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Brief Report

A Synthetic Framework to Match Concepts and Approaches When Managing Anthropogenic Threats

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Abstract: Anthropogenic threats impacting ecological targets should be mitigated and solved using fast and schematic tools useful in conservation strategies. Herein, we suggest a mixed and quick approach implementing coarse-grained (and expert-based) threat analysis with the fine-grained (and analytical) DPSIR (driving forces, pressure, status, impact, and response) framework of indicators, all included in a single causal chain. Both approaches are largely used in conservation but never combined. A simulated example of the application of the set of indicators (status, pressure, impact, and response) on dune ecosystems (and nested targets represented by halo-psammophilous plants) has been included. Due to its schematic format, values as targets, pressures as threats, and responses as conservation strategies have been unified in a single conceptual framework. This synthetic framework can also be used to communicate to academic students the complexities of socio-ecological systems on the conservation front lines using a simplified cause–effect chain.

Keywords: IUCN project cycle; threat analysis; DPSIR indicators; halo-psammophilous plants; academic student's training

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1. Introduction

Anthropogenic threats are human activities or processes that are causing or may lead to the destruction and degradation of biodiversity and natural processes [1]. In this regard, recently, Threat Analysis (TA) has been proposed as an invaluable coarse-grained framework for decision-making in conservation biology: its primary goal is to identify, characterize, quantify, and rank threats impacting ecological targets on the conservation front lines (Figure 1). TA allows for ranking of the anthropogenic threats in an order of priority using expert-based assessment [1]. After this evaluation, conservation managers may focus on priority threats (i.e., showing the highest ranks in expert-based evaluation) instead of acting opportunistically on random-selected or charismatic threats (see [1]).

At the same time, DPSIR is a framework useful to analyze and assess environmental problems through sets of indicators along the threat–target causal chain (i.e., D: indirect drivers, P: threat pressures, S: state of the system, I: impacts on ecological targets, and R: responses through projects and actions; [2]). In contrast with TA, in the DPSIR approach, it is possible to select indicators providing analytical measurements (not expert based as in TA).

We suggest that these two approaches could be unified in a single and simplified conceptual framework, allowing for clarification of the complex causal relationships among drivers, threats, and targets and, therefore, defining strategies of response (i.e., conservation actions) and monitoring expected outcomes. Therefore, following this schematic approach, it may be possible to quantify threats both at a coarse-grained (1° step, expert-based evaluation) and a fine-grained level (2° step, analytical measurements). Since these two approaches are useful for clarifying many components and relationships, their unification in a two-step sequence could make the task easier for conservation managers, starting with specific target- and/or threat-based projects (see [3]).

