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Perspective

Building robust, practicable counterfactuals and scenarios to evaluate the impact of species conservation interventions using inferential approaches

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ABSTRACT

Robust evaluation of the impact of biodiversity conservation actions is important not only for ensuring that conservation strategies are effective and maximise return on investment, but also to identify and celebrate successful conservation strategies. This evaluation can be retrospective (comparing the current situation to a counterfactual scenario) or forward-looking (comparing future scenarios with or without conservation). However, assessment of impact using experimental or quasi-experimental designs is typically difficult in conservation, so rigorous inferential approaches are required. Inferential assessment of impact is a key part of the new IUCN Green Status of Species, which greatly amplifies the need for standardised and practical species impact evaluation methods. Here, we use the Green Status of Species method as a base to review how inferential methods can be used to evaluate conservation impact at the species level. We identify three key components of the inferential impact evaluation process—estimation of scenario outcomes, selection of baseline scenario, and frame of reference—and explain, with examples, how to reduce the subjectivity of these steps. We propose a step-by-step guide, incorporating these principles, that can be used to infer scenario outcomes in order to evaluate past and future conservation impact in a wide range of situations, not just Green Status of Species assessments. We recommend that future non-experimental conservation interventions facilitate the process of evaluating impact by identifying the variable(s) that will be used to measure impact at the design stage, and by using conceptual models to help choose conservation actions most likely to have the desired impact.

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1. Introduction

Being able to quantify and demonstrate the effectiveness of biodiversity conservation is more crucial than ever (Ferraro, 2009; Walsh et al., 2012). Over the past few decades, conservation programmes have faced calls for accountability from financial backers and society more widely (Margoluis et al., 2009a; Stephenson, 2019). This is reflected in growing interest in outcomes-based finance models for conservation, where a design for gathering evidence and metrics for demonstrating achievement is a prerequisite of funding; in some cases, the funding is only provided once impact has been achieved (Jeffries et al., 2019; Withers and Zoltani, 2020). At the governmental level, agencies are being asked to report on the impact of their spending; for example, there is now a requirement for all US government foreign assistance, including the biodiversity funding programmes of the US Fish and Wildlife Service and USAID, to evaluate the outcomes of their conservation programmes abroad (U.S. Office of Management and Budget, 2018). Given accelerating downward biodiversity trends (Díaz et al., 2019), the need to ensure that conservation funding is being spent on successful projects with demonstrable impact is only likely to increase.

However, financial considerations are not the only driver of increased interest in evaluating conservation outcomes. On the eve of the United Nation's Decade for Ecosystem Restoration (2021-2030), much attention is currently focused on the new post-2020 Global Biodiversity Framework to be agreed between Parties to the Convention on Biological Diversity, and it is hoped this Framework will catalyse broad action to bring about a transformation in society's relationship with biodiversity. While the precise nature of the goals and targets of this new ambitious plan are yet to be agreed, a focus on measuring avoided declines and improvements achieved will likely remain, and tracking progress toward post-2020 targets will require robust methods to measure conservation impact.

The most defensible way to evaluate the impact of conservation interventions is through use of experimental designs such as Randomised Controlled Trials (Pynegar et al., 2018; Wilebore et al., 2019) or Before-After Control-Intervention (Conner et al., 2016); or quasi-experimental designs such as matching (Schleicher et al., 2020). The impacts of protected areas and Payments for Ecosystem Services schemes have been evaluated using these methods by a number of studies (e.g., Andam et al., 2008; Clements and Milner-Gulland, 2015; Wiik et al., 2019). However, these methods can be costly, and use of these designs to evaluate the impacts of conservation interventions is rare (Baylis et al., 2016). For example, matching requires multiple sites which have experienced the intervention, but many conservation interventions are tailored and targeted to one specific site.

Although use of such robust designs would be ideal, it is nonetheless vital that conservation impact evaluation becomes common practice, even when gathering experimental or quasi-experimental evidence is not available. Several studies (Butchart et al., 2006; Hoffmann et al., 2010, 2015; Szabo et al., 2012; Young et al., 2014; Garnett et al., 2019; Bolam et al., 2020) have used **inferential approaches** (bolded terms defined in Glossary) to quantify the difference conservation has made to species status. These studies estimated what the IUCN Red List of Threatened Species category of a given species would have been in the absence of conservation, based on expert judgment. This **counterfactual** status was then compared with the observed status (i.e., the Red List category).

The International Union for Conservation of Nature (IUCN) has recently published a new framework for assessing the impact of past conservation, and the potential for future conservation impact, at the species level: the Green Status of Species (IUCN, 2021). The Green Status of Species comprises five metrics that, together, assess a species' current recovery status and evaluate the past and potential future impact of conservation on recovery status (Akcakaya et al., 2018; IUCN, 2021; Fig. 1). The Green Status of Species is a new part of the Red List assessment, and there is already interest in its potential to assess conservation impact in a standardised way (Stephenson et al., 2020).

Here, we use the IUCN Green Status of Species as a base from which to explore the potential for evaluating conservation impact using inferential methods. We describe the key concepts of counterfactuals, scenarios, baselines, and frames of reference as they are used in the Green Status of Species framework, and propose a step-by-step guide that can be used to evaluate past and future conservation impacts in general, not just for Green Status assessments. While our primary aim is to provide guidance for assessing the impact of conservation actions that have already been carried out or planned, we end with recommendations for how future actions can be designed to facilitate impact evaluation.

