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BIODIVERSITY RESEARCH

Species prioritization for monitoring and management in regional multiple species conservation plans

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ABSTRACT

Successful conservation plans are not solely achieved by acquiring optimally designed reserves. Ongoing monitoring and management of the biodiversity in those reserves is an equally important, but often neglected or poorly executed, part of the conservation process. In this paper we address one of the first and most important steps in designing a monitoring program – deciding what to monitor. We present a strategy for prioritizing species for monitoring and management in multispecies conservation plans. We use existing assessments of threatened status, and the degree and spatial and temporal extent of known threats to link the prioritization of species to the overarching goals and objectives of the conservation plan. We consider both broad and localized spatial scales to capture the regional conservation context and the practicalities of local management and monitoring constraints. Spatial scales that are commensurate with available data are selected. We demonstrate the utility of this strategy through application to a set of 85 plants and animals in an established multispecies conservation plan in San Diego County, California, USA. We use the prioritization to identify the most prominent risk factors and the habitats associated with the most threats to species. The protocol highlighted priorities that had not previously been identified and were not necessarily intuitive without systematic application of the criteria; many high-priority species have received no monitoring attention to date, and lower-priority species have. We recommend that in the absence of clear focal species, monitoring threats in highly impacted habitats may be a way to circumvent the need to monitor all the targeted species.

Keywords

Endangered species, focal species, Habitat Conservation Plans, monitoring, multispecies conservation, Natural Community Conservation Plans, systematic conservation planning.

INTRODUCTION

With the shift from single-species to multispecies conservation, systematic conservation planning has received much attention in the academic literature and in on-the-ground programs to protect biodiversity (Cowling *et al.*, 1999; Pressey *et al.*, 1999; Margules & Pressey, 2000; Carroll *et al.*, 2003; Noon *et al.*, 2003; Moffett & Sarkar, 2006; Wilson *et al.*, 2006). Successful conservation plans, however, are not solely achieved by acquiring optimally designed reserves. Ongoing monitoring and management of species in those reserves is equally important but often neglected or poorly executed (Olsen *et al.*, 1999; Yoccoz *et al.*, 2001; Noon, 2003; Barrows *et al.*, 2005). Indeed, despite the large number of systematic planning tools available, conservation planning has been described as succumbing to an 'implementation crisis' (Salafsky *et al.*, 2002; Knight *et al.*, 2006). As a result, the conservation community is increasingly concerned with monitoring and measuring success of conservation actions (e.g. Conservation Measures Partnership, www.conservationmeasures.org). In this paper we address one of the first and most important steps in designing a monitoring program – deciding what to monitor.

Regional multispecies conservation plans have become a major tool in response to the increasing number of endangered and threatened species, communities and ecosystems. In the USA, these plans often take the form of federal Habitat Conservation Plans (HCPs) (US Fish & Wildlife Service, 1996; Smallwood,

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2000; Harding *et al*., 2001; Rahn *et al*., 2006). In an effort to increase the conservation value of HCPs, the number of 'covered species' included in these plans has grown from one species in the 1980s to nearly 200 species for plans currently considered. However, the ability of multispecies conservation plans to protect biodiversity and ecosystem processes has largely been untested.

Monitoring and management often require more resources and commitment than are usually acknowledged at the planning stage. The importance of explicitly considering budgets in the formulation and allocation phases of monitoring and management has been highlighted in the literature (Haight *et al*., 2002; Field *et al*., 2004, 2005; Hauser *et al*., 2006). Most studies assume that budgets are known and constant. However, when monitoring and management are conducted in an adaptive framework and are administered by a consortium of government agencies, non-government organizations, and private land owners, the total budget for monitoring activities is often unknown at the outset, changes over time, and depends somewhat on monitoring and management priorities. Volunteer groups also play an increasing role in monitoring and managing local biodiversity and can contribute to ongoing monitoring with minimal to no expenditure (Hoyer *et al*., 2001; Markovchick-Nicholls *et al.* in press), and there may be other ways to leverage funding for monitoring. Hence, while it is sensible to explicitly consider the available budget in planning monitoring and management activities, in practice it is prudent to devise a prioritization scheme for monitoring that is flexible enough to deal with statutory standards and realistic uncertainties and constraints.

