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How to prioritize allocating conservation efforts: an alternative method tested with imperilled herpetofauna

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Abstract

Several methods were developed with the aim of prioritizing conservation efforts. However, most of these methods were focused on ranking areas for land protection, without offering alternatives for sites poorly ranked. We propose an alternative method that allows prioritizing conservation efforts independently of the status of a specific area. The conservation priorities method considers data related with biodiversity, availability of suitable habitat and human pressure, on area-based units. This information is then standardized, obtaining a vector of three values, which reflects the situation of a specific area categorically (positive and negative) and quantitatively (how far from zero). Based on these values, specific conservation efforts can be settled at each area-based unit. We tested this methodology on several political units located at the Pampean Coastal Dunes in Argentina, using herpetofauna as surrogate taxon. Our results confirm the needs of performing several conservation approaches to deal with Pampean Coastal Dunes' problems. The conservation priorities method showed to be a useful tool to characterize sites and to set conservation efforts based on its specific status, supplementing current methodologies.

Introduction

The accelerated human global impact is reflected in a massive extinction process (Myers, 1993). The need for preventing biodiversity loss is clear, however, and because funds are limited, the global conservation community must decide where and how to invest (Pimm *et al*., 2001). Concerned about this problematic, biologists and practitioners have been working on finding methods aimed to prioritize conservation efforts (Margules & Usher, 1981; Usher, 1986; Mindreau *et al*., 2013). Many of these methods were focused on determining better sites to establish protected areas based on their biodiversity (Carwardine *et al*., 2008; Dudley, 2008; Valenzuela-Galván & Vázquez, 2008), sometimes considering the differential contribution of imperilled species to the overall richness (Fattorini, 2006) or including information coming from multidisciplinary sources (Álvarez-Berastegui *et al*., 2014).

Although establishing natural reserves to protect species has an unquestionable value, in many cases, this is not the only or the most effective alternative (Hockings, 1998; Razola *et al*., 2006). Likewise, most of the time, it is not possible to create a natural reserve in the best-ranked area resulting from the application of a specific methodology (Montesino-Pouzols, Burgman & Moilanen, 2012). Another lack associated with methods that rank areas is that they do not offer alternatives for sites poorly ranked (e.g. urban centres and/or low biodiversity areas) in which it is often possible to make conservation (Vignoli *et al*., 2009). Because of the diversity of scenarios that are commonly interacting at most landscapes, regions and ecosystems, it is highly needed to account for a variety of conservation actions aimed to deal with local problems (Chen & Roberts, 2008). A reliable method to prioritize conservation efforts should also propose which kind of management strategy would be more effective in a specific scenario.

The Argentinean Pampean Coastal Dunes are one of the last coastal grasslands of the Neotropics (Bilenca & Miñarro, 2004). These ecosystems represent a good example of a complex landscape in which several threats are interacting at numerous degrees (Iribarne *et al.*, 2001). Given that only a few patches of the original habitat remain, current but isolated attempts are being done aimed at promoting the protection of these ecosystems and its biodiversity (Celsi, unpubl. data).

Herpetofauna is an excellent surrogate taxon to consider in conservation studies (Lewandowski, Noss & Parsons, 2010; Nori *et al.*, 2013). Amphibians and reptiles are facing a worldwide conservation emergency, exhibiting the highest threat status among vertebrates (Grigera & Úbeda, 2000; Houlahan *et al.*, 2000; Sinervo *et al.*, 2010; Todd, Wilson & Gibbon, 2010; de-Pous *et al.*, 2011; Whittaker, Koo & Wake, 2013). This pattern is observed in many regions of the world, and the Pampean Coastal Dunes are not the exception, where amphibians and reptiles are of the most threatened species (Vega, Bellagamba & Fitzgerald, 2000; Kacoliris, Horlent & Williams, 2006).

In this work, we proposed an alternative method that allows prioritizing conservation efforts at a local scale. We especially looked that the results of this method become understandable for governments and practitioners in order to easy convert them in concrete conservation actions. We used the Pampean Coastal Dunes of Argentina as a study case, and herpetofauna as the assessed taxon. The Pampean Coastal Dunes are good subjects to test this methodology considering its heterogeneous status in terms of conservation. In addition, we discussed the potential effectiveness of this method in other habitats and/or based on other taxa.