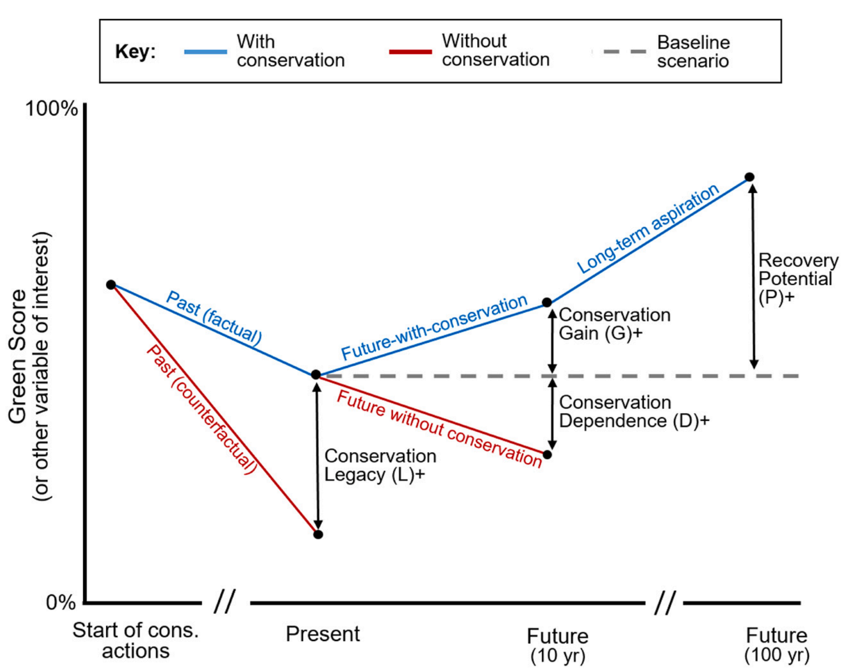

Fig. 1. Model for estimating past and future impact of conservation actions. Based on the expected trajectory of the species in various scenarios with and without conservation actions (scenario names given above each trajectory), the four conservation impact metrics (Conservation Legacy, Conservation Dependence, Conservation Gain, and Recovery Potential) are calculated as the difference between these trajectories and a baseline trajectory. These metrics can be positive (+) indicating that conservation has benefitted the species, or negative (−) indicating that conservation made the species' status worse. Dashes in the x-axis indicate that the temporal element is not to scale, which explains why the rate of change appears to modify rapidly.

2. Counterfactuals: inferring past conservation impact

The past and potential future impact of conservation on species recovery can be evaluated by comparing an observed or predicted species condition with the expected species condition under various **scenarios**, or alternative realities. To evaluate the past impact of conservation efforts, a situation where we know the true, or factual, outcome (i.e., the present status of the species), we generate a scenario called a **counterfactual**: an alternative past in which conservation efforts did not happen. Using available information, the trajectory that the species would have followed in the absence of conservation is estimated or inferred, and the current status of the species (observed, estimated, or inferred) is compared with the counterfactual status. In the Green Status of Species, the difference between the counterfactual status and the current status is known as the **Conservation Legacy** (Fig. 1).

Although the term 'Conservation Legacy' has only been introduced via the Green Status of Species, the concept itself is not new—assessing the effectiveness of implemented actions is perhaps the most common type of impact evaluation in conservation. However, because many conservation actions are undertaken without an experimental design, assessing their Conservation Legacy is not always straightforward. Table 1 gives a selection of designs which could in principle be used to draw inferences about whether a conservation action (or actions) has worked as intended. All of these designs assume that robust causal attribution is not possible, because the implementation of the conservation action(s) has not been designed to test its effectiveness (i.e., an experimental or quasi-experimental design has not been used).

Table 1
Potential methods for gathering inferential evidence to inform a scenario (counterfactual or future).

Method	Application notes
Logical argument	
Interrogation of the assumptions underlying the purported observed impact of conservation, to see how far along the chain (from conservation actions, to changes in vital rates and behaviour, to changes in population size and functionality, to changes in the species' Green Status) attribution can reasonably be inferred.	Evidence can come from key informants/ experts (see below), species status assessments, or documentation (e.g. project reports). Many programmes will not have thought through a causal chain a priori, or if they have it may not be at the appropriate scale (the assessment unit) making this **a potentially challenging process**.
Expert elicitation	
Asking a range of experts associated with the species to predict what would have happened, or what will happen, to the status of the spatial unit under the different past and future scenarios.	This is the approach that has been **most used to date** for evaluations of the impact of the Red List. Could feasibly be done as part of an Action Planning process. It relies on the judgment of experts, which brings a risk of different frames of reference. Mediation and expert elicitation techniques (such as a Delphi method) can be used to reduce bias and harmonise different experts' frames of reference.
Population modelling	
Retrospective or forward **modelling of species dynamics** (population, metapopulation or habitat), e.g. population viability analysis (PVA).	Such methods **can be used even in the absence of any conservation project** that is currently implemented, or when there is limited scope for causal inference (logical argument) based on project documentation. For example, models can be based on conservation actions that might be implemented in the future, or be informed by outcomes where the conservation action was aimed at other species.
Action plan assessment	
If **a prioritised action plan** is available and being reported against, then it could be possible to assess past and expected future progress against that plan, and assume that any improvement of an assessment unit's status is, or would be, due to the implementation of this plan. This assumption needs to be based on inference using one of the other methods.	This is a **rather indirect and implicit** application of the logical argument approach, but may be quicker and more feasible in an action planning context. In the long term, encouraging such a method could help increase the number of action plans developed, and enhance the robustness of their theories of change, targets, outcome measures, and monitoring plans.