Even when long-term monitoring is mandated and well funded, monitoring plans can fail because of indecision, or poorly made decisions, about what to monitor. Rarely can all components of biodiversity be monitored: some triage must occur at the outset (Possingham *et al*., 2001). This step is crucial for the implementation of a monitoring plan because it lays the foundation for all future activities and decisions. Once a monitoring program has gained momentum it may be difficult to change priorities because of perceived or actual 'return on investments' in components for which the monitoring budget has already been allocated. Hence, it is important to base prioritization decisions on sound science and directly relate them to the goals and objectives of the conservation plan as a first step in structuring a monitoring program.

Conservation plans are developed for many purposes, and before setting monitoring goals it is crucial that the objective of the plan is well defined (Nicholson & Possingham, 2006). In this paper we deal with the case where a primary objective of the conservation plan is to conserve target species composed of two main groups: (1) species deemed to be at risk of decline or extinction under current conditions or future threats, and (2) species intended to be focal species, the status and trend of which should indicate change in a broader set of species or ecological function. This objective essentially relates to minimizing extinctions in an established conservation area.

According to Salzer & Salafsky (2006) there are two major reasons for undertaking monitoring and evaluation. The first is to assess the status of biodiversity, and the second is to measure the effectiveness of management actions. These two motivations are tightly linked – decisions to take management action will be based on assessments of status and trends, while evaluations of the impact of management rely on assessments of status and trends in reference and managed scenarios. The major difference is that evaluations of management impact may not necessarily involve direct measurement of the intended beneficiary of the action. For example, if the management action is the abatement of a known threat, then the impact on the threat itself may be measured. Hence, it is important to distinguish between these two motivations for monitoring because this will determine monitoring priorities. In this paper, we address the first of these, prioritizing species for the purpose of monitoring status and trends, because this is most certainly the precursor of informed management decisions and links directly to monitoring of management impacts.

We present a strategy for prioritizing species for monitoring and management in regional multispecies conservation plans that uses existing assessments of threat, and the degree and spatial and temporal extent of known threats, to link prioritization of species to the overarching goals and objectives of the conservation plan. We consider both broad and local spatial scales to capture the regional conservation context and the practicalities of local management and monitoring constraints. We demonstrate the utility of this strategy through application to a set of 85 plants and animals in an established multispecies conservation plan in San Diego County, California, USA. While this strategy is in a similar vein as others proposed in the literature (Lambeck, 1997; Committee of Scientists, 1999; Holthausen *et al*., 1999; Noon *et al*., 1999; Hilty & Merenlender, 2000; Andelman *et al*., 2001; Groves, 2003), we apply it to an established multispecies conservation plan to demonstrate its value for identifying monitoring priorities in a systematic way.

STUDY AREA

California supports a vast proportion of biodiversity in the USA, with more native plant and animal species, and more imperilled native species, than any other state. The California floristic province is a global biodiversity hotspot (Wilson, 1992; Stein *et al*., 2000). The biodiversity of southern California is widely regarded as the most highly threatened in the USA. Habitat conversion and urban development are the most cited causes of extirpation (Tennant *et al*., 2001).

As a result of the intersection of human population growth and biodiversity, conservation planning in this region has been considered at both the broad and the fine scale. The San Diego Multiple Species Conservation Plan (MSCP) was one of the first regional plans developed and approved under the California Natural Community Conservation Planning Act. Its primary goal is to conserve natural communities at the ecosystem scale before species decline to the point of requiring protection under federal or state Endangered Species Acts, while allowing 'compatible land uses' (US Fish & Wildlife Service, 1996). The MSCP is also intended to provide protection and management for species already listed under the federal and state Endangered Species Acts to offset incidental take in developed areas outside the preserve. As of 2004, over 51,800 ha had been included in the preserve and lands continue to be added by the 14 participating jurisdictions and wildlife agencies (San Diego Association of Governments, HabiTrak GIS data). The 85 covered species targeted for protection under the San Diego MSCP include 39 animal and 46 plant species (see Appendices S1 and S2 in Supplementary Material). The covered species list comprises rare, threatened, and endangered species, as well as common and endemic species and species intended to serve as focal species and indicators of reserve connectivity. For more details on the creation and administration of the MSCP see Ogden Environmental and Energy Services (1998) and Hierl *et al.* (2005).

