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Assessing the Nature Reserve Management Effort Using an Expert-Based Threat Analysis Approach

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Abstract: In this note, we suggest the adoption of expert-based approaches for threat analysis to allow an assessment of the magnitude of efforts of wildlife management actions. Similar to what is proposed for expert-based quantification of threat events, in wildlife management this approach can be applied by assigning a score to the extent of the areas affected by management, their frequency and intensity of action, supporting the decision-making process and optimizing the management strategies, both ordinary (for example, in the operational management of nature reserves) and extraordinary (for example, within specific target-oriented conservation projects). Quantifying and defining priority ranks among management events can be useful: (i) to compare managed areas with each other or the same areas in different times; (ii) to adjust the allocation of resources among alternative management actions (assigning more or less resources in terms of time, budget, operators, and technology). Finally, similar to what is done in the threat analysis approach, managers could compare the effort (magnitude) of management at different times. We report, as an example, a first quantification for a case study carried out in a coastal nature reserve.

Keywords: management; impact; extent; frequency; intensity; magnitude

1. Introduction

In ecology, any event can be characterized by its regime in time and space [1]. This characterization is used in both the quantification of natural disturbances [2] and the analysis of anthropogenic threats [3–6]. More particularly, we define the term "regime" as the set of attributes (variables or parameters) that characterize a process (in our case, an anthropogenic disturbance event [5]).

The approaches characterizing anthropogenic threats have been mainly based on the evaluation and quantification (either analytical approaches or according to expert-based methods) of regimes of threats, for instance, considering the extent, frequency, duration, and intensity in order to obtain an overall value of impact (i.e., their magnitude). This approach, although criticized, has been adopted in many conservation contexts and appears effective to rank priorities in conservation (for review, see Reference [7]).

In our opinion, these evaluation approaches can be applied not only to such actions as anthropogenic threats but also to any event deliberately caused to carry out management actions

(for example, restoration projects carried out by agencies, etc.). Indeed, since both "threats" and "management actions" are human-induced processes, similar to what is proposed for expert-based quantification of threats, where these activities are assessed assigning (and summing) scores to their extent, duration, frequency, and intensity [5], in wildlife management we can assign a score to the extent of the areas affected by management, their duration and frequency, and, finally, the intensity of action. Since managers of conservation areas lack tools for measuring how they allocate management resources, these scores may support the decision-making process and adjust the management strategies, both ordinary (for example, in the operational management of nature reserves; [8]) and extraordinary (for example, within specific target-oriented conservation projects; [5]). The quantification and the definition of a rank of priorities among management events can be useful: (i) to compare managed areas with each other or the same areas at different times; (ii) to adjust ordinary or extraordinary management actions (that is assigning more or less resources in terms of time, budget, operators, technology).

In this regard, we aimed with this article at suggesting the adoption of the approaches in use for the analysis of threats also to allow an assessment of the magnitude of effort of wildlife management activities. More particularly, in this regard, we refer to "magnitude" as the amount of management effort (i.e., output) that has been devoted for each management action carried out by a park agency managing a nature reserve as an example, and we reported a first quantification in a case study (a coastal nature reserve).

2. Methods

2.1. Case Study

The study area corresponded to the "Palude di Torre Flavia" natural monument, a small protected coastal Mediterranean wetland (40 ha; Special Area of Conservation, according to the EC Directive on the Conservation of Wild Bird 79/409/EEC; code IT6030020) which is a relic of a larger wetland drained and transformed by land reclamation in the last century located along the Tyrrhenian coast of Central Italy (Latium; Municipalities of Cerveteri and Ladispoli; 41°58′ N; 12°03′ E) [9,10]. This reserve was established in 1997 to protect a large number of wet habitats and related breeding and wintering migratory birds. Indeed, in this area >180 species of birds have been censused with 40 species of high conservation concern (some of them "near threatened" or "critically endangered" following the IUCN (World Conservation Union) red list and included in 147/2009/"Wild Bird" EC Directive: among them *Charadrius alexandrinus*, linked to sandy beaches, and *Botaurus stellaris, Ixobrychus minutus, Nycticorax nycticorax, Ardeola ralloides, Plegadis falcinellus*, *Aythya nyroca* linked to salt marshes and ponds). The recent "measures of conservation" of this reserve (Città Metropolitana di Roma Capitale, 2010, unpublished data) focused on the conservation of a sufficient status of the species included in Wild Bird Directive through a set of measures (mainly: habitat restoration and threat mitigation).