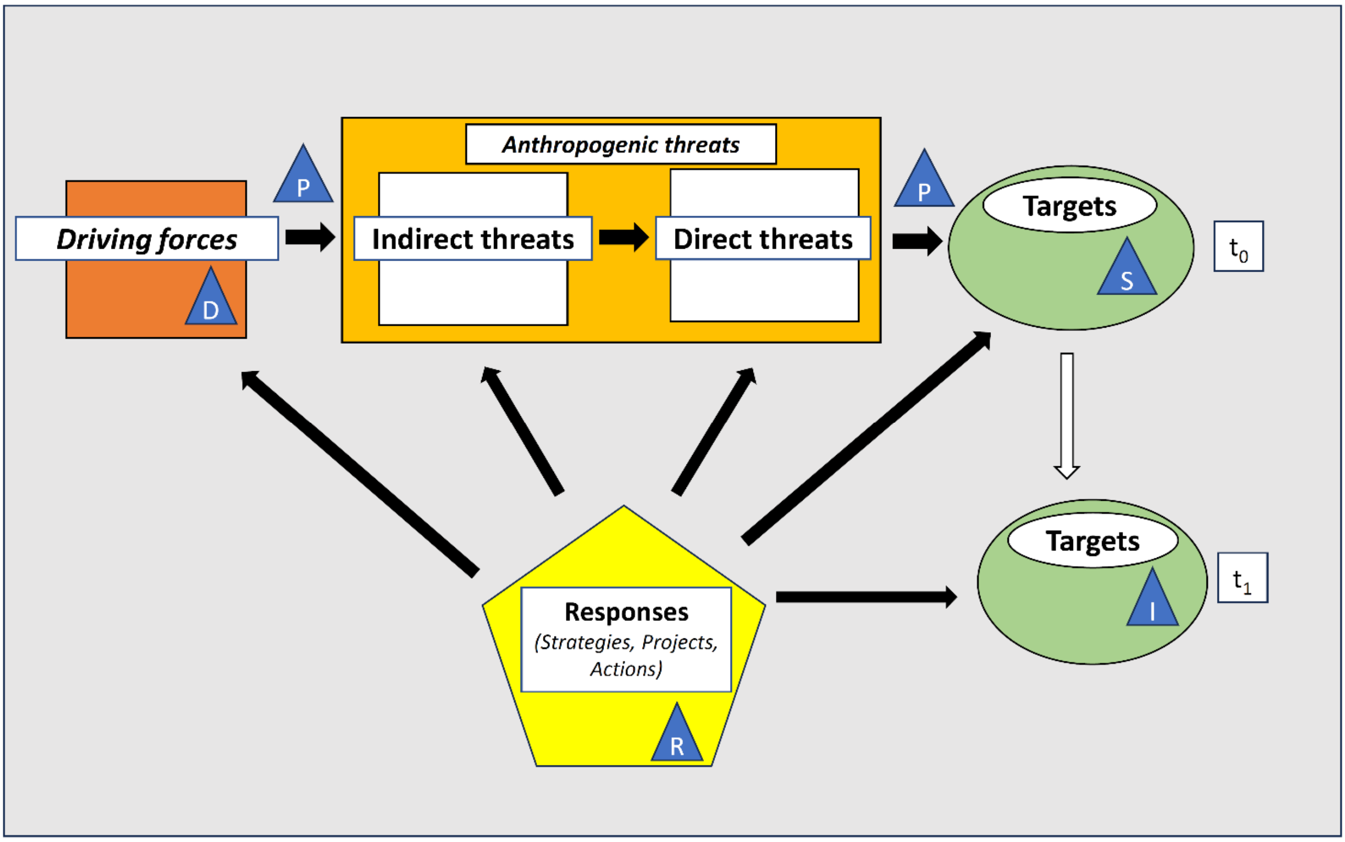

Figure 1. Causal chain in the threat analysis conceptual framework including DPSIR indicators (represented by blue triangles: D: driving forces, P: pressure, S: status; I: impact, and R: response).

2. An Integrated Conceptual Framework

TA as a conceptual framework is composed of components (drivers, threats, and targets) and relationships along a cause–effect chain. Using expert-based evaluations, it may be possible to obtain values of threat regimes (size area, duration, intensity, and frequency) that, once summed, may express a score of threat magnitude, as a coarse-grained proxy of the threat pressure [1,2]. Therefore, comparing multiple threats acting on ecological targets at sites of conservation concern, experts may rank them in a decreasing order of priority. Once the priority threats are obtained (i.e., with the highest magnitude; Figure 2 in red), it is possible to apply a set of DPSIR indicators in any step of the causal chain, thus obtaining, for example, an analytical (and not only expert-based) quantification of both threat pressure/impact and the target status using specific metrics (Figure 2).