Species-level biological monitoring goals have been a component of the MSCP from its inception. However, meeting these goals has been challenging due to a lack of resources to devote to all 85 covered species. Previous monitoring recommendations (Ogden Environmental & Energy Services, 1996; Atkinson *et al.*, 2004), while well structured and motivated, have faltered in part because of a perceived lack of explicit rationale and documented justification for monitoring priorities. The MSCP lists several objectives for biological monitoring, each of which will require a separate prioritization and monitoring program: document ecological status and trends, evaluate the effectiveness of management activities, provide new data on species populations and wildlife movement, and evaluate the indirect impacts of threats. Here, we present an explicit stepwise approach to prioritizing large sets of covered species for monitoring in multispecies conservation plans that is concordant with many of the stated MSCP monitoring objectives.

METHODS

The approach presented here was modified from Andelman *et al.*'s (2001) recommended steps for USDA Forest Service species prioritization for viability assessments under the National Forest Management Act planning regulations (Federal Register, 2000; 65, 67,580–67,581; Andelman *et al.*, 2004). This protocol was intended to identify at-risk and focal species for viability assessments. Since the overarching monitoring goals of the MSCP are to monitor the status and trends of the covered species and status and trends are directly related to viability, we used the protocols recommended in Andelman *et al.* (2001) as a starting point, and modified these as appropriate for the particular application of prioritizing covered species for monitoring in the MSCP. The ultimate goal is to prioritize the covered species into two main groups: at-risk species that are those deemed to be at risk of decline or extinction under current conditions or in the face of short- or long-term threats, and focal species whose 'status and trend provide insights into the integrity of the larger ecological system to which it belongs' (Federal Register 65, 67,580, 2000). The first group is constructed by considering those species that fall into the highest risk category as determined by some at-risk categorization scheme (e.g. The World Conservation Union (IUCN) Red List, NatureServe, Federal or State listings). Within the focal species group, the aim is to represent all relevant combinations of habitat association and risk factor (denoted generally as HA/RF). Where multiple species occur for each HA/RF pair, further prioritization is achieved by considering the spatial and temporal scale of threats, with the aim of selecting a representative species that can serve as a focal species for that HA/RF pair.

Spatial scale is important when considering risk status. Global scales are too broad to be of relevance to the MSCP, whereas the incorporated preserve is too small a scale to capture true risk to taxa. While monitoring and management will ultimately occur only on MSCP preserve lands, it is important to consider risk factors at a broader spatial scale, somewhat independently of the preserve, so that assigned risk status and the resulting prioritization is not purely an artefact of the way the preserve has been designated. This is especially pertinent when all proposed areas have not yet been incorporated into the preserve. In order to implement the protocol at a spatial scale relevant to San Diego County, we have chosen a two-tiered approach: the first tier focuses on selecting species and allocating them to broad categories, while the second tier ranks the species within each category. In the first tier, species are assigned to broad risk categories using State Ranks for California (and supplemented with Federal and IUCN listings) to capture risk status at the broad scale of the state. In the second tier, species are further prioritized within each risk category according to the number, degree and spatial extent of risk factors affecting the species within San Diego County, both within and outside the preserve system.

The first tier to prioritizing species for monitoring is based on at-risk and focal species prioritization recommendations from Andelman *et al.* (2001) and the broader ecological monitoring literature:

1 Apply an at-risk species classification using established risk rankings.

2 For each at-risk group, allocate species to categories based on the nature of the risk factor.

3 Using information on home ranges (or a surrogate such as body size (Purvis *et al.*, 2000)) or known distributions, further classify species in each group according to their spatial scale of response to risk factors.

4 Using information on life span or plant functional group (as a surrogate for life span), further classify species in each group according to their temporal scale of response to risk factors.

5 Select one or more focal species from each group that best represent the rest of the species in the group.

6 Stop when each discrete vegetation community type is represented by at least one focal species or when all risk factors have been associated with at least one focal species.

The pertinent pieces of information needed to prioritize the covered species according to steps 1–6 above are: (i) at-risk category (based on applicable ranking systems), (ii) threats and the degree and spatial extent of threats across a species' range within San Diego County, (iii) habitat associations of species, and (iv) temporal scale of the impact of threats. These are described in more detail below. Information was compiled from all known available sources (from the scientific literature, available reports, electronic databases and opinion of acknowledged experts where warranted) and systematically collated (see Appendix S3 in Supplementary Material). For the complete set of information sheets for all the covered species the reader is referred to Regan *et al*. (2006).