The vegetation is characterized by both saline and hygrophilous vegetation related to temporary and semi-temporary ponds. Along the coast, dunal environments are present which host the endangered bird species [9].

The area has been managed since 1997 by a Public Agency (Città Metropolitana Roma Capitale, Rome, Italy) through an operational staff composed of two technicians and two practitioner operators who know the occurrence of the different ordinary management actions that take place there. Ordinary management activities in the Torre Flavia nature reserve can be grouped into the following categories: (1) regulation, administration, and logistics; (2) Fruition (i.e., actions focused on guaranteeing the reserve is available for use through access points, paths, and visitor centers); (3) control; (4) conservation education; (5) communication; (6) training; (7) ordinary management of environmental components; (8) conservation; (9) research; (10) other activities.

2.2. Protocol

As mentioned above, in analogy to what happens when treating a threat regime [7], defining a range of attributes is an important step. Such attributes allow the definition of the total management effort, i.e., its magnitude. Among the different regime attributes (see Reference [7]), we selected three: extent, frequency (around an annual cycle), and intensity. More particularly: (I) Extent: according to Reference [11], extent represents the spatial or temporal range where activities, actions, or events occur. Scores: 4: the whole management area; 3: >75% of the area; 2: from 25 to 50%; 1: <25%; (II) Frequency: this indicates the number of anthropogenic events (in our case management actions) within the time unit. Scores: 4: daily; 3: weekly; 2: monthly; 1: annually; (III) Intensity (or severity): in threat analysis, and according to Reference [5], this term is indirectly connected to the degree of a target's damage/alteration (impact) which can be expected within specific circumstances. Applying this attribute to management actions, we can define "intensity" as the direct effort (excluding extent and frequency) necessary to have a potential positive impact on defined management targets regardless of the real outcomes on the different management targets. Scores: 4: very high management intensity (in terms of costs, technology, materials, operators involved); 3: high; 2: medium; 1: low.

We summed the abovementioned management attributes in a single final score named "Magnitude". In threat analysis, magnitude represents the capacity of a threat event to exert a pressure or an impact [10]. As such, this attribute is strictly dependent on the threat regime itself. Similar to the other attributes, in the absence of field or experimental data, magnitude can be calculated through the sum of scores assigned by skilled practitioners following an expert-based method. More in particular, magnitude is obtained by summing the regime attribute utilized [5]. In our case, we summed the scores obtained for the three selected regime attributes, i.e., extent, frequency, and intensity. Therefore, in our approach, management magnitude could represent the degree of a total effort (output management) devoted to an activity in terms of extent, frequency, and intensity. From a project management perspective, this effort can be considered the project output, or the set of energies dedicated to carrying out a series of actions for a specific category of activity, (see Reference [8]). It should not be confused with the project outcomes (i.e., with the effective results of the actions on the environmental components) which, in this case, are not measured.

To assign scores, we involved four operators having a comparable role (all management operators) and a large knowledge (>10 years) of management actions carried out yearly in the nature reserve (see Acknowledgments).

First, we selected the set of management actions (n = 35), grouped in 10 categories, to which the scores will be attributed (Table 1). Secondly, we built an "action/attribute" evaluation matrix that was submitted to operators who independently evaluated the extent, frequency, and intensity of each management action. The scores were subsequently added up obtaining a magnitude score, and the mean value (and standard deviation) was calculated. Therefore, magnitudes were ranked across 35 management actions using the scores provided by each of the four observers.

Table 1. List of (ordinary) management actions carried out in the "Torre Flavia" nature reserve (Special Protection Area). For each activity, a short description is reported.