Materials and methods

The conservation priorities method (CPM)

The CPM is aimed at defining conservation priorities on area-based units that conform a region or habitat of interest. Each unit is described by three sources of information: biodiversity value (BV), availability of habitat (AH) and human pressure (HP). The information is standardized and summarized to become more easily understandable and specific conservation actions are settled based on the obtained results.

The BV is the proportion of species inhabiting a unit in relation to the whole species inhabiting the region or habitat of interest. As proposed by other authors (Fattorini, 2006), the BV accounts not only for richness but also for conservation importance by weighting species based on its status. We used an improvement of the method of Reca, Úbeda & Grigera (1994; see Giraudo *et al.*, 2012a) for weighting. This method summarizes the available information about distributional range, ecological rarity, specific human effects (e.g. harvest, road kills), reproductive potential, size and abundance of each species. Each variable receives a value from 0 (best) to 5 (worst), representing its conservation status. The sum of these variables for each species results in a conservation value (CV) that can be then assigned to a conservation category. The BV for each unit is calculated as the sum of CV of all species inhabiting that unit divided by the sum of CV of all species inhabiting the whole region or habitat of interest. The BV can reach values of one (all the potential species are present in the unit) and shows a trend to zero when the number of species and/or the number of species with high importance decreases.

The AH is the proportion of suitable habitat in the unit. Other habitats can be also measured (e.g. urban centres, exotic forest, disturbed habitats) in order to better decide where to allocate specific conservation efforts like habitat restoration (see below).

The HP represents the pressure or impact of humans on the unit. Because human impact usually increases with human density, in our case, we used the log of the total number of people using the area (local population and tourists) as HP value. Each particular analysis must look for the best indicator of human impact to be used as HP value.

To facilitate the evaluation, we standardized the three metrics (BV, AH and HP; metric at the unit – mean/SD), getting values centred on zero that become comparable with each other. In the case of HP, we multiplied the metric by –1 to convert the higher values of human pressure into negative ones. In this way, units can be represented as vectors composed by three coordinates, and compared categorically (positive and negative status) but also quantitatively (how far from zero).

As results reflect the main values and needs of each unit, they can be easily converted to an effective conservation action to deal with the problematic highlighted by each metric. In Table 1, we show a list of conservation needs, summarized from the classification performed by the IUCN-CMP (2006) and a suggestion about when to consider it, based on example results coming from CPM.

Study case: Pampean Coastal Dunes

The Pampean Coastal Dunes (Buenos Aires province, Argentina) represent one of the last remains of coastal Pampas in South America (Cabrera, 1976). These coastal dunes are naturally split by Tandilia Mountain range, in two regions commonly recognized as oriental (north) and austral (south) dunes (Isla, Cortizo & Schnack, 1996). With the aim of offering tools for local governments and practitioners, we applied the CPM using counties as political units (called 'Partidos' in Argentina), considering that management decisions are taken at this scale. In those cases in which the areas of the counties range beyond Pampean Coastal Dunes, we only considered the area of the county included in the dune region (Fig. 1).

We used herpetofauna as the surrogate taxa for estimating BV. We determined the richness of each unit by considering voucher specimens deposited at recognized Argentinean museum collections; scientific literature (Kacoliris *et al.*, 2006; Celsi, Monserrat & Kacoliris, 2008; Williams & Kacoliris, 2011) and records gathered during the extensive fieldwork carried out in the region from 2004 to 2013

Table 1 Summary of conservation actions needed and when to consider them based on values from CPM

Actions needed	Summarized description	When to consider?
1. Land protection	Identify, establish or expand parks and other legally protected areas	(+) Values of AH, (+) values of BV, (+) values of HP
2. Habitat Restoration	Restore sites and habitats (including the creation of sanctuaries)	(–) Values of AH (potential areas for recovering habitat are needed), (+) values of HP
3. Species recovery	Manage or restore species (reintroduction and/or translocation programs)	(–) Values of BV (suitable areas for restoring species are needed)
4. Education and awareness	Actions directed at people to improve, understanding and skills and influence behaviour	(–) Values of HP
5. Law and policy	Develop, change, influence and help implement formal legislation, regulation and voluntary standards	(–) values of HP