(i) At-risk category

The species at-risk categories are based on federal or state listings or at-risk classification protocols from the California Native Plant Society (CNPS, for plants), Partners in Flight Species Assessment (for birds), NatureServe, or IUCN databases. The NatureServe database was used heavily as this provides the most comprehensive list of ranked plant and animal species for the USA. Species were assigned to one of three broad at-risk groups (Risk Group 1, 2, or 3 in descending order of risk level). Species classified as federally endangered (FE), G1 (NatureServe global ranks), and S1 (state rankings) received a ranking of 1. Species that were classified as endangered at the state level (S1) received a ranking of 1 if they were also highly ranked in another risk classification scheme. Species received a ranking of 2 if they were classified as S2 or G2. Subspecies presented a challenge for prioritization due to inconsistencies across at-risk classification protocols and because many of them are subject to ongoing taxonomic debate. Where discrepancies existed across ranking protocols, the state ranks were used to determine the at-risk category. Risk categories for all MSCP covered species appear in Appendices S1 (plants) and S2 (animals).

(ii) Threats/risk factors

Any monitoring plan designed for the purpose of informing future management activities must explicitly consider threats. In San Diego County, natural populations are faced with myriad threats that operate at different levels of intensity and spatial scales. The important components of risk factors to consider are the type and cause of the threat, the degree to which a risk factor contributes to the overall risk a species faces, and the spatial and temporal scale of the risk factor. It is important to note that the risk factors considered here are both realized threats that are currently affecting the status and trend of populations (e.g. altered fire regime, recreation activities) and currently unrealized threats that are expected to affect the status and trend of populations in the future. Risk factors are considered across the entirety of San Diego County and not just within the MSCP.

Threats were identified for each of the covered species by scouring available reports and the scientific literature. Twenty different threat categories were identified and defined by modifying The Nature Conservancy's Definitions of Sources of Stress (The Nature Conservancy, 2004). A full description of the threat categories is articulated in Regan *et al*. (2006) (for an alternative, yet similar, classification of threats see the 'IUCN-CMP Unified Classifications of Direct Threats and Conservation Actions' http://conservationmeasures.org/CMP/IUCN/Site_Page.cfm). Where discrepancies occurred, peer-reviewed scientific publications outranked information available from reports if the scientific publication was published after the dissenting report. For the most part, reports and expert opinion were heavily relied upon as these were the only sources of information available.

The degree to which the risk factor contributes to the overall risk faced by the species within San Diego County was split into three categories: high (H), moderate (M), and low (L). The spatial scale of the risk factor across the County was also broadly categorized: high (H = widespread across the species distribution within San Diego County), moderate (M = moderately spread across the species distribution), and low (L = low spread across the species distribution).

Due to the subjectivity of assigning risk levels, and degree and spatial extent of risks, a consensus had to be reached among three assessors (HMR, LAH, and HLS). Those items that remained uncertain were highlighted and brought to four experts (CSW and see Acknowledgements) for verification.

(iii) Habitat associations of species

Information on habitat associations of the covered species was compiled from available data sources. Distribution maps provided by the San Diego Multiple Species Conservation Program were used to assess the range and spatial density for covered plants. The San Diego Bird Atlas (Unitt, 2004) was used to assess the spatial distribution of bird species. All known habitat associations were recorded, as reported in the available literature.

(iv) Temporal response to risk factors

Temporal scale of response to the threats was also distinguished as either short term (a response of within 5 to 10 years), or long term (such as changes to hydrology or fire regime that may take longer than 10 years to affect the species). These crude distinctions are sufficient to capture general properties of the threats and their effect on populations for the purpose of prioritization. Because short-term responses to threats are more readily observed, and more imminent, than long-term responses, we rank species with short-term responses higher than those with long-term responses.

(v) Second tier approach to ranking

We recommend a second tier approach to prioritizing the species resulting from steps 1–6 of the first tier for a number of reasons. First, the steps assume the pool of species is large, perhaps much larger than the covered species list (as was the case for the USDA Forest Service species viability assessments). Ideally, the first tier approach to prioritization should be used to identify covered species for a multispecies conservation plan at the outset (Margules & Pressey, 2000; Groves, 2003). The MSCP covered species list is already the result of an ad hoc prioritization. Hence, application of steps 1–6 may not reduce the candidate species for monitoring any further. Second, for species not listed as rare, threatened, or endangered, it is highly uncertain that they actually do serve as surrogates due to a lack of documented rationale and scientific justification for their inclusion as covered focal species. Third, insufficient resources may exist to monitor all species identified from steps 1–6 as at-risk or focal species. At the very least, the MSCP should conserve (and monitor) at-risk species. The strategy used for ranking the covered species within each Risk Group according to degree and spatial extent of risk is as follows:

1 Species are grouped according to their at-risk ranking into Risk Groups 1, 2, and 3 in descending order of risk level (from i above).