Defining the variable which will be used to evaluate impact (for which a counterfactual value will be compared to the observed value) is a key decision in assessing the counterfactual (Fig. 2). Depending on the conservation action, the variable can be ecological (e.g. species population size or trend, Jellesmark et al., 2021) or social (e.g., human well-being indicators, Mbaru et al., 2021). The choice of variable may also affect the sensitivity of the impact assessment; if the scales of the conservation action and of the variable are mismatched, a **substantive impact** may not be observed, even if the action provides some benefit.

For the Green Status of Species, separate counterfactuals are evaluated for each **spatial unit**, i.e. distinct parts of the species' range. The variable used to evaluate impact is the species' **state** (Absent, Present, Viable, or Functional; see IUCN (2021) for definitions). The counterfactual states in each spatial unit are then used to generate the counterfactual **Green Score** (0–100%, where 0% indicates the species is Absent in all spatial units and 100% indicates it is Functional in all spatial units). For a full explanation of how the Green Score is calculated, see IUCN (2021).

In Fig. 2, we describe a step-by-step process that can be used for inferential evaluation of a counterfactual, which includes 3 crucial phases: 1) Define the scope, 2) Contextualise the conservation actions, and 3) Estimate conservation impact. We show how this process was applied to a real-world example using the case study below: assessing the Conservation Legacy of the Round Island Bottle Palm (*Hyophorbe lagenicaulis*) as part of its preliminary Green Status of Species assessment (Grace et al. in press).

2.1. Counterfactual case study: the Round Island Bottle Palm

Travellers' reports show that the Round Island Bottle Palm (*Hyophorbe lagenicaulis*) was once abundant on Round Island, Mauritius, but the population was greatly reduced when non-native rabbits and goats were introduced in the early 19th century (Asmussen-Lange et al., 2011). Conservation action has largely focused on invasive species eradication, and since then seedling survival has greatly increased (Maunder et al., 2002). In 2019, *H. lagenicaulis* was considered Present on Round Island (IUCN, 2021). As part of the testing and development of the Green Status of Species, we used the following method for assessing counterfactuals to assess whether the situation would be different if no past conservation had been undertaken (Fig. 2).

The first step in producing a robust counterfactual based on inferential evidence is the Definition stage (Fig. 2). We defined the area under consideration as the spatial unit of Round Island, an area of <2 km^2 to which *H. lagenicaulis* is endemic, and we defined the starting point of conservation action as 1957, when the island was designated as a nature reserve and access was forbidden to all except reserve managers and authorised researchers. Between then and 2019 (the defined end point), several other conservation actions took place, including eradication from the island of invasive goats in 1978 and rabbits in 1986, and ongoing management of invasive plants. These were our defined conservation actions; we wished to estimate the counterfactual in the absence of all of these actions (note that this does not attribute impact to specific actions; if we wished to do that, we could have run through the process in Fig. 2 separately for each action). The variable used to evaluate conservation impact was the state in the spatial unit (Absent, Present, Viable, or Functional).

We then moved to the Contextualisation stage (Fig. 2). At the starting point of the conservation actions, few individuals remained; though we could not find exact numbers for 1957, in 1975 only 15 adults, 6 young

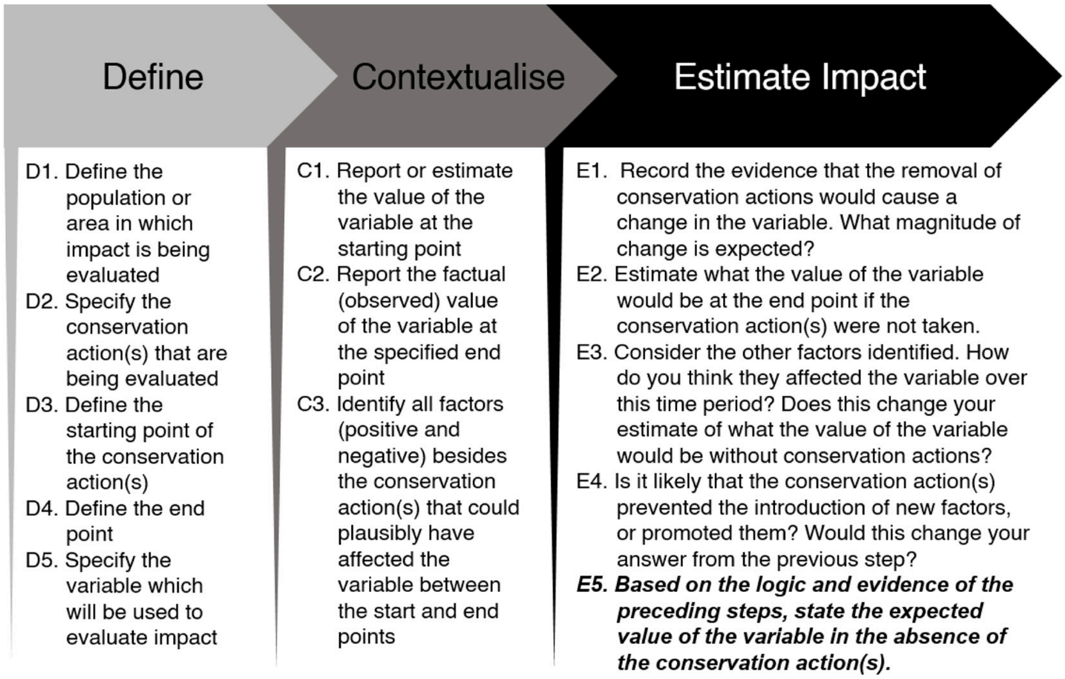

Fig. 2. Summary of a process that can be followed to generate inference-based counterfactual scenarios removing the effects of past conservation. For more explicit instructions, see Appendix 1 of the Green Status of Species Background and Guidelines (IUCN SCSTF, 2020).

trees, and 66 seedlings remained (North et al., 1994), meaning that at that time the value of the variable was Present (IUCN, 2021), the same value as in 2019 (the end point). The contextual **factors** that we expected to play a role in *H. lagenicaulis* state between 1957 and 2019 were rainfall, hurricanes and other major storms, and the growth rate of the species itself (the generation length is approximately 25 years; IUCN Global Tree Specialist Group, Palm Specialist Group, and Mascarene Island Plants Specialist Group, *pers. comm.*).

