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Mapping opportunities for environmental education in a defaunated landscape

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ABSTRACT

Due to historical defaunation and extensive land-use changes, central Chile lacks a megafaunal flagship species with which to attract attention to conservation of the region. We compare the ease of observing potential flagship species according to their distributions in the landscape, and the practical barriers to promoting nature tourism focused on those species, in those locations. First, we consider the distributions of a previously identified flagship fleet for nature engagement in central Chile, consisting of small animals and trees. Second, we map potential areas for the reintroduction or conservation of the guanaco (*Lama guanicoe*), previously identified as a potential phoenix flagship for central Chile, and the puma (*Puma concolor*), a native felid appreciated by global audiences. All the areas identified where flagship species are currently found, or could be reintroduced, are fragmented and show almost no overlap with existing protected areas. We conclude that there are fewest practical barriers to encouraging flagship observation in the flagship fleet species areas, compared to the phoenix flagship and the felid flagship options. We discuss opportunities for private protected area creation, nature tourism, and outreach programs promoting observation of the flagship fleet in these areas.

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Introduction

Animals, plants, and other species have many different roles, including symbolic roles, within human cultures, which affect how those species are treated in daily life (Descola, 2005). The conservation flagship approach attempts to build on this by promoting species and their representations as symbols of conservation programs. Empathy and the sensual and affective salience of other species to humans (their "charisma") also produces engagements with nature and conservation (Lorimer, 2007). Species familiarity is also associated with cultural significance (Correia et al., 2016). Flagship species thus attempt to present well-known species in ways that elicit empathy and charisma to attract attention to and promote engagement with conservation. However, the identification of which species should be used as flagship species is complex (Barua et al., 2011), and to some degree arbitrary due to the continuum of degrees of interest and forms of interaction between humans and other species.

Distance also affects types of engagements with flagships, and flagship efficacy. For example, the successful annual UK fundraising event Elephant Parade in support of elephant conservation in situ in India uses elephant representations that "work" in a UK context, although these are unrelated to local Indian representations and engagements (Jepson et al., 2011). By contrast, some well-known flagships, such as the polar bear as a representation of the perils of climate change, fail to motivate behavior change in people for whom the flagship and issue seem remote from their daily lives (Slocum, 2004). Thus, elephant flagship representations successfully attract support for conservation of distant animals, while polar bear flagship representations have failed to do so, illustrating the mixed track record of attracting attention to the conservation of distant species not directly observed or experienced by the target audience. The possibility of direct engagements with flagship species is expected to play a role in creating certain types of relations to conservation and nature, e.g. with the places, habitats and landscapes where flagship species live.

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The central, Mediterranean-climate zone of Chile is a hotspot of endemic plant and animal species (Simonetti, 1999). However, the low valuation of central Chilean landscapes by Chilean society, which is regarded as empty and lacking wild animals, translates into a lack of conservation effort (Root-Bernstein and Armesto, 2013; Root-Bernstein, 2014; Lindon and Root-Bernstein, 2015). In fact, it is the species and landscapes in the most remote parts of Chile that are best known and liked (Lindon and Root-Bernstein, 2015). This partly reflects a preference for creating protected areas in uninhabited scenic areas. It can also be accounted for by the cultural and political history of central Chile, where an erasure of landscapes and their human and non-human inhabitants has facilitated colonialism and industrial exploitation (Root-Bernstein, 2014).

To bring the endemic and native species of central Chile and their habitats more into the public imagination, with the aim of promoting conservation awareness and environmental education, a flagship "fleet" or group of eight known and liked animals and plants has been developed (Supplementary Material; Root-Bernstein and Armesto, 2013). However, convincing the wider public that these species inhabit landscapes perceived to be barren is a challenge. The goal that we address here is how to link conservation symbolism with personal experience in nature, for the promotion of conservation of habitats and landscapes of central Chile (Folmer et al., 2013).

The approach of designing a fleet of multiple flagship species was intended to compensate for the lack of a single charismatic megafaunal flagship candidate for the region (Root-Bernstein and Armesto, 2013). Targeted questionnaires, interviews and action-participation carried out in central Chile confirmed the lack of a single culturally significant charismatic large species and also formed the basis for selecting the best-known and appreciated species typical of the region (Root-Bernstein and Armesto, 2013; Root-Bernstein, 2014). Land-use changes and hunting since the colonial period have resulted in defaunation in central Chile (Armesto et al., 2010). Consequently, the flagship fleet species are relatively small and not highly abundant and visible. The flagship fleet is designed to appeal to a specific set of ways of interacting with the environment, e.g. collecting of observations, valuing autodidactic learning, or enjoying subtle poetic or spiritual experiences, all of which are valued in Chilean society.