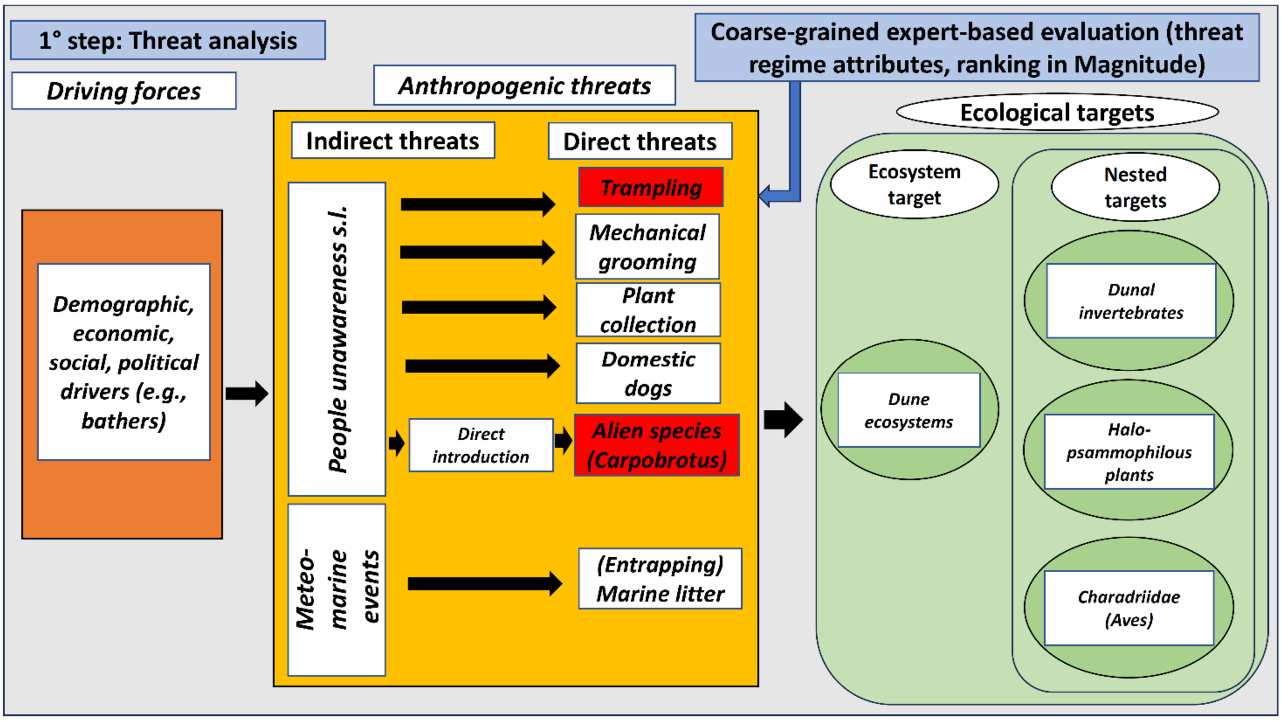

Figure 2. Example for dune ecosystems. First step: causal chains in a threat analysis conceptual framework including driving forces (demographic, economic, political, social, and cultural drivers, e.g., family bathers versus individual runners or kite-surfers), indirect threats (e.g., people unawareness and scientific illiteracy), direct threats (orange box), and conservation targets (green box; with 'nested targets' in the dune ecosystem). In this step, evaluation was provided by managers using expert-based approaches (see text for details).

3. A Simulation for Coastal Dunes

Herein, we report a simulated and synthetic example of the application of this conceptual framework to a specific target: coastal dune habitats hosting plant associations with halo-psammophilous species (details in [4]; Figure 3).

In the first step, a conceptual framework with a causal chain of targets–threats was built. In this framework, the targets are dune ecosystems including a set of so-called 'nested' targets, i.e., ecosystem components occurring inside dunes: invertebrates, halo-psammophilous plants, and plover birds (Charadridae: *Charadrius alexandrinus* and *C. dubius*, two species nesting on sand dunes; see [5]).

Regarding threats, experts may focus on the set of anthropogenic processes acting on coastal dunes and impacting the selected targets (i.e., people trampling, dogs, mechanical grooming aimed to clean the beaches, allochthonous species, and so on). In this step, experts may add all the events that they believe act as factors of impact on the targets. As stated, each of any threats will be target specific (i.e., trampling on plants, dogs on plovers, and litter as a factor of entrapment of invertebrates [5]).

The relationship between the boxes (of threats and of targets) inside the unified conceptual framework is only schematic and general. In a further step, experts will add target-specific causal relationships among threats and targets (symbolized, for example, by arrows or different colors). In Figure 3, the red boxes represent the target-specific threats acting on halo-psammophilous plants. When many threats act as a factor of pressure on the same target, expert-based procedures may be applied to define an order of priority among them. This approach (TA) has been detailed in [1]. Following this approach, experts may assign categorical scores (e.g., from 1—low to 4—very high) to a set of anthropogenic threats assessing their magnitude (as a proxy of total pressures). Magnitude represents a sum of scores for a set of threat regime attributes (e.g., extent of threats, intensity, duration, and frequency; details in [2]).

