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Systematic Review Protocol

Title
How effective are protected areas for reducing threats to biodiversity? A systematic review protocol

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Keywords
Protected areas – Conservation - Threats to biodiversity – Protected areas effectiveness – Threat reduction in protected areas

Background
Protected areas (PAs) have become one of the most important instruments to preserve nature and, when effective, can significantly reduce human pressure and derived threats to biodiversity. However, evidence suggests that despite the growing number and coverage of PAs worldwide, biodiversity trends continue to deteriorate, and human pressure increases outside and inside PAs. While many studies have focused on the effectiveness of PAs in maintaining ecological features, less attention has been given to the threat reduction potential of PAs, despite threats being one of the main factors leading to the need to conserve biodiversity. It is therefore essential to understand PAs' role in addressing threats. In this paper, we describe the protocol for conducting a systematic review to explore and review the evidence surrounding the effectiveness of PAs as an intervention to reduce threats to biodiversity. We will examine the role of PAs in addressing several types of threats. Thus, our primary research question is: How effective are protected areas for reducing threats to biodiversity?

Theory of change or causal model
Threats to biodiversity, such as land use change, overexploitation, pollution, invasive species, and climate change, drive biodiversity loss. Protected areas have been implemented to protect biodiversity against threatening human activities and provide species with optimal conditions to thrive. We aim to assess the role of protected areas as an intervention to reduce threats to biodiversity.

Stakeholder engagement
The objective and questions of this study have arisen from the authors' scientific motivation, with anticipated significant impacts on conservationists, area managers, and decision-makers. By assessing the success of current management strategies and methods for addressing threats to biodiversity, this research will improve our understanding of the effectiveness of PAs in addressing threats and identify PAs' main strengths and weaknesses according to their geographical location and socio-economic-ecological characteristics. This review will offer insights from various regions worldwide on what strategies and approaches work best in threat abatement within PAs. This knowledge transfer is particularly crucial for ecosystems facing similar problems in threat

abatement. By identifying the factors contributing to PAs' success, targeted policies and management strategies can be developed to promote conservation success and contribute to the Global Biodiversity Framework.

Objectives and review question
Research questions: How effective are PAs for reducing threats to biodiversity? • What threats are being studied? • How are threats being assessed? What type of study designs have been used? • What is the state of the evidence: number of studies, study location, intervention type, type of threats, and type of PAs (If available)? • What actions have been implemented to reduce threats in PAs, and what evidence exists of their effectiveness? • Is the relationship between threats and biodiversity considered? • What factors are associated with the success or failure of threats reduction over time?

Definitions of the question components
Population: Areas experiencing threats to biodiversity Intervention: Establishing protected and conserved areas Comparator: No protection or before establishment Outcome: Difference in threat state

Search strategy
Various search terms related to the Population, Intervention, Comparator, Outcome - PICO categories were used to define the search terms: (P) Areas experiencing threats to biodiversity: Threat, human impact, human pressure, anthropogenic impact, human activity, stressor, anthropogenic pressure. (I) Protected areas: Protected areas, conservation areas, nature reserve, sanctuary, national park, biosphere reserve, biodiversity reserve, wildlife habitat. (O) Difference in threat state: Reduce, effectiveness, impact. The keywords in each category will be combined using the Boolean operator ‘OR’; then, the three categories will be combined using ‘AND’. Additionally, an asterisk (*) is a ‘wildcard’ that represents any group of characters, including no character, while a dollar sign ($) represents zero or one character.

Bibliographic databases
Web of Science – Core Collection and Scopus

Web-based search engines
Google Scholar

Organisational websites
Wildlife Conservation Society (WCS), International Union for Nature Conservation (IUCN), Global Environmental Facility (GEF), World Wide Fund for Nature (WWF), Conservation International, BirdLife International, Regional sections of the Society for Conservation Biology (SCB)

Comprehensiveness of the search
Benchmark studies were selected based on the expertise of the review team, independent of the search strategy. These studies were chosen for their significant contributions to the subject area, focusing on the role of PAs in addressing threats to biodiversity. Additional studies were identified through separate searches using tools like Google Scholar and artificial intelligence resources, such as "Consensus" (https://consensus.app/search/) and "scite_" (https://scite.ai/). In total, 20 highly relevant benchmark papers formed the basis for developing the search strategy and assessing its comprehensiveness. To ensure the adequacy of the search strategy in retrieving pertinent literature, we reviewed the search output for relevant articles, including each benchmark article scoped. We refined the search strategy for articles initially not retrieved by adding keywords until all benchmark articles were successfully captured.

