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PERSPECTIVE

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An interoperable and standardized protocol for reporting systematic conservation planning projects

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We dedicate this work to Professor Bob Pressey (1953–2023), a tireless advocate for evidence-based conservation and leading proponent in establishing the discipline of systematic conservation planning.

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Abstract

Systematic conservation planning (SCP) is an operational and scientific framework that assists in deciding where, how, and when to implement conservation intervention. Studies using SCP approaches have proliferated due to their immediate relevance for applied conservation. For example, they can help identify cost-effective opportunities for expanding areas under conservation management to achieve high-level policy goals such as those of the Global Biodiversity Framework. Yet SCP can be conducted in various ways, and results can vary depending on problem formulation, parameterizations, contexts, and prioritization approaches. There is a need to facilitate comparison of SCP studies to understand key criteria and assumptions made in the planning process. Here, we propose a standardized reporting protocol for SCP that is readily applicable across study aims, realms, and spatial scales. The new Overview and Design Protocol for Systematic Conservation Planning (ODPSCP) describes the key steps from the design to the computational stages of SCP. It enables researchers, scientific editors, and decision- and policymakers to assess the scope and comprehensiveness of SCP exercises. To facilitate uptake and ease of reporting, the protocol is openly available through an interactive web interface and which can be further enhanced following methodological advancements in conservation planning. We encourage the conservation community to adopt the reporting protocol to promote transparency and reproducibility, standardized reporting as well as facilitate peer review and independent evaluation.

KEYWORDS

conservation prioritization, intercomparison, marxan, metadata, reporting standard, systematic conservation planning, zonation

1 | INTRODUCTION

The process of making management decisions about the natural world has long been a central theme in conservation science and policy (Beher et al., 2024; Hemming et al., 2022). The expansion and management of conservation areas plays a key role in several global—such as the Kunming-Montreal Global Biodiversity Framework (CBD, 2022)—and regional—such as the European Union Biodiversity Strategy for 2030 (European Commission, 2020)—biodiversity policies. These policies emphasize protected area expansions and the effectiveness of protected area management as key priorities. Scientific efforts to contextualize targets and reach optimal decisions using decision science, often rely on spatially explicit approaches (Gurney et al., 2023; Jung et al., 2024; Maxwell et al., 2020). Given the complexity of conservation decision-making, and to enhance transparency and trust, there is an urgent need to standardize the ways in which the scientific community reports on such efforts.

Here, we focus on concepts and methods from systematic conservation planning (SCP), recognizing that many other approaches exist to identify options to conserve nature. SCP has emerged as a leading approach for identifying where to place and how to manage conservation areas while considering possible co-benefits/trade-offs, costs and stakeholder preferences (Kukkala & Moilanen, 2013; Margules & Sarkar, 2007; Moilanen et al., 2009; Sarkar & Illoldi-Rangel, 2010). SCP can be applied at various stages of conservation projects, including objective and target setting, spatial prioritization, and monitoring. The methodological breadth and conceptual advances of SCP have transformed how spatial priorities can inform decision making (Kukkala & Moilanen, 2013). Yet the variability in SCP applications, resulting from input data and assumptions about parameters,

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makes quantitative and qualitative comparisons challenging. For instance, simply changing feature targets (parameters that specify, e.g., "what proportion of a species range we want to protect") in SCP software (e.g., Marxan) can drastically alter the selection of priority areas (Carwardine et al., 2009). Similarly, using different optimization algorithms or objective functions with the same biodiversity data can result in different outputs (Hanson et al., 2019; Moilanen, 2008). SCP applications are recognized as robust and evidence-based approaches to identify priorities, yet there is clearly a need to record the variety of analytical choices to improve transparency, reproducibility and usefulness.