Management Category	Rationale
Regulation, Administration, and Logistics	The management staff carry out activities related to the organizational and coordination aspects, personnel management, regulatory-planning, administrative and accounting, logistics.
Fruition (i.e., actions focused on guaranteeing the reserve is available for use through access points, paths, and visitor centers)	The managing agency has the task of identifying and making available all those areas in the nature reserve covering a relevant interest.
Control	Management include the surveillance of the reserve, carrying out periodic checks to prevent abuse and disturbances of ecosystem components. In this regard, the events taking place are monitored (e.g., to prevent possible threats) and compliance with the regulations, indications, boundaries, and behavior in the protected area is periodically checked.
Conservation Education	The purpose of conservation education is to make the protected area known (involving and exciting) to the younger generations by making them aware of its environmental value. To this end, experiential, engaging, and operational activities are carried out directed at primary, secondary, and high school students, using the innovative approaches of conservation education.
Communication	This category of management activities aims to communicate the environmental, landscape, historical, archaeological, social, anthropological characteristics as well as the threats, management activities, and the work of the stakeholders in the protected area (for example, fish farming), and, finally, the events that occurred in the area (storm surges, fires, etc.) and any other type of information, both to a general public and to specific social targets (fishermen, birdwatchers, teachers and students, researchers, local stakeholders).
Training	Training consists of a series of actions aimed at increasing the experience, skills, and capacity (both naturalistic–environmental, operational–managerial, and educational) in operators who will provide support for the management of the area protected. In the protected area of Torre Flavia, training is carried out through stages, internships, courses, both in the field and in appropriate locations (schools, universities, dedicated spaces) through lectures, working groups, and even using different techniques or field trips with a definable time frame.
Wildlife Management (management of specific ecological targets)	Control of water levels: Since 2001, the managing body has taken steps to establish a relationship with the local reclamation agency so as to maintain the depth of the water at levels available for water birds and other vertebrates. In this way, the park authority can now take advantage of the consortium's water resources during periods of water stress and, if necessary (for example, during extreme dry periods), the operators can open the water intake supplying the reservoir. The park staff verifies the needs by monitoring the water levels and comparing these measures with those necessary for maintaining the ecological conditions. Fish management: Since 1938, the Palude di Torre Flavia has been used as a reservoir for the breeding of euryhaline fish, that is, from species that tolerate a wide range of salinity (mainly mullets and eels). This activity was interrupted in 2004. As a result of this interruption, it was necessary to forcefully remove, with a certain periodicity, the fish. These animals (>50 cm in length) can be found, especially in summer, in critical conditions (shallow water with limited amount of oxygen and high temperatures). Reed management: Reeds (*Phragmites australis*) are a dominant grass that in suitable ecological conditions tend to expand, competing with heliophilous species of wet environments (as rushes and sedges, belonging to the EU habitat type 1410 - *Juncetalia maritimi*). Therefore, reeds represent a potential risk for this vegetation of great ecological interest and must be periodically controlled through mowing, controlled fire, and flooding.

Table 1. *Cont.*

Management Category	Rationale
Conservation	Plover's nest conservation: Along the coastline breed some nesting pairs of plovers (*Charadrius alexandrinus* and *C. dubius*) threatened by trampling, dogs, off-road vehicle transit, intentional removal of nests and eggs, fishhooks and lines. Locally, the protection of nests has already been started for over ten years by the staff working in the protected area. Coypu census and control: The presence of Coypu (*Myocastor coypus*) in this protected area requires a careful evaluation of the impacts of this species on the natural vegetation that, in turn, can be reflected on many species of birds nesting in the reeds. Non-native freshwater turtles: In the channels of the Palude di Torre Flavia there are numerous species of non-native turtles related to the freshwater environments that are periodically released by citizens. To control these non-native populations so as to avoid possible episodes of competition with the autochthonous species, as well as other types of impacts, it can be foreseen to carry out periodic operations to remove the animals using nets placed transversely to the canals or traps suitable to be placed in the basking areas. *Carpobrotus:* Along the coast, some non-native herbaceous habitats have been cultivated. Among these, *Carpobrotus acinaciformis/edulis* is a highly invasive South African species with great autonomous dispersion capacity. Removal interventions must be planned by the park authority, even assuming a communication to the public aimed at increasing the knowledge of the species and making it aware of the impacts it can manifest. Wildlife rehabilitation: Wild animals are periodically delivered with various problems: road and other impacts, dog predation, poisoning (e.g., ingestion of marine litter), entrapment (for example due to the presence of fishing lines). Since locally there are no structures or personnel able to provide them with assistance, these animals are transported to wildlife rehabilitation centers entitled to carry out this activity.
Research	Scientific research in a protected area is an essential activity. It allows you to know (and be aware of) the values of the protected area, their occurrence, distribution and temporal dynamics, also in relation to environmental changes occurred or in progress; know and quantify the factors and processes of natural and anthropogenic disturbances on specific components; and assess the effectiveness of management actions before and after the interventions implemented through monitoring protocols that make use of appropriate indicators. Depending on the research purposes, the entire protected area of Torre Flavia (or specific sectors within it) may be the object of study. The sampling methods and protocols depend on the research objectives. Research in Torre Flavia can be carried out either by the operators of the park or by external researchers, undergraduates, trainees, PhD students, volunteers (e.g., birdwatchers) in the context of theses or projects of different types (for example, ringing activities) based on the needs that may arise from time to time.
Other Activities	Torre Flavia also lends itself to allow for exercises carried out by specific agencies (as civil protection), mainly using spaces along the sandy shore, obviously excluding ecologically sensitive areas, e.g., birdwatching and nature photography courses.