Search update
N/A

Screening strategy
The compiled library will undergo meticulous duplicate removal. Then, a thorough evaluation of titles and abstracts will be undertaken, guided by the provided eligibility criteria. Items with uncertain eligibility will be preserved for subsequent analysis. The authors and the review team will divide the screening into two steps. Firstly, a title and abstract level screening and, secondly, at the full-text level. As a check for consistency at the title and abstract stage, the review team will assess a random subset of 10% of the total articles found. For this subset, we will test agreement using the Kappa index and define the threshold of Kappa≥0.6 as a moderate agreement. All discrepancies will be discussed and reviewed to increase consistency and if necessary, increase the specificity of the inclusion and exclusion criteria. In cases of uncertainty, we will tend towards inclusion; thus, articles will be passed on to the second step and assessed at the full-text level. Then, each article found to be potentially eligible based on the abstract will be evaluated for inclusion by reviewers studying the full text. During the full-text screening stage, we will document the excluded studies and the supporting reasons for their exclusion. Moreover, if a review team member is an author(s) of the studies to be considered, they will have no role in decisions regarding inclusion or critical appraisal, and other reviewers will do this instead.

Eligibility criteria
According to the PICO components, the selection of the inclusion criteria is based on identifying studies that investigate the effectiveness of PAs in controlling threats to biodiversity and contribute to our understanding of the role of PAs in biodiversity conservation. Specifically, we aim to identify studies that measure changes in threats to biodiversity within PAs or their buffer zones: POPULATION - Areas experiencing threats to biodiversity Studies measuring the change of threats state to biodiversity in PAs. The threats reported in the studies must be present in the IUCN threat classification scheme. The reported threats must be anthropogenic (no geological events) and can be assessed directly or indirectly, such as proxies of threats measured by human drivers (Eg. Human footprint index) INTERVENTION - Establishing protected areas Eligibility criteria: Site(s) designated to conserve biodiversity: including all types and designations of PAs such as national parks, wildlife sanctuaries, nature reserves, biosphere reserves. COMPARATOR - Before and after control of threats inside PAs Studies with a temporal dimension referring to actions, implementation, or related synonyms to control threats in PAs. Studies that compare threats inside-outside PAs and/or before and after threat mitigation control OUTCOME - Difference in threat state Studies measuring changes in threats to PAs: Temporal Studies, Comparative Studies and Management Comparison Studies. Study type: Studies that employ comparison groups and/or utilize before-after (BA) or before-after control-impact (BACI) study designs will be included. Languages: English

Consistency checking
The authors and the review team will divide the screening into two steps. Firstly, a title and abstract level screening and, secondly, at the full-text level. As a check for consistency at the title and abstract stage, the review team will assess a random subset of 10% of the total articles found. For this subset, we will test agreement using the Kappa index and define the threshold of Kappa≥0.6 as a moderate agreement. All discrepancies will be discussed and reviewed to increase consistency and if necessary, increase the specificity of the inclusion and exclusion criteria. In cases of uncertainty, we will tend towards inclusion; thus, articles will be passed on to the second step and assessed at the full-text level. Then, each article found to be potentially eligible based on the abstract will be evaluated for inclusion by reviewers studying the full text. To maintain consistency in our review process, at least two team members will independently assess 10% of the articles selected at the abstract level and discuss disagreements. This sample will be used to evaluate the inclusion or

exclusion of articles during the full-text screening stage. During the full-text screening stage, we will document the excluded studies and the supporting reasons for their exclusion. Moreover, if a review team member is an author(s) of the studies to be considered, they will have no role in decisions regarding inclusion or critical appraisal, and other reviewers will do this instead.

Reporting screening outcomes
The outcomes of the screening process will be reported as the list of selected articles according to the inclusion criteria. A supporting file will record the excluded articles at each screening stage. At the full-text level screening stage, we will record the excluded studies and the reasons supporting their exclusion

Study validity assessment
Eligible studies will be critically appraised after the full-text review. The systematic review will utilize the Collaboration for Environmental Evidence (CEE) Critical Appraisal Tool to evaluate the validity and risk of bias of the selected studies (Konno et al., 2021). Designed for assessing risk of bias in primary research studies, the tool provides a structured and transparent way of evaluating the quality and relevance of environmental conservation evidence. Three reviewers will independently conduct validity appraisals of the selected studies to maintain consistency. Validity appraisal results for each study and reasons for exclusion will be reported in a separate file.

Consistency checking
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Data extraction strategy
An evidence table will be constructed using data extracted from the selected studies, including study characteristics, PA information, and threat assessments. The extracted information will be based on the PICO elements. In cases where information is missing, we will declare it as non-reported (-). A minimum of three reviewers will perform the data extraction, and to ensure consistency, a set of ten studies will be first coded together. If uncertainties arise, they will be discussed among reviewers. The methods for data extraction, including additional columns and categories, and synthesis will be refined during the early phases of the review. The data from the selected literature will be extracted and saved in Excel spreadsheets and will be part of the supplementary information of the systematic review. As part of our methods, we pilot-tested the data extraction template on a subset of studies to ensure that it captured all the relevant information and was easy to use. The pilot testing allowed us to refine and adjust the template to ensure it was comprehensive and effective for extracting data from all studies included in the review.

