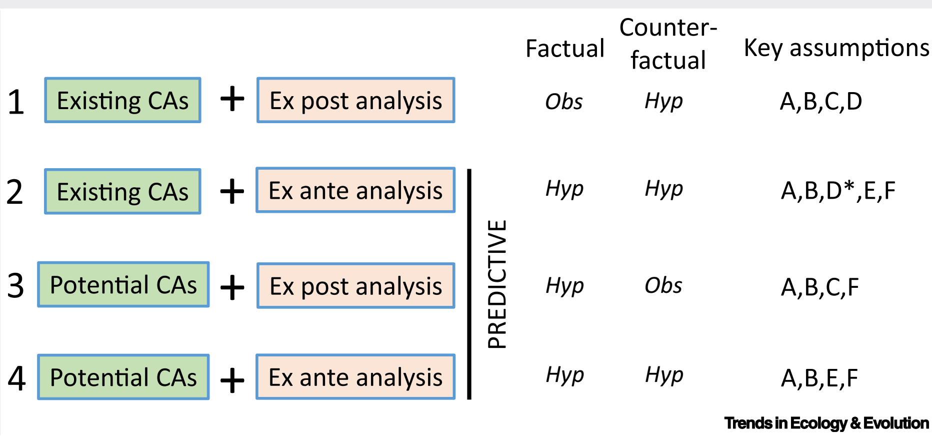

Figure I. Retrospective (1) and predictive approaches to estimating the impact of conservation areas. Key assumptions: (A) constraints on implementation, such as resistance to protection of areas with extractive potential, will not reduce the impact of recommended future CAs, whether predicted or guided by retrospective studies, or narrow the differences in impact between alternative ways of allocating CAs; (B) findings from case study regions apply to other regions that might differ in data availability and ecological, socioeconomic, and political contexts; (C) *ex post* lessons for placing future CAs are not affected by changes in the nature, intensity, and distribution of pressures from extractive uses (but see [106]); (D) all biophysical and socioeconomic factors relevant to the locations of CAs being evaluated have been accounted for in selecting counterfactual sites; (D*) indicates that matching is optional; (E) models of future extractive uses and resulting outcomes for biodiversity are not affected substantially by changes in the nature, intensity, and distribution of pressures (but see [106]), and analyses, such as info-gap [48] and uncertainty bounds around models, allow risk of error to be managed in setting priorities; and (F) expected levels of security from extractive activities within CAs, perhaps varying from full to zero, and the consequences for protected biodiversity are accurate. Abbreviations: CAs, conservation areas; Hyp, hypothetical; Obs, observed.

reality of protracted implementation of CAs [61]. When formal quantitative models are not feasible, expert assessments [50] and qualitative modelling, including theories of change [44,62], can inform the location and management of new CAs by identifying causal links between interventions and impact. Spatially explicit prediction of impact (Box 2) opens the way for formulating impact targets (Box 3) with characteristics that avoid the pitfalls of protected area targets developed in recent decades (Box 4).

The urgent need for impact prediction can be understood by considering the extensive identification of conservation priorities, at scales ranging from global to local, using widely varying data inputs and analytical methods and directing large investments [63]. Prioritizations are essential for action but, when boiled down, all are predictions about the most effective way to allocate limited conservation resources. Prioritizations often involve implicit and untested assumptions and beliefs about the relationship between the indicators they use and the impact that maximizing those indicators will achieve [8]. By contrast, explicit impact predictions can be scrutinized, refined, and subjected to sensitivity analyses to estimate how much difference CAs can make. Importantly, impact prediction can test already established approaches to prioritization so that they can be compared and improved. Here again, there is a clear choice for scientists and practitioners, continue to base priorities on implicit mental models of the future with unstated assumptions and unknown impact, or base them on where and when CAs can best avoid the loss of biodiversity by developing explicit, accountable models, both quantitative and qualitative.

Barriers to impact evaluation

Some of the most important perceived barriers to evidence-informed conservation policy reflect the low priority of conservation on the political agenda [64]. Probably the most fundamental

Box 3. What would impact targets look like?

The context for CA impact targets is the overarching goal of retaining and restoring biodiversity [80,107] or, put another way, global outcomes [11], which will require impact on multiple fronts in addition to CAs. Those fronts include sustainable use and shifts in patterns of consumption of natural resources, action on climate change, and modification of cities and infrastructure [1]. Global outcomes, translated into jurisdictional outcomes, therefore set the scene for guidance on jurisdictional impact targets, including those for CAs (Box 4). Impact targets become the contribution that CAs should make to these global outcomes. Precedents for such guidance are engagement with jurisdictions to achieve Sustainable Development Goals [3] and devolution to national governments of implementation measures to limit global warming.