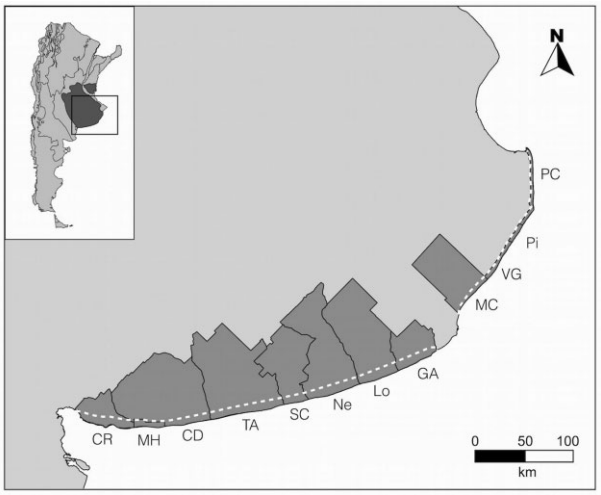

Figure 1 Map showing the location of the Pampean region in Argentina (upper-left), the limit of Pampean Coastal Dunes (white-dotted lines) and the counties that contain dunes areas (dark grey). PC, Partido de La Costa; Pi, Pinamar; VG, Villa Gesell; MC, Mar Chiquita; GA, General Alvarado; Lo, Lobería; Ne, Necochea; SC, San Cayetano; TA, Tres Arroyos; CD, Coronel Dorrego; MH, Monte Hermoso; CR, Coronel Rosales.

(Kacoliris *et al.*, unpubl. data). For each species, we used the CV from the last national categorization of amphibians and reptiles of Argentina (Abdala *et al.*, 2012; Giraudo *et al.*, 2012b; Vaira *et al.*, 2012).

We used high-resolution imagery from Google Earth to estimate the availability of suitable habitat (AH). We divided the historical area of Pampean Coastal Dunes in three types of units: (1) dune grasslands without human modification or with a depreciating one (suitable habitat remaining); (2) urbanizations, including towns, cities and touristic villages; and (3) forestry, which are exotic tree plantations and represent potential areas to perform habitat restoration. We estimated the area of each polygon using Quantum GIS (QGIS Development Team, 2015).

We used population size information from national governmental statistics as data of human pressure (HP; Edwin, 2012).

Results

The species richness of Pampean Coastal Dunes includes 12 amphibians; 14 lizards and amphisbaenas; and 13 snakes. Unstandardized BV was very homogenous among sites, ranging from 0.67 to 0.81, being the austral counties the most diverse. AH values were very different among counties, since besides their different sizes, the counties show different amount of habitat loss related to human development. In Fig. 2, each county is shown, highlighting the quantity of habitat remaining, and the presence of urban centres and/or forestry.

The values of HP were the most dissimilar among units, in relation with the high differences related to human use of each coastal county (Fig. 3). The relationship among the three metrics is represented in Fig. 4 to allow a better understanding about the whole scenario of Pampean Coastal Dunes.

Within the frame of these results, the proposed conservation strategies are (a) land protection: the best county to promote the creation of a new protected area is Coronel Dorrego, followed by Coronel Rosales and Tres Arroyos; (b) habitat restoration: a good number of counties should be considered for habitat restoration; however, this could be possible only in Lobería, San Cayetano and General Alvarado, considering the extension of habitat that can be potentially recovered (forestry not directly associated to urban centres, see Fig. 2); (c) education and awareness plus law and policy: Partido de la Costa, Villa Gesell and Pinamar are the better counties to promote and reinforce these kind of activities considering the density of people that can be reached (see Fig. 3); and (d) species recovery programmes can be considered for several counties (e.g. Villa Gesell, Pinamar, Necochea, General Alvarado, Lobería and San Cayetano) after deep assessments aimed to meet the assumption of historical equal distribution of all the species at the whole Pampean Coastal Dunes. Because species recovery must be related to positive values of AH, the better sites for developing this kind of management would be Villa Gesell and Necochea.

Discussion

As posed by Possingham *et al.* (2001), methods developed by conservation biologists should be useful to deliver