Finally, we estimated conservation impact (Fig. 2). We used a logical argument approach (Table 1) to estimate what the species' current status would be in the absence of the defined conservation actions. The species had previously been an abundant member of the palm community, but following the introduction of goats and rabbits, both number of adults and recruitment rates declined dramatically, reaching a low point in 1986 of 8 adults and 18 seedlings (the final year invasive mammals were present on Round Island; North et al., 1994). Therefore, between 1975 and 1986, the total population declined from 87 to 26 individuals (a 70% decline), even with some conservation measures in place (there was restricted access to Round Island over the entire time period, and goats were eradicated by 1978). If that trend continued, the population size in 2019 would be predicted to be <1. Given this trend, we estimated that if no conservation actions had been taken, the species would now be Absent on Round Island (see also Section 5.1, *Dealing with uncertainty*). The effectiveness of the eradication of goats and rabbits as a plant conservation measure was indicated by the evidence that numbers of seedlings and trees continued to decline until 1986, when both species were entirely removed from the island; after which the number of seedlings dramatically increased.

However, we also needed to consider whether factors besides the conservation action could have affected species status between the start and end points. The absence of favourable changes (for the species) in rainfall or storm frequency on Round Island since 1986 strengthens the argument that conservation actions were responsible for the improved seedling recruitment, and that it would not have improved if conservation actions had not been taken—thus, on the **balance of probabilities**, the improved observed state of the species relative to the counterfactual state can be attributed to conservation. The final step was to consider whether the conservation actions taken could have prevented additional threats or introduced new ones. After invasive goats and rabbits were removed, the density of invasive grasses increased, introducing competition to the palm seedlings (R. Young, *pers. obs.*). The result of this competition is reflected in the current observed state of the species, which would possibly be higher without this competition. On the other hand, it is highly likely that restricted access to the island from 1957 limited the arrival of new exotic species, which would have harmed *H. lagenicaulis* even further. However, since the counterfactual state determined in the previous step was already the lowest possible value (Absent, indicating no mature individuals or seedlings remaining), this did not change our estimate of the counterfactual state.

3. The frame of reference: a critically important consideration

Counterfactuals and other scenarios of conservation impact are generated by assessors within a **frame of reference** (or contextual framing; Bull et al., 2020). Depending on the frame of reference, the resulting scenarios can differ substantially. For example, based on their frame of reference different expert assessors may have different views on the extent to which a species would have declined in the absence of a particular conservation action, or on the degree to which climate change will affect the species' range in the near future. They may also differ on the likelihood of a planned intervention actually being implemented. However, evaluations of conservation impact need to be standardised and replicable, despite being done by different assessors with their own frames of reference. Therefore, providing guidance on managing and reducing variation in frames of reference is vital. Previous studies have identified actions which are important for adjusting the frame of reference when making conservation evaluations, thereby ensuring transparency and repeatability of such assessments (Hoffmann et al., 2015; Young et al., 2014; Bolam et al., 2020). These include: consistent guidance on building the counterfactual scenario (in particular, what counts as conservation); guidance on the balance of evidence required to assess whether a conservation action has had an impact (e.g. beyond reasonable doubt or on the **balance of probabilities**); use of explicit methods to account for uncertainty and inter-assessor differences;

requirement for detailed supporting documentation (on species population trends, threats, conservation actions); use of standardised protocols to review the assessment.

We suggest that the key to creating replicable counterfactuals and scenarios is to minimise variation between different **observers**' frame of reference in the first place, for example by providing standardised instructions which will help ensure that different assessors approach the question in the same way (Fig. 2, Appendix 1 of IUCN SCSTF, 2020) and to provide review mechanisms that can flag and address possible bias (Appendix 2 of IUCN SCSTF, 2020).

4. Inferring future conservation impact

While estimating the counterfactual in order to evaluate the success of past conservation efforts has long been a focus, there is growing interest in looking forward to project the potential future impact of conservation. Predicting future conservation impact is used to inform decision-making around ecological restoration and, more recently, to design 'biodiversity offsets' which aim to compensate for the residual impacts of economic development activities on biodiversity (BBOP, 2012; Laitila et al., 2014).

When looking into the future, there is of course no observed value of the variable of interest against which to compare scenario results. Instead, we compare various future scenarios to a baseline scenario (Fig. 1). This baseline scenario can be either static, where it is assumed that in the absence of future conservation actions the current species' status will not change, or dynamic, where it is assumed that contextual factors (besides conservation interventions) will affect future species trajectories either negatively or positively. The choice between a static and dynamic baseline scenario is not trivial; analyses have demonstrated that the choice of baseline fundamentally determines the amount of biodiversity offsetting required to reach no net loss of biodiversity (e.g. Bull et al., 2014).

The Green Status of Species method includes two future scenarios (Fig. 1) for which baseline choice greatly changes the perceived impact of conservation:

- A *future-without-conservation scenario*, which predicts the trajectory of the species into the short-term future (10 years) if all ongoing and planned conservation actions were to cease. The **Conservation Dependence** metric (which measures avoided declines) is calculated as the difference between the outcome of this scenario and the status of the species under the baseline scenario in the short-term future.
- A *future-with-conservation scenario*, which predicts the trajectory of the species into the short-term future (10 years) if all ongoing and planned conservation actions were carried out. The **Conservation Gain** metric (which measures expected improvements) is calculated as the difference between the outcome of this scenario and the status of the species under the baseline scenario in the short-term future.