As a start to discussion, impact targets for CAs, to be supplemented with technical guidelines for jurisdictional refinement, might look something like the following (see also [25,50]):

- By 2030, the management of existing CAs, including security from intrusions of unsustainable extractive activities, will avoid the loss of (*X* amount of biodiversity) within CAs that would otherwise have occurred since their establishment and/or promote the recovery of (*Y* amount of biodiversity) within CAs that would otherwise not have occurred.
- By 2030, the establishment and management of new CAs will have avoided the loss of (*X* amount of biodiversity) that would otherwise have occurred outside the existing CA system and/or promoted the recovery of (*Y* amount of biodiversity) that would otherwise not have occurred outside the existing CA system.

Like the 2020 Aichi targets, impact targets would rely on global delegation of governance to jurisdictions (Box 4). Although global impact scenarios can be useful for high-level assessment of policy options [58], they necessitate extreme generalization of critical information, including threats to biodiversity, the diversity and complexities of spatial interventions, factors confounding the effects of interventions, and socioeconomic considerations. Impact targets for jurisdictions require counterfactual scenarios developed at appropriate resolutions and over extents that, in many cases, will be smaller than jurisdictions. Allocating any informed targets to jurisdictions, including those for impact, is more complicated than allocating uniform area targets [11].

There are potential trade-offs between ambitious conservation targets and some aspects of human well-being [3], on the face of it more difficult to resolve in less-developed countries [108]. However, increasing understanding of the interdependencies between biodiversity and aspects of human well-being is leading to frameworks for integrating progress towards multiple Sustainable Development Goals [3,108–111].

political constraint on basing decision-making on impacts is the requirement for societies to give up some extractive opportunities, forcing trade-offs with resource-based livelihoods, confronting influential extractive sectors, and increasing conservation costs per km^2. Expediency will therefore constrain the mainstreaming of impact evaluation, while CAs that are residual to extractive uses can be sold, misleadingly, as win–win solutions. Another political barrier is risk aversion. Predicting impact, which is essential for effective decisions, inevitably involves uncertainties around patterns and intensities of future threats. Further, seeking impacts pushes protection toward more threatened and contentious areas with more tenuous prospects for some species and correspondingly higher risk of failure.

Other brakes on adoption of impact evaluation relate to characteristics of organizations, including the considerable investment, institutional branding, and claims of importance around some approaches to identifying conservation priorities by agencies and non-government organizations (NGOs) [8,65]. Exposing prioritization methods, essentially untested predictions about where to best allocate limited resources, to impact evaluation might lead to unwelcome findings [66].

Political and institutional barriers are difficult to overcome in the absence of high-level guidance on conservation impacts, but the analysis in Box 1 indicates that strategic direction itself needs an overhaul. As a case in point, the globally influential Aichi Target 11 for 17% CA coverage of land and 10% of oceans [9] has arguably been a force against achieving conservation impact, motivating instead a race to increase areal coverage in the most expedient ways, politically and

Box 4. Toward policy guidance for jurisdictional impact targets

Essential characteristics of impact targets (Figure I) can be summarized with the same five SMART criteria (specific, measurable, ambitious, realistic, time-bound), listed later, that were meant to underpin the Aichi 2020 targets [112] (three additional criteria in [73]). SMARTness is necessary but not sufficient for targets, constraints on which also include approaches to building consensus [113], institutional norms, governance arrangements, and marginalization of key stakeholders [114]. The credibility of targets depends also on the difficult balance between two SMART criteria: ambition and realism [113,114].

Specific. Post-2020 impact targets should be unambiguously related to avoided loss and promoted recovery and should concern outputs or within-CA outcomes only if these have a clear and feasible path to impact (Box 1). The risk of this path being subverted by economic and political interests or naïve conservation science requires triggers to indicate failure of links to impacts [8].

Measurable. Quantitative targets are essential [115,116]. Qualitative terms, such as 'effectively and equitably managed' and 'well-connected' (from Aichi Target 11), are subject to varying interpretations and offer no basis for gauging success. The same limitations apply to relative terms, such as 'substantially', 'reduce', and 'increase', and undefined constraints, such as 'where feasible', 'minimize', and 'maximize' [113,117]. Targets should be directed to named components of biodiversity and require data that reflect real changes and are responsive and accurate [3,116,118,119].