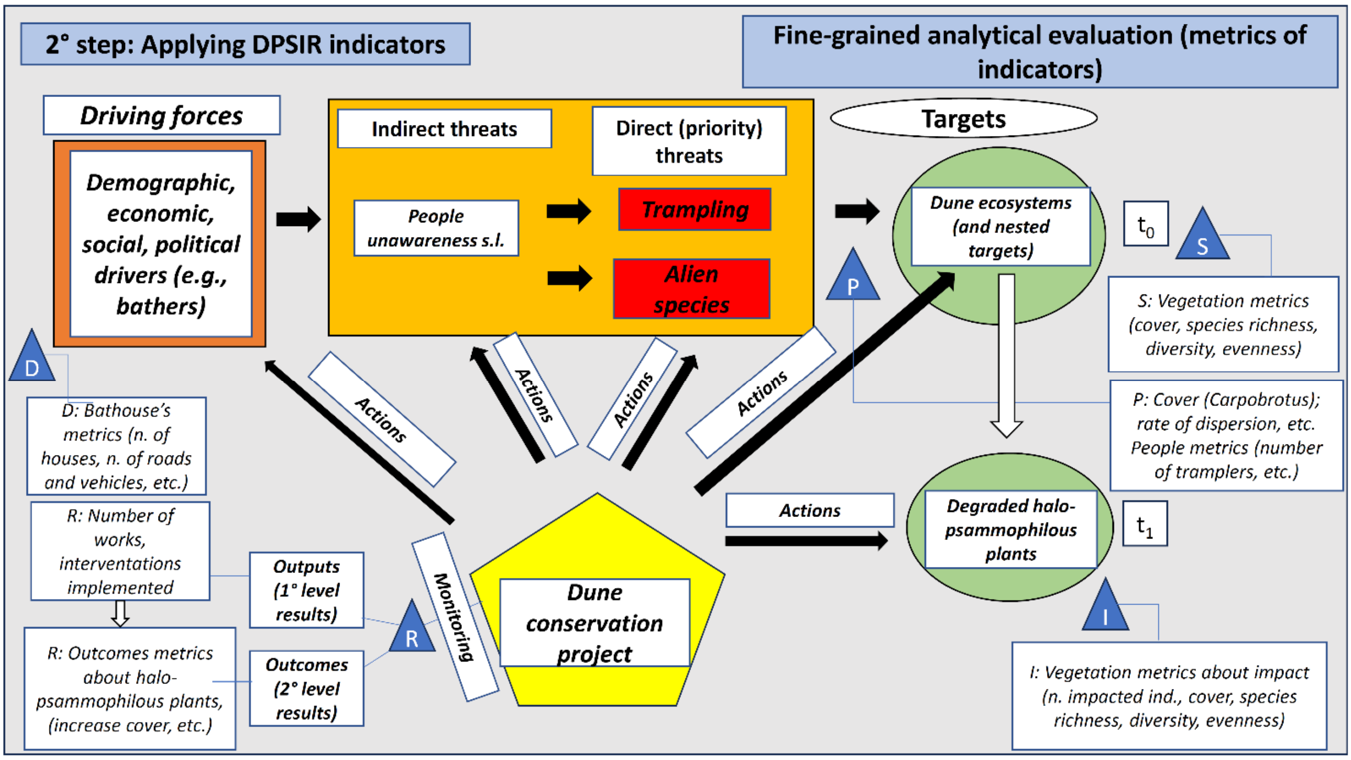

Figure 3. Example for dune ecosystems. The second step includes the DPSIR approach providing sets of analytical indicators useful for quantitative measurements. See text for details: Abbreviations as in Figure 1.

The assessment of threats using only expert-based scores is useful to obtain a ranking among these anthropogenic processes. However, once the priority threats are obtained (i.e., threats showing the highest magnitude as assessed by experts, i.e., the highest rank), a further step involves the selection of specific indicators of pressure, status, and impact. These steps allow for the assignment of analytical measurements useful in project monitoring (e.g., for before–after quantitative comparisons; see the BACI approach [6]).

In our simulated example, if the experts obtained the highest ranks for two threats acting on plants (trampling and alien species), it may be necessary to add analytical pressure indicators such as the number of people tramplers/space/time (regarding trampling threat) and metrics of vegetation cover (or rate of propagule dispersion) regarding allochthonous (i.e., non-native) species (such as, for example, *Carpobrotus* sp.). Analogously, halo-psammophilous dune plants may be arranged using status indicators (cover, species richness, diversity metrics, and so on) obtained using classical field sampling techniques.