The estimation of the future-with- and future-without-conservation scenarios follows a process similar to that for estimating the counterfactual (Fig. 2); full guidance for evaluating these scenarios can be found in Appendix 1 of the Green Status of Species Background and Guidelines (IUCN SCSTF, 2020).

Not all assessors will need or wish to separate future conservation impact into avoided decline (Dependence) and improvement (Gain) as is done for the Green Status. Conservation Dependence, for instance, is a metric that only makes sense to calculate if there are already conservation actions in place (if not, Dependence equals zero). Conservation Gain may be a more relevant metric in many cases; for example, when evaluating potential for No Net Loss it is more common to explore scenarios where conservation actions are added rather than taken away (e.g. Bull et al., 2014). Nonetheless, the scenarios from which two these metrics are derived provide important general lessons about baseline setting.

The Green Status method also includes a third future scenario: an aspirational scenario of sustained conservation efforts and conservation innovation over the long-term (100 years) to evaluate the maximum **plausible** improvement in the status of the species (Fig. 1). The Recovery Potential metric for a species is calculated as the difference between the outcome of this scenario and the current status of the species. We do not discuss this scenario in detail here because the other two future scenarios usefully demonstrate key concepts in impact evaluation, but guidance for evaluating this scenario can be found in IUCN SCSTF (2020).

4.1. Setting a baseline scenario

The most straightforward choice of baseline scenario against which to compare future scenarios with or without conservation is to use the current, observed status of the species, i.e., a **static baseline**. Using the current status of the species as a baseline scenario implies that in the absence of conservation action, we assume that nothing changes. This is unlikely to be true and will lead to estimated outcomes being conservative whenever conservation is actually keeping species from declining (Bull et al., 2014). There are also many situations where using the current status of a species as a baseline scenario would be inappropriate (for example when there is ongoing degradation of habitat caused by factors outside of conservationists' control, such as climate change; e.g. Maron et al., 2015). Misleading results that disincentivise conservation may be produced with a static baseline if there is likely to be a substantial trend in species status either up or down, regardless of planned conservation action (Bull et al., 2014; Fig. 3).

Therefore, an alternative approach is to compare our future scenarios to a **dynamic baseline**, a scenario in which things proceed as they are currently, i.e., according to "business as usual". Using a dynamic baseline scenario can provide a more accurate assessment of the importance of conservation for the short-term future of the species. This is especially the case when the status of the species is expected to deteriorate despite the continuation of current conservation actions. In such a case, using a static baseline scenario (the current observed status) may result in a zero or even negative Conservation Gain, even if conservation is in fact expected to substantially slow the deterioration of the species' status (Fig. 3).

As defined for the Green Status of Species, in a business-as-usual scenario (i.e. the dynamic baseline scenario), all current conservation actions (including those very likely to be in place within 1 year; see IUCN, 2021) continue without enhancement (e.g. a protected area remains in place with the same level of management effectiveness, or control of invasive species continues according to the same programme); the impact of these continued actions is measured by the Conservation Dependence (Fig. 3). Additional conservation actions (i.e., actions which are planned to be implemented within the 10 year window) contribute to Conservation Gain (Fig. 3, Glossary).

It may appropriate to define the business-as-usual (dynamic baseline) scenario differently to the above, based on the impact evaluation goals for a given set of conservation actions. The important thing is that the baseline scenario, and the assumptions feeding into it, must be clearly stated in order for it to be an informative reference point.

4.2. Baseline scenario case studies: white-eared Opossum and Redbay

To demonstrate the importance of using a dynamic baseline scenario when species status is expected to change in the future regardless of the conservation intervention, we consider two species for which future scenarios were generated as part of the testing and development of the Green Status of Species (Grace et al. in press). The future impact of conservation was first assessed using a static baseline scenario (the current status of the species), and then compared against a dynamic scenario.