Ambitious. High-level targets have often balanced perceptions of sufficiency and achievability rather than drawn on findings from conservation science [79,120,121]. Downward pressure on impact targets will be considerable because avoided loss and, in many cases, recovery depend on reducing the effects of extractive activities rather than 'protecting' areas not at risk from them.

Realistic. Aspects of realism are achievability and the need for impact targets to be understood and applicable by those who need to take action. Policy-makers need simple and relevant measures that relate directly to policy priorities and decisions to be taken [122]. Targets intended to influence the general public need to appeal to public interests and concerns [116]. Other aspects of realism are the need for reduced complexity of targets relative to feasible indicators [117], cost-effectiveness of indicators to assess target achievement [116], and the need for cohesion across agreements, agencies, and policies [112,123].

Time-bound. While endpoints for target achievement are expected, some measurable targets framed in relative terms, such as halving rates of loss (from Aichi Target 5), require explicit baseline dates for comparison to endpoints [116].

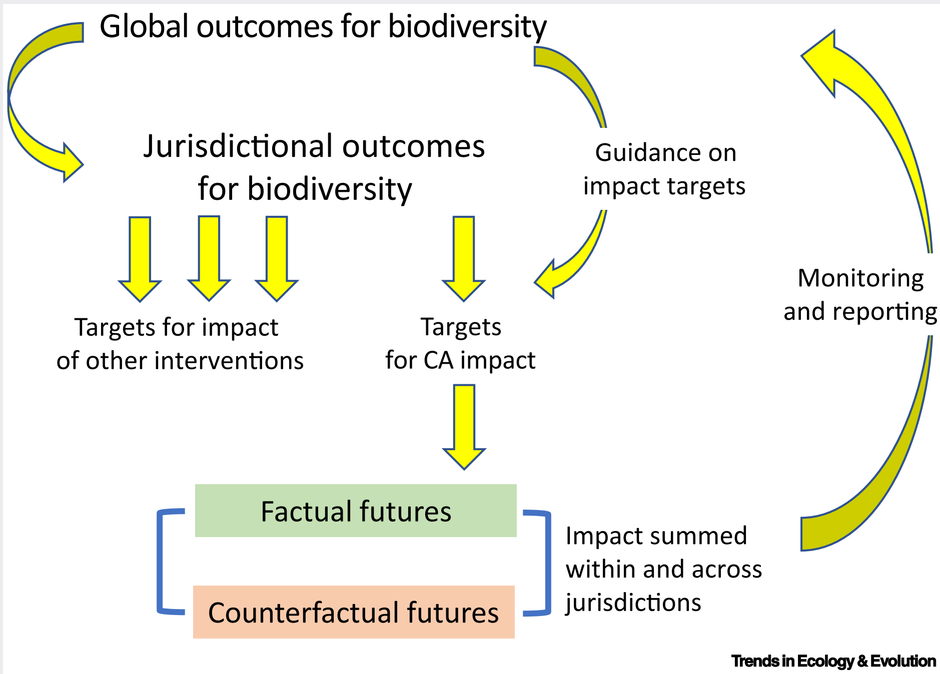

Figure I. Impact targets allocated to jurisdictions, with guidance from global institutions. The first step is to specify required global outcomes [3,80], which are then devolved to jurisdictions, as they have been up to 2020. Recognizing that the primary purpose of CAs is to achieve conservation impact, guidance will be needed for jurisdictions to achieve outcomes through CA impact targets that rely on quantitative [57,58,105] and qualitative [44] modeling of factual and counterfactual futures (Boxes 1 and 2). Factual and counterfactual scenarios are the basis for prioritizing for impact (blue lines) at appropriate resolutions and extents, in many cases much smaller than jurisdictions. Abbreviations: CA, conservation area, comprising protected areas and other effective area-based conservation measures.

economically [11,67–72]. Qualitative statements about representation and effective management, meant to guide the quantitative parts of Target 11, have been largely ineffective (Box 4) [73]. Targets for CA percent coverage still have their defenders [74], and percentages of ecoregions protected are still proposed as a measure of sufficiency [75,76], even though considerable residual biases arise within ecoregions [27]. To the extent that percentage targets motivate residual CAs, imminently threatened biodiversity remains unprotected and declines or disappears [11,26]. To avoid the same perverse outcome, arguments for more ambitious percentage targets, even stratified by ecoregions [75,77–79], must be tempered with targets for retention both within and outside CAs [80] and, in that context, with quantitative requirements for CA impact, directed at features defined at much finer resolutions than ecoregions [11,26].