Meta-data extraction and coding strategy
An evidence table will be constructed using data extracted from the selected studies, including study characteristics, PA information, and threat assessment. For example: Metadata: Authors & Publication year, title, publication type, journal, DOI, scale (e.g., Local, regional, global), ecosystem type, threat assessment method, does the study include a control? What variables are considered? Taxonomic group(s) studied, methods, reported threats, data location within article, comments. Protected areas characteristics: Name, category, size (km2), year of establishment (designation), assessment period, management type, socio-economic features, and relevant conservation features. Information relating to the inclusion criteria: a) Population: Reported threats IUCN Threat Classification Scheme V3.3, proxies of threats. b) Intervention: PA(s) characteristics: Name (if individual PA reported), number of PAs (When multiple PAs have been assessed, study area or country, year of establishment, management type, additional information. c) Comparator:

Assessment period, study type, study using control variables? Comparison type of the study (eg. Time, control variable, management type?) d) Outcome: Threat level assessment after control and/or comparison (Value, effect, and in comparative analysis: Was the PA more effective than the control? effect of PA on overall threats (Positive, neutral, negative), identified factors leading the threat change, additional data (and additional comments. Additional calculations: To be defined according to the findings. Initially, results will be reported as the percentage of effectiveness of the PA/threat control strategies to change the threat state over time (Value and effect tabs) (Positive and negative values refer to positive and negative effects, respectively).

Consistency checking

A minimum of three reviewers will perform the data extraction, and to ensure consistency, a set of ten studies will be first coded together. If uncertainties arise, they will be discussed among reviewers. The methods for data extraction, including additional columns and categories, and synthesis will be refined during the early phases of the review. The data from the selected literature will be extracted and saved in Excel spreadsheets and will be part of the supplementary information of the systematic review. As part of our methods, we pilot-tested the data extraction template on a subset of studies to ensure that it captured all the relevant information and was easy to use. The pilot testing allowed us to refine and adjust the template to ensure it was comprehensive and effective for extracting data from all studies included in the review.

Potential effect modifiers/reasons for heterogeneity

Effect modifiers leading to heterogeneity in the results will be identified during the full-text screening and recorded for the included studies. Likewise, where applicable, we will collect information on the methods used to assess the impact of potential effect modifiers. Due to the nature of our study, several biogeographic, environmental, and socio-economic factors could result in the heterogeneity of impacts found in different studies. Some of the potential effect modifiers identified in previous studies include the category of PA, governance type, geographical location, and topographic features, size of PA, date and period of establishment, the socioeconomic context of the state or country of PA, ecosystem type, among others (Geldmann et al., 2013; Sharma et al., 2020). A complete list of effect modifiers will be included in the systematic review.

Type of synthesis

Narrative and quantitative where possible

Narrative synthesis methods

The data synthesis will comprise an extensive narrative synthesis and a summary of findings using descriptive statistics. The narrative synthesis will describe the strength and validity of the evidence along with the study findings. Tables and figures will be produced to summarise the results and will be available as supplementary information on the systematic review. In the process of data extraction and critical appraisal, steps are taken to minimize bias in the result. Using the categories identified in the critical appraisal, a sensitivity analysis will be conducted to test the effects of the validity assessment (e.g., exclusion of articles) and the robustness of the studied outcomes.

Quantitative synthesis methods

While meta-analyses are a powerful tool for synthesizing data, they require a homogeneity of outcomes and methods that might not be present for the included studies of this review due to the heterogeneity of the data and methods used to assess the effect of PAs on threats. However, a meta-analysis will be conducted if the collected data (or a portion thereof) permits meaningful quantitative comparisons.

Qualitative synthesis methods

N/A

Other synthesis methods
N/A

Assessment of risk of publication bias
In the process of data extraction and critical appraisal, steps are taken to minimize bias in the result. Using the categories identified in the critical appraisal, a sensitivity analysis will be conducted to test the effects of the validity assessment (e.g. exclusion of articles) and the robustness of the studied outcomes.

Knowledge gap identification strategy
N/A

Demonstrating procedural independence
If a review team member is an author(s) of the studies to be considered, they will have no role in decisions regarding inclusion or critical appraisal, and other reviewers will do this instead.

Competing interests
The authors declare that they have no competing interests

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Author’s contributions
KPC and JG jointly conceived and designed the study. KPC developed the first draft of the protocol with inputs from EV and JG. KPC, EV and JG participated in the formulation of objectives, search terms and study inclusion criteria. KPC conducted the searches. KPC, EV and JG contributed to the revisions of the protocol. All authors provided critical comments for revision. All authors read and approved the final manuscript.

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