The White-eared Opossum (*Didelphis albiventris*) is broadly

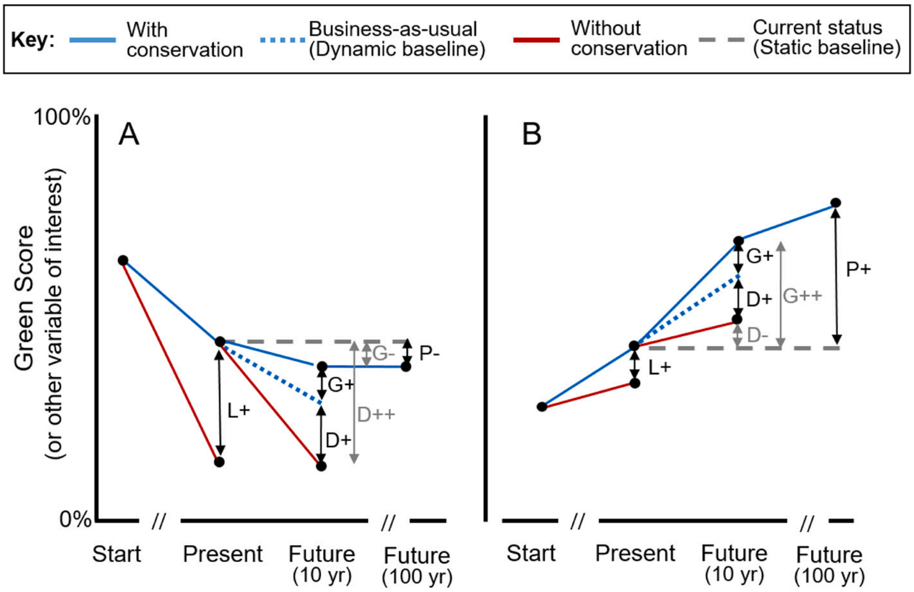

Fig. 3. The choice of baseline (dynamic vs. static) influences the calculation of Conservation Gain (G) and Conservation Dependence (D) but not Conservation Legacy (L) or Recovery Potential (P). **A)** For species expected to continue to deteriorate despite conservation action, a dynamic baseline is recommended to calculate Dependence and Gain. Using a static baseline produces a negative Gain (−), implying that continued conservation would negatively affect the species, which is not the case in this figure. It also overinflates Dependence (++). **B)** For species expected to continue to improve regardless of conservation action, a dynamic baseline is also recommended. Using a static baseline results in negative Dependence (−), implying the species would be better off if conservation stopped, which is not the case in this figure. It also overinflates Gain (++). **Both:** Dashes in the x-axis indicate that the temporal element is not to scale, which explains why the rate of change appears to modify rapidly.

distributed throughout many ecosystems east of the Amazon Basin, extending from northeastern Brazil southward into central Argentina (Chemisquy and Martin, 2019). The species is currently classified as Least Concern on the IUCN Red List in terms of extinction risk, and it occurs in a number of protected areas. The preliminary Green Status assessment aimed to assess the current state of the species (Absent, Present, Viable, or Functional) in each of the distinct spatial units occupied by the species (biogeographical regions; Morrone, 2014). The assessment then estimated the future impact of conservation by playing out scenarios to infer if and how the state of the species would change in each spatial unit if conservation were continued or discontinued in the short term. However, the result was considered counterintuitive—the species' Conservation Dependence (status in the future-without-conservation scenario minus baseline status) was reported as negative, which seemed to imply that the White-eared Opossum would be better off if protected areas were degazetted. This inconsistency arises due to the use of a static baseline; repeating the analysis with a dynamic baseline led to a more rational conclusion. This is because, independent of conservation action, the White-eared Opossum is expanding its range in the south, tracking human development of rural areas and benefitting from the resources provided in human-occupied areas (Carrera and Sauthier, 2014; Cruz et al., 2019). Thus, as a by-product of predicted human growth, opossum spatial unit populations in the southern parts of the species' range are anticipated to improve in status from Viable to Functional over the time considered in future scenarios based on changing conditions outside of protected areas. When measured against this dynamic baseline scenario rather than a static one, the species' Conservation Dependence is reported as zero rather than negative—a result consistent with a widespread species that is associated with human settlements and disturbed habitats.

A more common case is that of a species expected to decline in spite of conservation efforts. Here, the use of a dynamic baseline scenario may be even more important, as using a static baseline scenario can obscure the potential positive impact of conservation. The tree redbay (*Persea borbonia* sensu *lato*) is common throughout the eastern United States, but since 2002 it has been under attack from a pathogenic fungal symbiont that causes the disease known as laurel wilt (Kendra et al., 2013). The disease, which kills adult trees with up to 90% mortality (Spiegel and Leege, 2013), has reached all parts of the species' range. It is also very difficult to control its spread in forests (Kendra et al., 2013). It is not surprising, therefore, that the species' Green Status state is expected, based on preliminary assessment, to decline from Functional to merely Present within three redbay generations in most spatial units, even with continued efforts to contain the pathogen. Using a static baseline, the Conservation Gain (status in the future-with-conservation scenario minus baseline status) is negative—which incorrectly implies that continued conservation action would negatively affect species status (Fig. 3A). In reality, in a future-without-conservation scenario some spatial units on the periphery of the species' range are predicted to become Absent, which is not expected to happen in the future-with-conservation scenario, where integrated pest management is expected to prevent these declines (e.g. Martini et al. 2020). In this case, using a dynamic baseline scenario indicates that Conservation Gain from this species will be low but positive, providing a more informative picture of the potential impact of conservation.

4.3. When to use a dynamic baseline scenario

Certain diagnostic approaches can help assessors decide if a dynamic baseline is more appropriate than a static one. In general, if there is evidence that conservation will prevent or slow decline relative to business as usual, or the situation will improve due to factors other than conservation action (e.g., changes in weather patterns) a dynamic baseline scenario should be explored.

In the context of the Green Status of Species, assessors who carry out an assessment using a static baseline scenario and see a result of negative Conservation Dependence or Conservation Gain may wonder if this is a 'true' result (given that it implies a negative impact of conservation), or if the choice of baseline is to blame. This is not a trivial question, as sometimes conservation interventions do negatively affect species outcomes (e.g. Sonter et al., 2019). Using a static baseline, a 'true' negative result for Conservation Dependence is signalled only if there is also zero Conservation Gain (i.e., conservation is expected to confer no benefit over the current species status, and status is expected to improve if conservation stops). The opposite is true for Conservation Gain, where an assessment using a static baseline only indicates a 'true' negative result if there is also zero Conservation Dependence. If a negative result is obtained but these conditions are not met, reassessment using a dynamic baseline scenario is appropriate.

Regardless of whether a static or dynamic baseline scenario is used, the overall short-term conservation impact (sum of Conservation Dependence + Conservation Gain) remains the same (Fig. 3). Therefore, if all that one is interested in is understanding the overall impact of conservation, a dynamic baseline provides no more information than a static baseline. However, if the objective is to accurately assign Conservation Dependence and Conservation Gain (e.g., to estimate the degree to which discontinuing conservation will have a negative impact, and continuing conservation will have a positive impact on status), then dynamic baselines are usually more appropriate, especially in a rapidly changing world.