Numerous conceptual and methodological advances have expanded the capabilities of SCP (Giakoumi et al. 2025). For example, it is now possible to directly consider aspects of connectivity (Beger et al., 2022; Daigle et al., 2020; Hanson et al., 2022), multiple objectives (Dujardin & Chadès, 2018; Jung et al., 2021; Schuster et al., 2023) or management zones (Chapman et al., 2025; Hermoso et al., 2023; Law et al., 2021), costs (Adams et al., 2010; Armsworth, 2014; Jantke & Schneider, 2011; Kujala et al., 2018; Mazor et al., 2016), different facets of biodiversity such as genetic or functional diversity (Carvalho et al., 2017; Jung et al., 2021; Pollock et al., 2017), and optimization of resource allocation in both space and time (Alagador & Cerdeira, 2019; Doxa et al., 2022; Lagabrielle et al., 2018). Yet, existing frameworks are rarely applied, many studies commonly overlook key factors, such as stakeholder engagement (Álvarez-Romero et al., 2018; Jung et al., 2024), and are pursued from a purely scientific viewpoint. Although guidance exists on how to properly conduct SCP projects (Lehtomäki & Moilanen, 2013; Sarkar & Illoldi-Rangel, 2010) and how to avoid common mistakes (Game et al., 2013; Maxwell et al., 2020; Pressey et al., 2021), a standardized general protocol for facilitating relative comparisons among approaches and documenting key decisions and parameters has yet to be established (despite earlier efforts for the marine realm; Álvarez-Romero et al., 2018; Fabbrizzi et al., 2023). We recognize that SCP studies can be complex and heterogeneous in problem formulations, data, or management options. However, broad similarities exist across studies, including several key "building blocks" of their design, such as objectives, features, or parameter choices. As experts in scientific SCP applications, we foresee that the number of such studies will accelerate in the coming years, especially as the scientific community strives to contribute toward national and global policy goals. Thus, we emphasize the need for a standardized reporting protocol to improve reporting and communication of planning properties.

Standardized reporting protocols have been widely adopted in conservation and ecology. Examples include reporting protocols for agent-based models (Grimm et al., 2006), population viability assessments (Pe'er et al., 2013), stage-structured demographic information (Gascoigne et al., 2023) or species distribution models (Zurell et al., 2020). These protocols aim to support a diversity of approaches, and thus are not prescriptive. Standardized reporting protocols can provide a bridge between best and common practice, listing what can be done rather than what should have been done. This is particularly relevant for SCP, where implementations often face constraints in funding, time, human expertise, and data. However, the information assembled by a reporting protocol could allow for a better assessment of the suitability of a particular planning action to address a conservation problem.

We argue that scientific studies applying SCP approaches should, at a minimum, report on key criteria related to their planning process. For example, increasingly more analytical frameworks and methodological advances are proposed every year, but there is rarely consistent reporting on whether these advancements are implemented (McIntosh et al., 2018). Indeed, based on an assessment of the state of conservation planning in Europe, planning solutions rarely account for various aspects of complexity (dynamic conditions, future proofing, multiple objectives, connectivity, etc.) and simpler scoring approaches for the identification of "priorities" remain common (Jung et al., 2024). Area-based conservation, and in particular SCP, has also come under increased scrutiny, with some scientists questioning the reliability of its inputs and lack of realism (Langford et al., 2011), and hence the real applicability for decision makers and planners especially when a theory of change is not clear (Wyborn & Evans, 2021). Clearly, there is a need to ensure that SCP studies are transparent about their intended purpose and choices made in their development and application.