Poor communication between scientists and practitioners has commonly been identified as a barrier to uptake of evidence in real-world decisions, reflecting differences in background, objectives, work cultures, and time frames of concern [64]. As well, pervasive, genuine misconceptions slow the adoption of rigorous impact evaluation. It is critical to build conservation professionals' understanding of the limitations of widely used measures (inputs, outputs, and outcomes) and the risk that basing decisions on them could compromise impacts [8]. Even when impact evaluation is accepted and pursued, there can be misplaced confidence in before–after (BA), control–intervention (CI), and BACI (before–after–control–intervention) sampling designs. Designs that lack careful matching of protected and unprotected sites can overestimate impacts [7], and many comparative studies are based on unreliable assumptions or fail to account for human tendencies to preempt or misdirect formal protection [81].

There are also practical difficulties in rolling out impact evaluation. Barriers identified by practitioners include lack of funding, time constraints, and failure to plan for rigorous evaluation [82]. Resistance can arise from concerns about diversion of limited resources from field programs, results obtained too late to guide projects, lack of necessary expertise, and lack of reward combined with increased exposure and risk for organizations taking unilateral initiatives in evaluation [66,83]. Fundraising by NGOs for evaluation will remain difficult if some donors fail to appreciate the tenuous links between, on one side, plans developed (inputs) and protection implemented (outputs) and, on the other side, impact as a measure of difference made (Box 1). The most rigorous retrospective estimates need specialized design [7,34], with costs restricting implementation to larger organizations. Evaluating impacts is also challenged by unsolved technical problems applicable to all measures, including complex ecological, social, and economic responses to CAs, both within and outside them [84]. Policy targets and operational objectives for impact do not yet exist, so the way forward is obscure to many. Targets and objectives for impact will need agreement on future counterfactual conditions within jurisdictions in the absence of additional CAs, and the difference that could be made by CAs (Box 4).

Concluding remarks: overcoming barriers

Increasing calls by scientists and practitioners to embed impact evaluation within CA planning, funding, and policy [85] reflect a broader movement toward evidence-informed, adaptive decision-making in conservation [86]. Mainstreaming impact evaluation would bring CAs in line with other public good investments in medicine, education, and development aid [87] and with estimating the additionality arising from interventions for carbon mitigation [88]. For all these areas of endeavor, impact evaluation is a core activity.

Given political barriers to achieving impact, evidenced by the pervasively residual nature of protected areas [19,26], leadership is needed urgently from the Convention on Biological Diversity, prominent NGOs, and independent researchers to redefine conservation progress, recognizing that measuring means rather than ends might be politically convenient but can have perverse and irreversible consequences for biodiversity. The goal here is to place measures of impact at the core of policy targets and operational objectives. The trail has been blazed by clinical medicine, which has achieved a shift in the professional norm to routinely incorporate evidence, with intolerance of decisions that contradict evidence without good reason [89].

The necessary leadership is beginning to emerge, much of it in developing countries. Researchers have clearly demonstrated the importance of impact evaluation [90] and continue to refine methods [44]. Among recent NGO initiatives, the World Wildlife Fund-United States has mainstreamed impact evaluation as part of conservation monitoring and decision-making [34] and made inroads into predicting impact with interventions' theories of change. Conservation International [83] and the Wildlife Conservation Society [91] have embarked on the same shift in emphasis. The Durrell Wildlife Conservation Trust and the International Union for Conservation of Nature (IUCN)'s Species Survival Commission have estimated impacts with counterfactual measures of extinction risks of threatened species [92,93], and a notable recent impact-related initiative is IUCN'S Green List of Species [50]. The Rainforest Alliance and the Royal Society for the Protection of Birds have begun impact evaluations of their activities [82,94].

The effectiveness of such leadership depends, of course, on the receptiveness of other key players. Major donors need to understand that measures of progress, such as plans completed

Outstanding questions

How reliably and cost-effectively can impacts that are difficult to detect with remote sensing be evaluated? Examples of such impacts on land relate to hunting, selective logging, and stock grazing. Experience from marine evaluations points to the need for intensive field sampling and, less commonly, ecosystem models.

How should the uncertainty inherent in forecasting be handled in predictions of impact, and how is that uncertainty propagated by errors in ecosystem models, estimates of effectiveness of different types of conservation areas in mitigating threats, and expected recovery times? One approach would be to use error bounds to err on the side of overstating threats and understating biodiversity value. Another approach would be to relinquish impact predictions with more than a threshold level of uncertainty and replace them with priorities based on representation.