The effect of threat impact on the target status deserves to be quantified using appropriate impact indicators. In our case, they may coincide with plant metrics about impact at the population/community level (e.g., size of impact cover, species richness, diversity, and evenness).

The DPSIR approach also involves indicators of driving forces and responses. Therefore, we may also add (i) a set of driving force indicators (e.g., the number of bathers in the surrounding area and the consequent number of motor vehicles parking as drivers for the trampling pressure) and (ii) a set of response indicators related to results obtained both in terms of outputs (actions provided to solve the threats) and outcomes (effective results for the conservation targets; details in [2]).

All these indicators may be useful to define the specific project goals. For example, a conservation project aimed at conserving dune plants against anthropogenic threats can include the following specific objectives, respectively focused on improving (maintaining/increasing) the status of the targets and reducing pressures and impacts:

(a) Focused on status: "increase of the X% of size cover (or richness, diversity etc.) of the halo-psammophilous dune plants in specific sites and times";
(b) Focused on pressures: "reduction of the X% of number of people trampling on dunes in specific sites and times" (threat trampling) or "reduction of the X% (or eradicating the 100%) of size cover of *Carpobrotus* units in specific sites and times";
(c) Focused on impacts: "reduction of the X% size of the impacted cover, species richness, diversity, etc. in specific sites and times".

Many indicators are available in the arena of plant ecology and some of them may be included in this framework. For example, Ellenberg indicator values have very extensive application in Europe [7], resulting in them being very useful in monitoring a territory and its changes [8]. These indicators may be included among the status indicators or, if evidencing degraded conditions, they may be included among the impact indicators. Analogously, hemeroby indicators [8] may be considered indicators of the status of the targets moving along a scale between not degraded (i.e., not impacted) conditions (i.e., level 1 of the Kovarik scale) until the highest level of degradation (i.e., level 10 in this scale: [9–11]).

However, the effectiveness of the DPSIR framework depends heavily on the choice of indicators. In this regard, project managers should involve experts both in ecological targets and anthropogenic threats to select and validate appropriate indicators.

4. Conclusions

At present, the demand for monitoring of species, communities, and landscapes is becoming ever more pressing at different scale levels. Matching the TA and DPSIR approaches may serve as a valuable expert-based tool for conservation strategies, for example to (i) select the priority threats (highest magnitude) acting on specific targets (with TA); (ii) select appropriate analytical indicators (with DPSIR); and (iii) define achievable project goals focused on maintaining ecosystem components (status indicators) and reducing or mitigating threats (pressure indicators), stresses, or impacts (impact indicators), especially at sites such as nature reserves or toward targets of conservation concern.

Nevertheless, although it is a fast and cost-effective tool to clarify action priorities, TA still sees limited use in the Mediterranean basin (e.g., [12]). In Italy, although these approaches (TA or DPSIR) have been used independently in nature reserve management plans and conservation measures (Nature 2000 sites; [5]), they have never been adopted in a unified way. Therefore, this brief report aims to stimulate the combined use of these approaches. Moreover, our proposal, based on problem-solving logic [1,2], is only theoretical. In this regard, empirical evidence will be necessary to test its effectiveness and practicality to achieve effective outcomes in practical applications. In this regard, we stimulate conservation practitioners to adopt this combined framework.

However, there are some critical points that should be considered. First, although this framework may be useful for clarity and synthesis, it might oversimplify socio-ecological interactions. This fact could lead to the omission of critical details that might be important for accurate conservation planning and assessment carried out in complex socio-ecosystems. Therefore, project managers should be aware of this possible limitation. Second, TA is an expert-based procedure; although this approach is useful on the conservation front lines when time and budgets are limited and analytical data are scant, expert judgment can introduce subjectivity and cognitive bias, which may affect the accuracy of the framework. Therefore, scores obtained in TA assessment should be critically analyzed, also using brainstorming techniques to overcome these criticalities [13,14].

However, as part of the limitations, this framework can also be used to communicate to academic students the complexities of socio-ecological systems on the conservation front lines using a schematic and synthetic language in order to clearly understand the logic behind conservation strategies, similar to other approaches using causal chains and frameworks in conservation [15–18].

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