2 Species in each of the Risk Groups are ranked by the number of high-level threats ('high' from ii above) facing each species, then ranked further by their total number of threats. Temporal response to threats is used as a tie breaker where necessary, with species having short-term responses ranked higher.

RESULTS

The application of steps 1–6 identified most covered species as candidates for monitoring. That is, given the numerous risk factors and habitat associations of covered species, many HA/RF groups comprised only one species. Furthermore, for HA/RF groups with multiple species, no species stood out as obvious focal species. This necessitated further ranking within the broad risk groups using the second tier approach.

The prioritization of species according to degree of risk (second tier) appears in Appendix S4. Within each risk group, species experiencing more high-level threats should receive higher priority for monitoring than those with fewer (indicated by the order the species are listed, with highest priority from top to bottom). At the very least, the MSCP should be protective of species in Risk Group 1. Risk Group 1 species were further prioritized to assist in decision-making in the face of limited resources – species at the top of the list should be given higher priority over lower-ranked species. If resources allow, as many covered species as possible should be monitored. Again, species in Risk Groups 2 and 3 have been prioritized according to risk factors to assist in decision-making.

The most prominent threats to covered species can also be highlighted with this approach (see Appendix S4 in Supplementary Material). The top five threats to plants, in decreasing order of occurrence and severity, are habitat loss, invasive species, off-road vehicles, recreation/human disturbance, and altered fire regime. The top five threats to animals are habitat loss, altered hydrology, invasive species, predation, and recreation. The five most prominent threats for plants and animals, respectively, impact most of the covered plant and animal species.

Figure 1 shows the number of species that have been studied or monitored to date, ranked by risk group (see also Appendices S1 and S2 in Supplementary Material). It is important to note that these include a wide variety of data collection activities including species inventories, baseline determinations of plant cover, and population surveys. Data analysis for the purpose of informing management decisions or future monitoring direction has been patchy. So while data have been collected for many of the covered species (see Appendices S1 and S2 in Supplementary Material) over the period of 1995–2005, they have not been used in an integrated multispecies monitoring program (see Hierl *et al*., 2005 for details of data collected). The

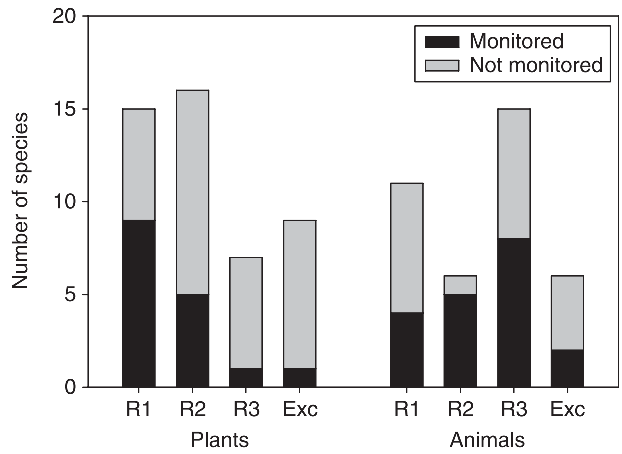

Figure 1 Number of Multiple Species Conservation Plan (MSCP) covered plants and animals that have been monitored over 1995–2005, as a function of risk group. R1 refers to the number of species monitored and not monitored in Risk Group 1, etc. Exc. refers to covered species that were excluded from the prioritization due to taxonomic debate or because their occurrence is not confirmed within the MSCP preserve.

results in Figure 1 show that there is no obvious pattern or rationale for current monitoring decisions in terms of how such decisions relate to the goals and objectives of the MSCP. Indeed, many highly at-risk species (Risk Group 1) receive no monitoring at all, whereas half of the Risk Group 3 animal species are monitored. Furthermore, data collection has been a priority for some covered species that are not currently known to occur within the MSCP reserve system (even though potentially suitable habitat for them exists).