5. Guidance for building robust and replicable counterfactuals and scenarios

The four Green Status scenarios represent situations where conservation action did not take place at all, continues as planned, ceases or intensifies. To build these scenarios, we must estimate the influence of conservation for a given species in each spatial unit, both in the past and the future. To inform counterfactual scenarios, we may have monitoring (trend) data from the past, but very rarely do we have conservation actions that were implemented in a way that enabled robust evaluation allowing causal attribution (for example using a Before-After-Control-Intervention design or a Randomised Control Trial). Instead, we tend to have observations or inferences of change in species status, and information on the conservation action(s) carried out.

Even in the absence of an experimental or quasi-experimental design, it is possible to use the methods in Table 1 to infer whether conservation has had an impact. When the Green Status of Species was in development, the majority of test assessors chose to use the logical argument approach (over 90%), as demonstrated in the *Hyophorbe lagenicaulis* case study. This preference is likely because of its relative ease of implementation and because this method can be undertaken by one person; most test assessments were carried out by individuals or small teams (IUCN Species Conservation Success Task Force, *pers. comm.*).

The logical argument approach can be made more defensible if it can use evidence about the effectiveness of different conservation interventions, based on the systematic review of a range of studies (e.g. Wordley et al., 2018). For example, we might be able to infer the likely change in our variable of interest that would be obtained if invasive predators were removed from part of a species' range based on our understanding of the demonstrated impacts of these actions in similar circumstances. In addition, if conservation actions are designed in an experimental way in the future, then the evidence for the past influence of conservation on a species in a particular assessment unit will become stronger; this will also enable conservationists to be more confident about the likely impact of future conservation.

In Fig. 2 we provide a series of steps and checkpoint questions to generate scenarios for measuring conservation impact, using counterfactuals as an example. Appendix 1 of the Green Status of Species Background and Guidelines (IUCN SCSTF, 2020) provides a further series of steps and checkpoint questions that guide assessors through the process of building each of the four Green Status scenarios. These could be generalised to assess impact using other metrics. By working through these steps, which encourage assessors to think beyond their personal (possibly narrow) frame of reference, assessors are more likely to produce scenarios that could be independently generated by another assessor. Any of the methods in Table 1 can be used to provide evidence for the scenarios when going through these steps, as could more robust methods of causal attribution (if available).

5.1. Dealing with uncertainty

Constraints on data availability can introduce considerable uncertainty to scenarios. Estimating the counterfactual for the Round Island Bottle Palm was relatively straightforward because of the small size of the area being considered, historical accounts of past abundance and changes since threats were introduced, and robust monitoring which allowed us to track number of individuals over the timeframe of the intervention. However, sometimes counterfactuals and future scenarios will need to be estimated with very limited supporting data. One option is to run through the processes in Fig. 2 multiple times; once using the best estimate of the scope and impact of threats and conservation actions, once using the most optimistic scenario to produce a maximum estimate of species status, and once using the most pessimistic scenario to produce a minimum. Reporting a range of minimum, best, and maximum values makes uncertainty transparent and increases the utility of scenario estimates (Bull et al., 2015; Hoffmann et al., 2015; Bolam et al., 2020).

5.2. The use of review processes to reduce inter-observer variation

Ideally, impact assessment would be a collaborative process, where many perspectives contribute to the determination of important factors, conservation actions, and their likely impact; this would result in scenarios arrived at by the consensus of multiple experts, which should make them more robust, defensible, and replicable. Red List assessments, for example, are often done in workshop settings, where knowledge is shared among experts and the process is facilitated by someone experienced in the Red List categories and criteria. However, as is the case for Red Listing, there will be many cases where Green Status assessments are undertaken by one person, or multiple people from the same organisation (who may have similar perspectives and biases). There must therefore be mechanisms in place to reduce potential bias. Appendix 1 of the Green Status of Species Background and Guidelines (IUCN SCSTF, 2020) ends with a final step of self-review. In this self-review, assessors are asked to disclose any conflicts of interest, and to check their Green Status assessment results against the Red List assessment for the species to identify any obvious discrepancies.

Following the completion of an assessment, good practice suggests it should be externally reviewed; this is required for Green Status assessments, aligning them with Red Listing. Appendix 2 of IUCN SCSTF (2020) contains a series of questions for the external reviewer(s) of the assessment. It is important to note that the external reviewers are also required to disclose any potential conflicts of interest. Including two steps of review, both internal and external, is a critical step in producing defensible scenarios. While the questions in these two appendices are somewhat specific to the Green Status assessment, the spirit of the questions can be used to guide the review of other assessments of conservation impact.

It is quite likely that assessors, and reviewers, may differ in their assessments, potentially because of their different frames of reference. Fortunately, there are techniques which can be used to arrive at scenario consensus, or at least to minimise differences to the extent possible. These include participatory scenario-building, **Delphi methods**, and minimising the sum of the perceived differences between assessors (see Bull et al., 2020 for more details).

6. Conclusions for conservation

The launch of the IUCN Green Status of Species will bring impact evaluation to the attention of a wide range of conservationists. Indeed, through it, many practitioners will be exposed to the ideas of counterfactuals, baseline scenarios, and frames of reference for the first time. In order for the Green Status to grow as it needs to over the coming years in order to become a global indicator, the process of impact evaluation must be accessible to all. In this paper, we have demonstrated how impact can be assessed using inferential evidence, removing a perceived or actual barrier to entry posed by some empirical methods. The glossary of key terms, step-by-step process (Fig. 2), and discussion of common issues presented here can serve as a reference for those hoping to conduct a Green Status of Species assessment or as an introduction to inferential impact evaluation more generally.