What are the relative biodiversity impacts of CAs in relation to vegetation clearance, stock grazing, suppression of invasive species, and adjustment of species distributions to climate change and, in aquatic environments, in relation to fishing, petroleum extraction, and water quality? Given that potential impacts for such threats will often be uncorrelated spatially, how can decision-makers resolve choices between them?

Across planning regions, how does the balance of priority to achieve biodiversity impact shift between imminently threatened and temporarily secure areas when there are changes in factors, such as acquisition cost, management cost, species compositional turnover, persistence of species in fragments, and timeframes for expected avoided loss and promoted recovery?

What are the trade-offs between impacts for biodiversity and those for human well-being? How do trade-offs vary in different social, economic, and political contexts, and under what circumstances can strong impact for both be achieved?

on paper or extent of implemented protection, could be counterproductive. Moreover, conservation spending by NGOs represents only a small fraction of that by national governments and multilateral organizations, such as the Global Environment Facility. Data availability for extensive impact evaluations remains a significant gap that can be filled mainly by governments and multilaterals.

Strategies for rolling out impact evaluation should emphasize that retrospective estimates are needed only for a sample of CAs across variations in data availability and ecological, socioeconomic, and political contexts. For both retrospective and predictive approaches, strategies will have at least six aspects: (i) promoting impact evaluation as central to organizations' planning, learning, and accountability; (ii) training in principles and methods; (iii) requiring impact evaluations as a condition of funding; (iv) minimum standards for impact evaluation [82]; (v) best practice demonstration approaches by well-resourced organizations (e.g., [34,52]); and (vi) less demanding approaches, still rigorous and tested, applied more widely. On this last point, even qualitative theories of change linking investments to expected impacts [44] would improve many policies and on-ground decisions because they require explicit consideration of causal mechanisms and potential confounding factors. Indeed, a theory of change should be the first step in any impact evaluation [44,95].

New and urgently needed developments are global guidance on jurisdictional impact targets (Boxes 3 and 4), scaled down to operational objectives and planning approaches for local interventions. The feasibility of such targets is already demonstrated by initiatives, such as the Green List of Species [50]. Perverse outcomes are likely, unless guarded against. A persistent problem is the failure of surrogacy, attention focused on the target at the expense of things it is meant to represent [23,24]. For example, avoided loss of native vegetation could be both a target for and indicator of impact, but the indicator would become decoupled from loss of biodiversity if processes other than outright conversion, such as grazing and altered fire regimes, were important for species persistence. Another problem is deliberate gaming of targets [24]. Risks here include overstatement of the impact of less strict CA categories, preference for uncertain, and politically easier, long-term impacts over more certain, but more difficult, short-term impacts [96], and expedient progress toward integrated metrics, such as the Red List Index [23], or targets, such as Aichi Target 5, by favoring features that are easiest to protect.

Methodological challenges [84] and topics needing further research (see Outstanding questions) are not reasons to delay mainstreaming of impact targets. As in any field of research and development, methods for impact evaluation will continue to evolve, like accepted methods for biodiversity indices [97] and CA management effectiveness [14]. Available methods for impact evaluation are adequate to guide decisions now and are considerably more informative about the basic purpose of CAs than other measures being applied [8].

The overall impact of the global CA system at any point in time (Figure 1) is the cumulative result of thousands of individual decisions about establishing, expanding, and managing individual CAs. The more urgently and strongly policy makers, scientists, and practitioners focus decisions on impacts, the wider will be the gap between the counterfactual future of biodiversity and the future realized through CAs.

Acknowledgments

This paper arose from a workshop in Washington DC, funded by the Global Environment Facility's Scientific and Technical Advisory Panel. We thank Mark Zimsky for supporting the workshop. For discussions, we thank Paul Ferraro, Val Kapos, Georgina Mace, Michael Obersteiner, and Alex Pfaff. We are grateful to Vanessa Adams and Edmond Sacre for critical comments on Box 2. R.L.P. and G.G.G. acknowledge the support of the Australian Research Council.

Author contributions

R.L.P. led the writing and analysis of conservation area strategies and funding programs. P.V. contributed to the writing and analysis. All other authors contributed to writing.

Declaration of interests

No interests are declared.

Supplemental information

Supplemental information associated with this article can be found at https://doi.org/10.1016/j.tree.2021.06.008.

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