In this work, we propose a new standardized reporting protocol that can accompany any spatial planning study conducted within a SCP framework. The aim of this protocol is to provide scientists, scientific journal editors, decision makers and conservation planners and practitioners with a comparable and comprehensive protocol for characterizing a spatial planning exercise (Figure 1). The protocol also enables the assessment of how conceptual aspects (e.g., socio-economics or connectivity) were methodologically accounted for in the analyses, allowing policy makers and scientists to assess scope and appropriateness for a given context (Figure 2). It has been developed through multiple iterations among leading SCP practitioners to ensure that it is fit for

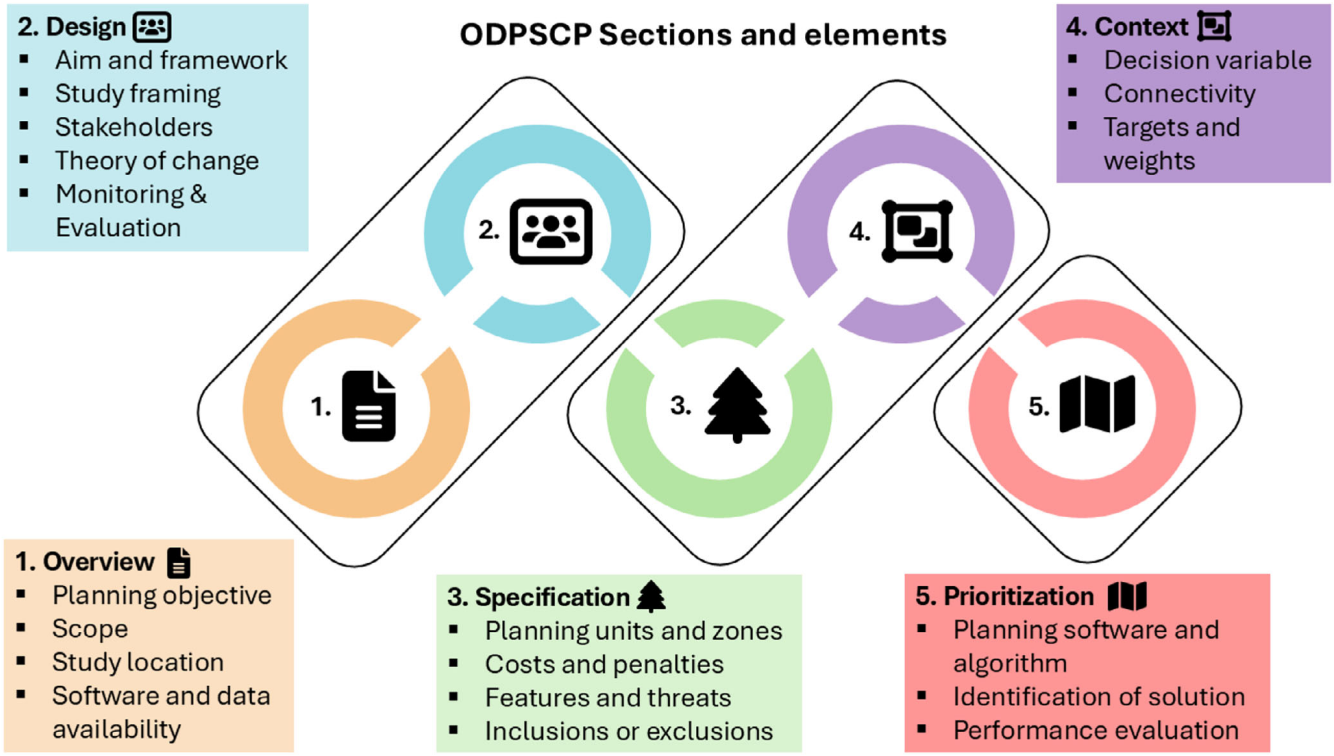

FIGURE 1 Broad schematic of the protocol showing its five key elements (Overview, Design, Specification, Context, Prioritization). Overview (1) and Design (2) protocol questions aim identify the broad aims and setting (Overview), and the purpose of the planning exercise and how it aims to achieve impact (Design). Specification (3) considers what type of data was included in the planning, while context (4) protocol questions ask planners how such data was treated in the planning problem and what other aspects influenced any decisions. Finally, information on how the solution is identified in Prioritization (5), including how the performance of the solutions is evaluated (C). All used icons are openly licensed.

purpose. We encourage the SCP community and editors handling SCP manuscripts to adopt and refer to this reporting protocol when publishing new scientific and gray literature. The proposed protocol does not aim to specify a list of best practices for SCP, rather we build on previous reviews of SCP concepts and frameworks (Game et al., 2013; Groves & Game, 2016; Kukkala & Moilanen, 2013; Pressey & Bottrill, 2009).