Figures 2 (plants) and 3 (animals) display the number of covered species and the number of threats they face in each habitat type. When considering habitat types in conjunction with the number of major threats experienced by species using those habitats, riparian/riparian woodland areas rank the highest for animals, followed by grassland and salt marsh, then coastal sage scrub. For plants, chaparral and coastal sage scrub rank the highest, followed by closed cone forest and vernal pools.

DISCUSSION

This study modified an existing methodology for the identification of species for viability assessments and applied it to the prioritization of species for monitoring in a multispecies conservation plan. While seemingly straight-forward to implement, this approach has seldom been applied. This case study demonstrates that such protocols for prioritization can be very useful for detailed ranking of large sets of species according to risk. Additionally, it provides a framework for organizing existing relevant information on which to base informed and transparent monitoring and management decisions.

Our findings are novel in that the protocol highlighted priorities that had not previously been identified and were not necessarily intuitive. Evidence of this is that many high-priority species have

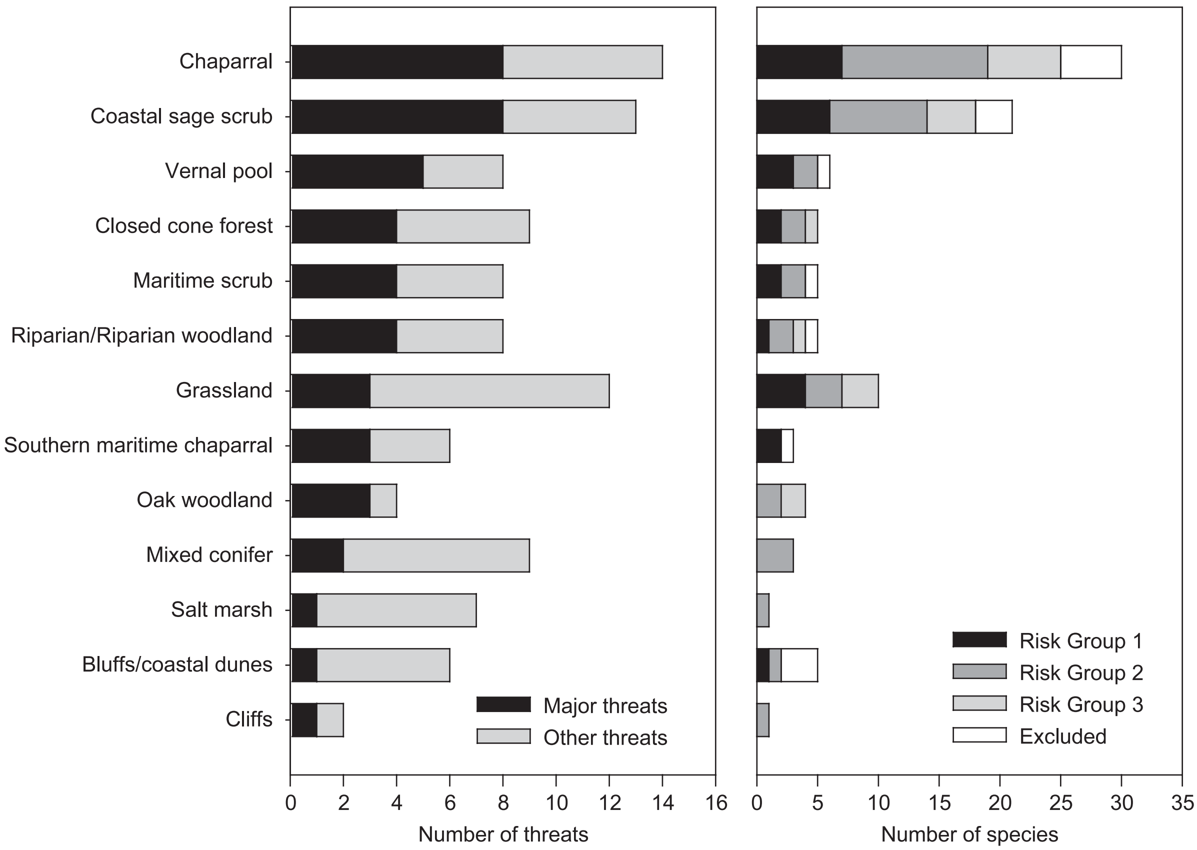

Figure 2 Number of Multiple Species Conservation Plan covered plant species and number of threats (Major = high-degree; Other = moderate and low-degree threats) by habitat type. Note that the 'number of threats' refers to the number of distinct threats to species occurring in the habitat type. Hence, in each bar a distinct threat only appears once.

received no monitoring attention to date, and lower-priority species have (Fig. 1; see also Appendix S4 in Supplementary Material). For instance, almost all of the animals in Risk Group 2 receive some monitoring, whereas less than half of the animals in Risk Group 1 receive any monitoring at all. Plants fare slightly better in that more Risk Group 1 species are currently monitored than plants in the lower risk groups, but they fare worse than animals in the number of species monitored, even though there are more covered plants than animals. It is clear from this analysis that undocumented biases currently exist in MSCP monitoring priorities and that these need to be addressed in future monitoring decisions.