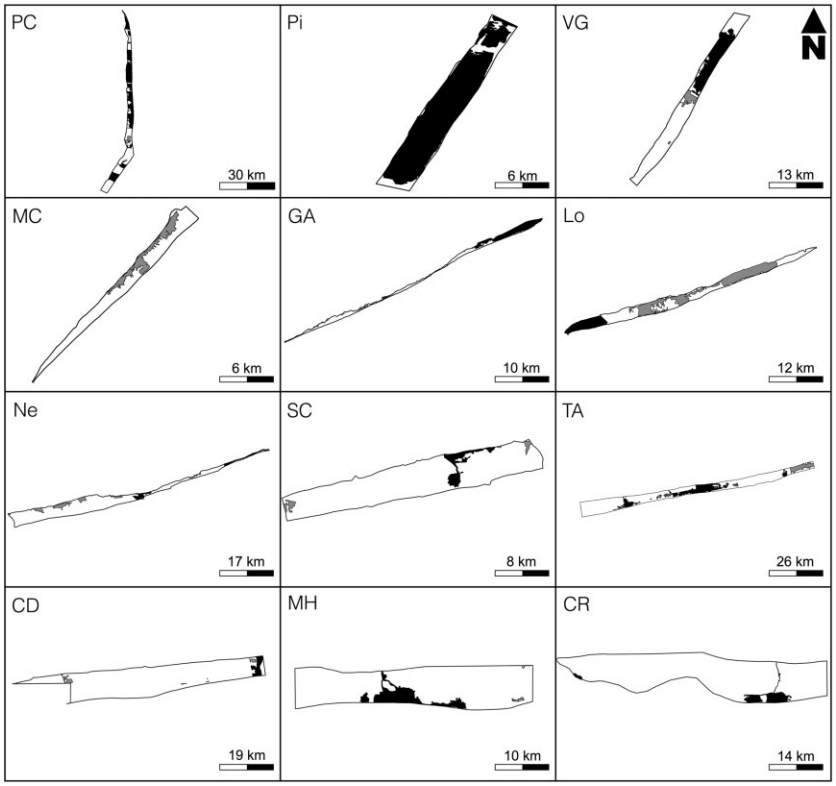

Figure 2 Counties that include dunes in their areas (see references to abbreviations in the legend of Fig. 1). Black areas represent urban centres, grey areas represent forestry and white areas represent suitable habitat.

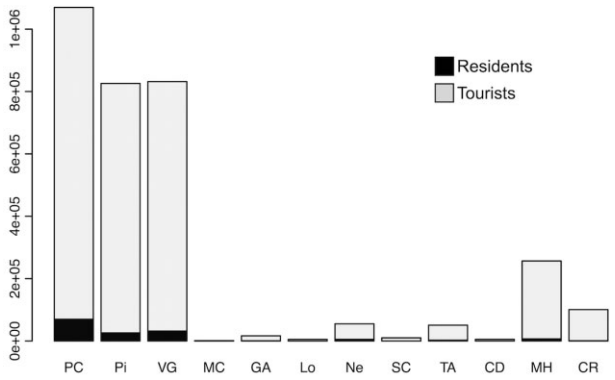

Figure 3 Total number of residents and tourists (*y*-axis) using dunes areas at each county (*x*-axis). See references to abbreviations in the legend of Fig. 1.

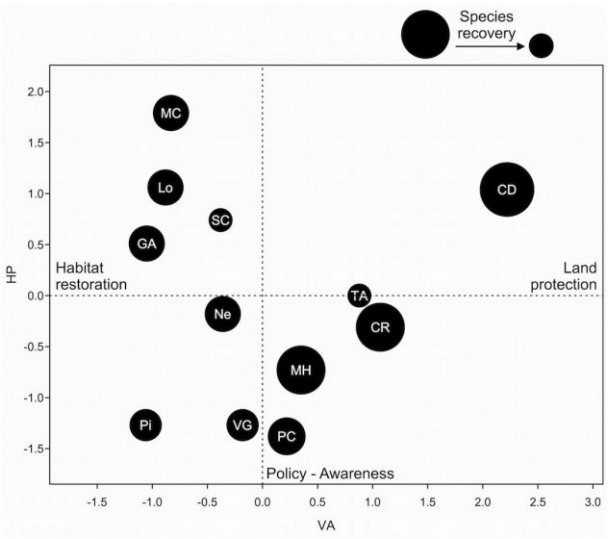

Figure 4 MPC values for each county. BV values are represented as sizes of circles and were unstandardized for a better representation. Proposed conservation actions are represented as trends to limit values of HP, VA and BV. See references to abbreviations in the legend of Fig. 1.

effective, science-based decision for practical use by managers and policy makers. In this frame, our method demonstrated to be a valuable tool for establishing priority conservation actions. Besides CPM allows areas to be quickly categorized based on their natural attributes and degree of disturbance, it also present some advantages over methods that only rank areas for land protection. CPM allows the identification and prioritization of conservation actions independently of the status of the assessed area. This is important if considering that species can be protected beyond natural reserves (Vignoli *et al.*, 2009) and many times governments are concerned at performing conservation actions in areas with several degrees of urbanization (Kacoliris, pers. obs.). Another advantage of CPM is that results obtained through this method can be easily understood and converted into effective management actions.