2 | PROTOCOL DEVELOPMENT

The protocol was conceived through two sequential iterations, with the initial drafting of the elements, followed by co-authors—all leading experts in SCP analyses—providing feedback and testing the interactive platform, and the final identification and clarification of key elements. The number of fields was designed to capture essential characteristics of the planning project while allowing sufficient flexibility for authors. For the development of the ODPSCP (**O**verview and **D**esign **P**rotocol for **S**ystematic **C**onservation **P**lanning) reporting protocol we took inspiration from extensive SCP reviews (Álvarez-Romero et al., 2018; Jung et al., 2024) and reporting protocols from other fields (Fitzpatrick et al., 2021; Grimm et al., 2006; Sarkar & Illoldi-Rangel, 2010; Zurell et al., 2020).

The protocol is primarily aimed at peer-reviewed studies applying SCP, although we encourage its use in all planning exercises—including white papers and technical reports—to promote standardization. A planning study is relevant for the protocol if it: (a) uses decision theoretic or multiple-criteria-based algorithmic approaches, (b) is spatially explicit, spatial–temporal, or at least uses spatially explicit input to identify areas and actions, and (c) has at least one biodiversity and/or conservation objective (although multi-objective planning projects can also be entered).

3 | KEY ELEMENTS OF THE PROTOCOL

The resulting ODPSCP protocol is based on five key elements of reporting information: Overview, Design, Specification, Context and Prioritization (Figure 1). Elements in **O**verview describe the broad characteristics of a planning work, for example, the location and spatial and temporal resolution and extent, and whether code or data are shared. For the latter, the protocol is not prescriptive on the types of data or software to be shared, although users are encouraged to indicate where raw inputs (of features, threats or parameters) and outputs (e.g., spatial prioritization results, performance summary) can be acquired for full reproducibility. We acknowledge that some data (e.g., exact localities of critically endangered species) may be sensitive, and justifiably remain confidential. With **D**esign elements, planners can clarify the purpose of the study, a theory of change (i.e., a description of how and why a desired change is expected to happen in a particular context) and framework used, types of scenarios evaluated and whether and how stakeholders participated in the planning. **S**pecification elements record properties of the data used, such as the type and size of planning units, whether socioeconomic costs or proxy threat variables were used, decisions on included or excluded areas in the study region, and which levels of taxonomic organization (e.g., species, ecosystems, processes) are used. **C**ontext elements relate to the formulation of the planning problem, including the decision variable (e.g., whether to select an area or not), time horizon and other key constraints like connectivity or conservation features' targets. Finally, information on how the **P**rioritization is achieved includes the type of algorithmic approach, how final priorities were identified and performance evaluation metrics chosen. Additional fields in the protocol can provide extra space for algorithmic details, such as the problem formulation used (e.g., a minimum set problem). The protocol aims to capture the primary parameters and design choices underlying the spatial planning, and less implementation and post-implementation activities. However, users can add information on whether a monitoring and evaluation plan exists, and if so, how it will be executed and what will be evaluated.

Choosing an appropriate number of elements to include in a reporting protocol always balances asking too little and too much. The full protocol contains 73 fields of which 28 are mandatory to be filled in by any user (Table S1). Mandatory fields are those which every SCP application regardless of purpose, audience, data and software should be able to answer, such as the realm (e.g., Terrestrial, Freshwater, Marine) and the purpose of a study (e.g., Area-based evaluation) and which software was used for prioritization (e.g., Zonation). In some cases, answering a mandatory question leads to additional optional fields to provide further details. For example, if connectivity was considered in the planning (Beger et al., 2022), it is possible to provide further detail on how exactly this was considered. The ratio of mandatory to optional fields is balanced to avoid overburdening users, particularly for less complex applications.