In addition to the species prioritization, there are a number of useful outcomes stemming from the application of the step-down approach that can assist in monitoring decisions. The information compiled in Figs 2 and 3 can assist in prioritizing habitat types for monitoring based on threats to covered species. It should be noted, however, that 'habitat' is a species-based concept. For the purpose of MSCP species monitoring, it is only relevant to prioritize habitats in terms of the covered species occurring there and the threats those species face within their habitat (as opposed to the threats to the habitat itself). While threats to the habitat itself are significant risk factors, they are a subset of the many threats covered species face. Species life-history traits and their response to all major risk factors need to be considered in designing habitat monitoring and such monitoring should be performed in conjunction with other species-specific monitoring. It will be insufficient to monitor habitat cover through aerial photographs, for instance, when predation is a major risk factor for a given species. Habitat monitoring, performed in an appropriate way for the associated covered species, could have the greatest value if performed in areas where the most covered species occur.

The selection of focal species has received much attention in the monitoring literature (Noss, 1990; Kremen, 1992; Pearson, 1994; Simberloff, 1998; Canterbury *et al*., 2000). Despite many years of effort, the utility of focal species remains controversial (National Research Council, 1995; Niemi *et al*., 1997; Lindenmeyer, 1999; Andelman & Fagan, 2000). We argue that even though focal species concepts are often invoked in the selection of conservation targets, a risk-based approach to species prioritization is better justified for status and trend monitoring. This is because of the necessity of directly managing and monitoring at-risk species, the paucity of evidence establishing the validity of focal species in many cases, and the difficulties in structuring a monitoring plan to capture status and trends of focal species that are meaningful for the broader biodiversity (Rubinoff, 2001; Lindenmeyer *et al*., 2002).