One of the biggest potential hurdles to impact evaluation in conservation is its perceived subjectivity, because conservation actions are rarely evaluated using experimental frameworks, or indeed designed with impact evaluation in mind (Baylis et al., 2016). Providing a common framework and review process under the IUCN Green Status of Species helps reduce this subjectivity. Nonetheless, conservation interventions often take place in dynamic and externally-influenced situations, in which general lessons from elsewhere may not be applicable, and unintended consequences are likely (Larrosa et al., 2016). Because of this, the 'context' steps we describe in Fig. 2 are critical for understanding and measuring conservation impact using inferential approaches. Going forward, identification of these factors at an earlier stage—during the design of conservation actions—is a practical step that can be taken to make the process of impact evaluation described here easier, and also increase the likelihood of generating meaningful conservation impact.

We recommend this because building consideration of contextual factors into the design of conservation actions strengthens the argument that a particular set of actions has had an impact, even if the evidence is inferential rather than experimental. For example, Margoluis et al. (2009b) recommend that prior to deciding conservation actions, a conceptual model should be created which includes conservation targets, threats, and other factors and, importantly, expresses what is known about the links between them. This conceptual model can also be translated into a results chain, where the expected effects of the planned action are described (Margoluis et al., 2013). Use of these tools and others would reduce the subjectivity of inferential evaluation of conservation impact (Baylis et al., 2016). Critically, if the performance of different conservation actions can be robustly evaluated using inferential evidence, it could one day be possible to compare the relative impact of different conservation actions to the recovery of a given species over the three scenarios discussed here (Conservation Legacy, Conservation Dependence, and Conservation Gain), which would be invaluable information for conservation planning, financing, and policy.

The difficulties we have highlighted in evaluating the impact of past conservation actions is not a criticism of the conservationists involved in designing and implementing these actions. Conservation interventions are often designed with less-than-complete information, facing trade-offs of time, resources, and competing interests (Evans et al., 2017). While we welcome the ongoing shift in biodiversity conservation and management toward a more rigorously evidence-based approach to decision-making and impact assessment, we simultaneously acknowledge the crucial need for frameworks to evaluate past conservation actions that were not specifically designed with robust impact evaluation in mind. This will allow us to both celebrate the achievements of past conservation actions and improve conservation decision-making going forward.

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Declaration of competing interest

The authors declare no conflict of interest in submitting this work. The work is all original research carried out by the authors. All authors agree with the contents of the manuscript and its submission to the journal. No part of the research has been published in any form elsewhere, nor has similar work been published or submitted elsewhere. This manuscript is not being considered for publication elsewhere while it is being considered for publication in this journal. Any research in the paper not carried out by the authors is fully acknowledged in the manuscript. All sources of funding are acknowledged in the manuscript, and there are no direct financial benefits of publication for the authors to declare. No ethics approvals were required for this research.

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Glossary

Glossary: *terms relevant to evaluating conservation impact for the purposes of an IUCN Green Status of Species assessment; many of these terms are generally relevant for evaluating the impact of wildlife conservation activities at different scales (e.g., project level).:*

Term: Definition

Balance of probabilities: An event or outcome is only recorded as having occurred if, using the evidence available, the probability of occurrence is higher than the probability of it not occurring.

Baseline scenario: A reference trajectory against which other scenario outcomes are compared

Conservation action: Human interventions intended to have a positive impact on wildlife and/or the environment (regardless of their realized impact)

Conservation dependence: IUCN Green Status of Species term: the expected change in species status from the baseline over 10 years, if all conservation actions relevant to the species were halted today and no new actions were introduced

Conservation gain: IUCN Green Status of Species term: the expected change in species status from the baseline over 10 years, if all currently operating conservation actions relevant to the species continue, and considering conservation actions which are expected, on the balance of probabilities, to come into effect within one year

Conservation legacy: IUCN Green Status of Species term: the difference between a species' current status and the status estimated under the counterfactual

Counterfactual: A scenario used to estimate an alternative current state where no past conservation took place

Delphi methods: Expert elicitation approaches where consensus is approached using multiple rounds of questionnaires sent individually to a group of experts, with discussions between rounds.

Dynamic baseline scenario: General meaning: A baseline scenario used to determine future conservation impact; dynamic baseline scenarios correct for potential confounding factors by changing over time.Green Status of Species meaning: A scenario where current conservation actions (and those that are very likely to take effect within 1 year of the assessment) continue unchanged.

Factor: Anything expected to have an impact (positive or negative) on a species' status

Frame of reference: The context in which a counterfactual or scenario is being created

Green score: A species-level indicator of progress toward recovery generated by an IUCN Green Status of Species assessment, ranging from 0 to 100%

Inferential approaches: Methods for attributing impact that do not use experimental or quasi-experimental evidence

Observer: The person(s) creating counterfactuals or scenarios, who each bring unique biases to the process

Plausible: Used to describe an event or outcome which, on the balance of probabilities, is likely to occur/have occurred

Recovery potential: IUCN Green Status of Species term: the maximum plausible change in species status from its current status over 100 years

Scenarios: Alternative sequences of events that lead to alternate species trajectories

Spatial unit: A discrete part of a species' range identified in an IUCN Green Status of Species assessment

State: Green Status of Species term: The condition of a species (Absent, Present, Viable, or Functional) within a spatial unit. Each state is associated with a numeric weight (Absent - lowest, Functional - highest). The combination of states across all of a species' spatial units under a specified scenario yields the Green Score

Static baseline scenario: A baseline scenario used to evaluate future conservation impact that assumes no change over time

Substantive impact: General meaning: An impact sufficient to change the value of the variable being used to evaluate impactGreen Status of Species meaning: an impact sufficient to change the State of a species within a spatial unit