For some actions (e.g., fences, signs, social media, research) the intensity score was assigned by evaluating the collective effort made by operators to achieve that specific output (e.g., for social media: effort to design communication strategy; for research: effort devoted to define protocols, experimental design, and data analyses). The comparison of the average magnitude values among the various actions was calculated using Friedman test [12]. The alpha was set at the 0.05 level. Statistical analyses were performed using SPSS 13.0 software.

3. Results

The mean magnitude scores for each attribute calculated for each management action are shown in Figure 1. In our case study of ordinary management of a protected area, we observed a significant difference among management actions ($\chi^2 = 83.186$, $p < 0.001$; d.f. 34, Friedman test) with administration, communication, and beach clean ups being the actions demanding the most effort (mean magnitude > 10) and bird-watching courses and wildlife rehabilitation being the actions demanding the least effort (≤ 5) (Table 2).

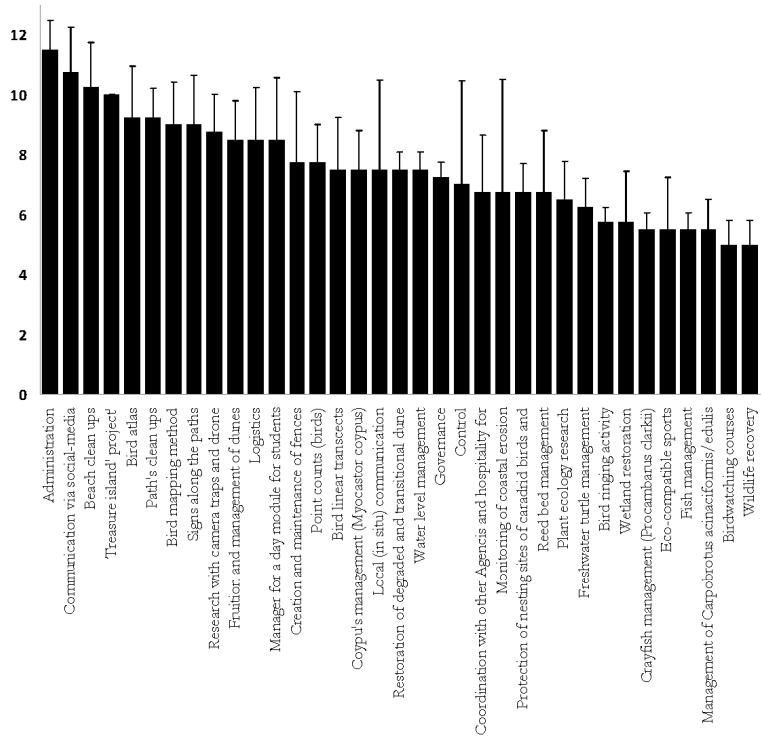

Figure 1. Mean magnitude scores (and standard deviations) for the management actions selected.

Table 2. Mean magnitude score for the management actions (and categories, in bold) selected for the case study (Torre Flavia wetland nature reserve).

Management Categories (and Actions)	Mean Magnitude	SD
Regulation, Administration and Logistics		
Administration	11.5	1.00
Logistics	8.5	1.73
Governance	7.25	0.50
Fruition (i.e., actions focused on guaranteeing the reserve is available for use through access points, paths, and visitor centers)		
Creation and maintenance of fences	7.75	2.36
Signs along the paths	9	1.63
Path's clean ups	9.25	0.96
Management of dunes	8.5	1.29
Control		
Control	7	3.46
Conservation education		
Treasure island "project"	10	0.00
Communication		
Local (in situ) communication	7.5	3.00
Communication via social media	10.75	1.50