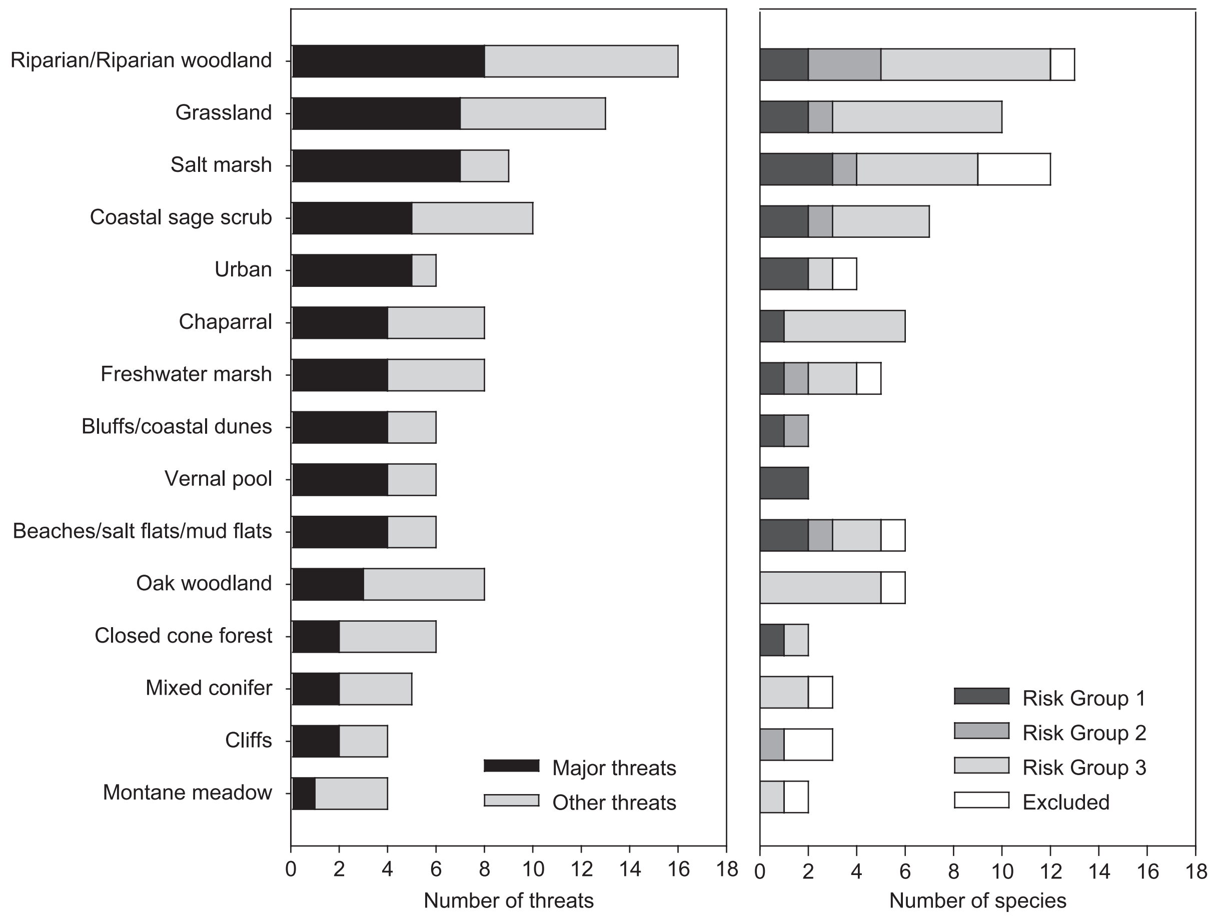

Figure 3 Number of Multiple Species Conservation Plan covered animal species and number of threats (Major = high-degree; Other = moderate and low-degree threats) by habitat type. Note that the 'number of threats' refers to the number of distinct threats to species occurring in the habitat type. Hence, in each bar a distinct threat only appears once.

In the absence of clear focal species and insufficient resources to monitor all covered species, how can we gauge the status and trends of species that are not high risk and cannot be monitored directly? We suggest that the prioritization methods presented here can be used to make monitoring decisions about an alternative indicator of status and trend–threats. The results in Appendix S4 provide information on the most prominent threats and the species impacted by them in the MSCP. Figures 2 and 3 reveal the habitats containing the most threats to species. This information can be used to identify the most serious threats to covered species and where those threats occur. Six threats stand out as the most serious for most of the covered species: habitat loss, invasive species, off-road vehicles, recreation/human disturbance, altered fire regime, and altered hydrology. While it is always preferable to monitor the covered species directly if resources allow, threats may be a more feasible alternative for monitoring status and trends. They may also be more reliable and relevant than focal species for a monitoring plan because they directly link to management (as highlighted previously by Salafsky & Margoluis, 1999).

It is important to note that the prioritization presented here forms only one component of a much larger adaptive management framework (Salafsky & Margoluis, 1999; Wilhere, 2002; Stem *et al.*, 2005; Williams *et al.*, 2007). While prioritization for monitoring status and trends of target species is an important first step in such a framework, it is insufficient on its own as a tool for ensuring a successful conservation plan. Ongoing management and subsequent evaluation will be necessary to determine if the conservation plan is meeting its stated objectives. It may also be necessary to monitor and evaluate additional components of biodiversity, such as communities or ecosystems, to determine if the objectives of the conservation plan are being met. In an adaptive management framework, knowledge about changes gained from managing biodiversity should be used to update priorities for status and trend monitoring. If new threats appear, or if the status of a species changes, monitoring priorities should be revised accordingly.

Southern California has taken a leading role in regional conservation planning in the USA, and San Diego's MSCP is at the forefront. Strategies developed to improve the planning, implementation, and monitoring of regional conservation programs can benefit the many HCPs and other regional conservation programs currently under development. We believe that the methods presented in this paper, and applied to an established conservation plan, go some way to ensuring scientifically defensible monitoring programs that can gauge the success of conservation plans.

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SUPPLEMENTARY MATERIAL

The following supplementary material is available for this article:

Appendix S1 Table of MSCP covered plant species in PDF format. They are sorted by number of threats and degree of risk.

Appendix S2 Table of MSCP covered animal species in PDF format. They are sorted by number of threats and degree of risk.

Appendix S3 Information sheet for organizing species information in PDF format.

Appendix S4 Species prioritization tables in MHTM format. Rankings are based on at-risk status and threats facing the species.

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