Although there exists a link among CPM results and conservation actions, some considerations must be taken before to decide implementing any kind of management. Regarding BV, negative values would indicate that a specific area has a low biodiversity and/or less representation of endangered species, becoming a potential area for planning reintroduction programs. In these cases, the availability of suitable habitats should be also considered and the assumption of historical equal distribution of species should be assessed.

A low value of AH indicates that the proportion of suitable habitat is small, being habitat recovery a good option to consider. However, this activity may only be made in scenarios where habitat could be effectively recoverable (like forestry areas in our study case but when urban areas are not pervasive). A reasonable link exists between HP and the size of urban areas (more people needs bigger urbanizations); therefore, land protection and habitat restoration will be more feasible at sites with positive values of HP.

When higher values of AH are obtained, land protection would be a good option. This is in agreement with the 'island biogeography theory' of MacArthur & Wilson (1967) considering that big reserves are better for protecting biodiversity. However, when land protection becomes possible, some extra considerations must be taken; better sites will be those ones with good values of AH and BV but also should be the ones better connected (also in agreement with the islands theory).

Low values of HP would be indicating areas with a high density of humans. In such cases, an option would be the promotion and creation of specific laws and policies aimed at minimizing the current impact of some activities (like the prohibition of off-road vehicles in dunes in our study case) and the development of educational/awareness raising strategies to reinforce conservation actions. Given that a lower HP indicates a higher density of people living and/or using an area, by developing outreach material and educational activities, a higher impact in behavioural change of people can be achieved.

Once a site with low HP was selected to perform education and awareness activities, a strategy should be defined framed on educational objectives. In this step, it would be important to take into consideration values of BV and AH, since the strategy will be different depending if positive or negative values were obtained. For example, when BV is positive in a site, a simple strategy could be focused on highlighting the importance of biodiversity and/or on the values that key species have in the area. In the other hand, when BV is negative, the strategy could be focused on showing potential impacts that are related to this low biodiversity (if this is the case) and how to alleviate threats on these habitats.

In the case of Pampean Coastal Dunes, conservation cannot be faced with a single approach. Only a combination of management strategies based on locally based problematic would offer an integral action plan to better allocate conservation efforts. Regarding the sources of information, BV did not show large differences among counties. This makes sense if we consider that Pampean Coastal Dunes do not comprise a large area and despite their geological differences (Isla *et al.*, 1996), most of the dune habitats are originally represented in both dune regions. Since the BV is highly influenced by species richness, it may be sensitive to false absence of some species (e.g. species that have not been detected in the area so far). This should not be a great problem in our study case because Pampean Coastal Dunes have been intensively and extensively explored. However, in less explored regions, the BV could incorporate a correction factor based on the detection probability of species in order to make the metric more robust.

In our case, we applied the method developed by Reca, Úbeda & Grigera (op. cit.) for weighting, considering that it allows a more deep discrimination when most of the conservation categories among taxa are similar. However, alternative methods can be used, as the one developed by Fattorini (2006), which considers conservation categories coming from IUCN criteria.

Regarding the AH and the HP, the main cause for differences is related to the dissimilar development of urban centres among oriental and austral counties. Some of the oriental counties were the most fragmented because they are nearer to the capital city of Argentina (Buenos Aires) and consequently, urban centres showed an earlier and faster development, being historically the main touristic centres. Considering that the austral counties show the highest AH, and they have the smallest proportion of protected areas (1% in the austral counties vs. 21% in the oriental counties), our results should be considered in order to reinforce a current project aimed at declaring a nature reserve at Coronel Dorrego (Celsi *et al.*, 2010).

Since in this work, the AH was adapted for the specific situation of the dunes, only some categories of land use were considered further than suitable habitat remaining. If the method is planned to be used for other regions or areas, an easy adaptation should be done, by including new but enough categories in order to represent the specific situation of the new areas evaluated.

The CPM supplement the limitations of other methods framed on searching better areas for land protection because it can be used for ranking; besides, it provides alternatives to sites poorly ranked. As previously discussed, we think that the method could be easily adapted for several scenarios, becoming an important tool for establishing conservation priorities.

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