4 | USING THE PROTOCOL

As part of this manuscript, we provide a full overview table with all protocol fields and descriptions (Table S1), and an empty template in the form of a Microsoft™ "docx" file with individual headers (Appendix S1). Both can be used to fill out the protocol offline as they contain all required fields. To support adoption of the ODPSCP standard, we also offer, an interactive web application to guide users through the protocol with documentation and examples for several fields. The protocol is hosted online on at least two different mirrored servers (main website: https://odpscp.iiasa.ac.at). To export the protocol, users should complete all mandatory fields for each element group (Table S1) and may add optional information where applicable. Visual guidance (i.e., tool tips) and examples are provided for each element. Additionally, we provide a comprehensive glossary explaining commonly used terms in SCP, based either on references or the authors' expertise. The glossary is maintained on the protocol website, and can be continuously expanded pending further conceptual and methodological SCP advancements. Once the various fields have been filled in, the interface can generate a completed ODPSCP protocol in machine-readable (tabular like csv) and document (Microsoft Word® or PDF) formats, of which the latter can be conveniently appended to published manuscripts as supplementary materials.

The code for the R-shiny platform is openly available (https://github.com/iiasa/ODPSCP) and any new versions will be released there. We emphasize that the protocol is not static and further versions released on the repository might improve on the reporting of individual elements. Other developments and forms of integration supporting the protocol are also possible. For example, existing SCP software (such as prioritizr; Hanson et al., 2024) or platforms such as the Marxan Planning Platform (MaPP) could provide automated routines for processing the data and settings used in prioritization to generate a machine-readable configuration file, which could, in turn, be uploaded and parsed on the protocol website or be added as a supplement to the protocol. Lastly, it should be stressed that the aim of the protocol is not to create a complete ontology of all input data streams and assumptions. Much contextual but relevant information might require additional documentation or protocols to support it; for example, the methods underlying feature creation, such as threat or species distribution mapping, should rather be reported elsewhere or referred to in the ODPSCP protocol.

FIGURE 2 Rationale for promoting and use of the ODPSCP standard in SCP studies.

5 | PROSPECTS ON THE USE OF STANDARDIZED REPORTING

Any reporting protocol can only succeed if it is adopted by the community. Similar protocols for ecological modeling have gained broad adoption (Fitzpatrick et al., 2021; Grimm et al., 2006). Journal editors and reviewers have a critical role in promoting the use of protocols for increased transparency and comparability (Figure 2). Ultimately broad adoption of this protocol could improve policy recommendations by allowing prioritization outcomes to be assessed based on their underlying assumptions and relevance to specific goals. It could also provide an opportunity to continuously assess the 'field', for example whether studies are becoming more complex, having a clear theory of change and involve stakeholders in their design (Jung et al., 2024; Langford et al., 2011). However, completing reporting protocols can only be a first step toward more transparency in SCP and a protocol should not be seen as a primary description of scientific research compared to the visualization of complex planning exercises for example through schematics or flowcharts (Szangolies et al., 2024).

SCP as a discipline is constantly advancing with ongoing conceptual and software developments. A non-exhaustive list of recent advancements includes the use of cloud computing to foster inclusive decision-making by engaging non-expert stakeholders in collaborative spatial planning (MaPP, https://marxanplanning.org/), accounting for non-linear inputs in reserve selection (Buhler & Benson, 2024), novel compactness approaches (Weerasena et al., 2023) or the rise of reinforcement learning in reserve design (Equihua et al., 2024; Silvestro et al., 2022). These and other advances might require regular updates of the ODPSCP to accommodate such developments. By making the code underlying the platform openly available and providing long-term research infrastructure we hope to support the continuing development of the protocol.

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DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study. Filled out protocol examples of existing studies can be found on the code repository (https://github.com/iiasa/ODPSCP/).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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