Table 2. *Cont.*

Management Categories (and Actions)	Mean Magnitude	SD
Training		
Manager for a day module for students	8.5	2.08
Wildlife management (management of specific ecological targets)		
Water level management	7.5	0.58
Fish management	5.5	0.58
Reed bed management	6.75	2.06
Monitoring of coastal erosion	6.75	3.77
Conservation		
Protection of nesting sites of caradrid birds and psammophilous vegetation	6.75	0.96
Wetland restoration	5.75	1.71
Restoration of degraded and transitional dune environments	7.5	0.58
Alien species management		
Coypu's management (*Myocastor coypus*)	7.5	1.29
Freshwater turtle management	6.25	0.96
Crayfish management (*Procambarus clarkii*)	5.5	0.58
Management of *Carpobrotus acinaciformis/edulis*	5.5	1.00
Wildlife rehabilitation	5	0.82
Research		
Bird ringing activity	5.75	0.50
Bird mapping method	9	1.41
Bird linear transects	7.5	1.73
Point counts (birds)	7.75	1.26
Bird atlas	9.25	1.71
Research with camera traps and drone	8.75	1.26
Plant ecology research	6.5	1.29
Other activities		
Coordination with other agencies and hospitality for initiatives	6.75	1.89
Birdwatching courses	5	0.82
Eco-compatible sports	5.5	1.73

4. Discussion

In wildlife management and conservation, the evaluation of management effort is of priority relevance [13,14] and a large number of approaches have been used as decision-support tools to prioritize actions in conservation projects by following different criteria (for example: Triage: [15]; Eisenhower matrix: [16]). In this case, we treated the individual management actions of a case study (ordinary management of a protected area) as activities each one carried out with an effort expended (magnitude = management output) and addressed to obtain a specific effect (i.e., a potential positive impacts = outcomes) on the environmental targets. Similar to what is suggested in the case of analysis of threat events, for which it is possible to quantify the magnitude of impact through the assignment of scores by experts to regime attributes ([5,10]; reviewed in Reference [7]), also in this case it was possible to quantify the total effort (= impact magnitude) considering a series of regime attributes.

The abovementioned approach can be useful to know the potential impact (expressed as a magnitude score) of the various actions, in terms of management effort, both ordinary (e.g., ordinary management of a protected area) and extraordinary within a project cycle (e.g., problem-solving and management through projects). For example, this method can be used to compare management efforts between different protected areas (for example, nature reserve systems managed by a single agency). Furthermore, chief managers could use this approach to better target (i.e., to balance) the different management or project activities. For example, in our case a high magnitude of the administrative sector emerged, given the critical state of the protected area (where many threats impact on targets of conservation interest). This indication can adjust our management strategy; indeed, it might be

more appropriate to exercise a higher management magnitude towards operational activities aimed at controlling some environmental processes in progress (coastal erosion, control of alien species). Finally, similar to what is done in areas of conservation concern through threat analysis (see Reference [17]), managers could compare the effort (magnitude) of management at different times.

However, this approach can be even more complex and detailed. First: the evaluation can also use other attributes of management activities (duration, reversibility, predictability, urgency, importance; reviewed in Reference [7]). Second, further details may be added to assign specific weights of relative importance of individual attributes, if circumstances require it [18]. When managers adopt this approach, they should also examine which of the three variables might be more important or reflective of what is attempting to be measured and possibly change the simple equal weighting, not just accepting this preliminary simple index of effort. Third, we used a simple expert-based procedure obtaining average values provided by a limited number of operators on the assumption that combining the expertise of several individuals will provide more reliable results than consulting few individuals. Fourth, our approach calculated only the management effort (outputs) and further analyses could be devoted to obtaining scores about the real effectiveness on conservation targets (management outcomes). In this work, our aim was understanding where the total management effort is addressed, independently from the real effectiveness on conservation targets (biodiversity) and a comparison between management effort (outputs) and real effectiveness (outcomes) could be important to evaluate the role of management agency and their real role as conservation organization (i.e., measuring effort is just one step, but measuring real outcomes is important for the mission of a park agency). Finally, you can adopt other approaches (for example, Delphi techniques performed to develop consensus among experts over several rounds of deliberation, known as "open Delphi"; [19]). Moreover, management evaluation can be implemented using graphical approaches, for example, through n × n matrices and graphs (for threats: e.g., [20]), widely used in environmental project management [21]. Last but not least, since this approach can be useful to effectively address management budgets and resources, we think that this approach using discrete variables may be included in the disciplinary context of discrete optimization problems [22], aimed at finding the best solution from all feasible solutions (in our case, highlighting what are the management actions for which the greatest effort is dedicated and, if necessary, direct it towards conservation priorities). Our case study revealed that the public park agency devoted the largest share of effort to administration and less effort to true conservation practices. Such allocation of resources away from conservation has been denounced by wildlife practitioners [23,24]; our proposed scoring method allows potential resource misallocation to be quantified and evaluated.

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