A second approach to filling the large charismatic flagship species gap is to consider reintroducing such species. Species reintroductions need to consider a wide range of factors, including the original causes of species loss and whether those have been controlled; local stakeholder support; existence of suitable habitat for the species to be reintroduced that is large enough for a self-sustaining population; the genetic origins of the reintroduced individuals; and welfare and survivorship during and after release (IUCN/SSC, 2013). Here we consider the possible flagship benefits of two large symbolic candidate species that have been proposed or recommended as conservation flagship species relevant to central Chile.

Two species that could be could be reintroduced, protected or rewilded to improve public perceptions of biodiversity are guanaco (*Lama guanicoe*) and puma (*Puma concolor*). The guanaco's reintroduction to central Chile as a phoenix flagship, or reintroduced species used to promote conservation, is supported by Chilean urban dwellers (Lindon and Root-Bernstein, 2015). Regionally appropriate models for its reintroduction have been proposed (Root-Bernstein et al., 2016). Global assessments show that wild felids are widely appreciated species, and thus they have been recommended as flagships to promote conservation around the world (MacDonald et al., 2015). This recommendation has been made in spite of the fact that in local contexts, including the Chilean one, they are often implicated in human-wildlife conflict (Herrmann et al., 2013). If they could be reintroduced and protected under suitable conditions, both species have been predicted to have strong symbolic power.

The guanaco, puma and flagship fleet are not mutually exclusive flagships and could all be used to promote environmental education and conservation awareness in central Chile. However, it is clearly more difficult to carry out a reintroduction and conservation program than to simply promote existing, if hard to find, species. We thus ask how much area there is, and how it is distributed, where one can see all of the flagship fleet, compared to the area available for guanaco and puma reintroduction. The size and spatial distribution of areas where flagships can be experienced by their audiences will contribute to whether they seem remote and irrelevant, or engaging and present in central Chilean landscapes. We assessed where the maximum number of flagship fleet species are concentrated and thus potentially observable. These areas would be high priority suitable sites for nature tourism and environmental education activities. Next, we mapped habitat where puma and guanacos could be reintroduced. We discuss the possibilities for linking flagship symbolism to nature experience in each set of identified areas.

Materials and methods

Our study area included the administrative regions of Coquimbo, Valparaíso, Region Metropolitana, Bernardo O'Higgins and El Maule, being the administrative regions corresponding to central Chile, and including principal cities and towns (e.g. Santiago, Rancagua, Valparaíso, Viña del Mar, San Fernando, Curicó, Talca, Linares) from which the target public, urban nature tourists, could be drawn.

The species distributions were obtained from the most up to date available layer sources. *Lycalopex culpeaus, Pteroptochos megapoidius, Athene cunicularia, Calopistes palluma* polygon layers were obtained from Marquet et al. (2004) at various scales depending on the scales of the original bibliographic sources, including reports of presence and maps, from which they were obtained. *Octodon degu* polygon distribution was obtained from Nature Server (Patterson et al., 2005), at 1:1,000,000 scale. Tree species distributions (*Lithrea caustica* and *Acacia caven*) were extracted from vector layers at 1:50,000 scale from the most complete vegetation and land cover classes map for Chile provided by the Chilean Forestry Services Database at 1:50,000 resolution. We were not able to find distribution maps for the tarantula *Grammostola mollicoma*, so we excluded this flagship species from analysis. We identified areas where the distributions of all 7 species overlapped using vector overlay of the polygons. Polygons drawn at large scales are likely to include some spaces that are errors of commission: the species are not really present within the whole polygon. Thus, using the 1:50,000 scale from the tree data to determine overlaps should reduce errors of commission. Furthermore, both the tree and the animal species are typical of semi-open habitats such as matorral, espinal, and successional or patchy habitats. Thus, it is unlikely that areas where the two tree species are found are actually "vacant" areas within the animal species polygons where they are never found or cannot occupy.

In identifying areas with maximum species overlap (7 out of 7 species), we weighted the importance of each species equally. The original study (Root-Bernstein and Armesto, 2013) indicated that the species should be presented as a set to facilitate a narrative-based environmental education strategy based on how the species interact. Furthermore, we have no data to indicate whether some of the flagship fleet species are more preferred by particular audiences (Root-Bernstein and Armesto, 2013). We checked whether the 7-species overlapped area coincided with protected areas. National protected area boundaries were obtained from the World

Database on Protected Areas (WDPA IUCN) and private protected areas boundaries from Núñez-Ávila et al. (2013).

In order to identify the potential reintroduction and conservation habitat suitable for guanaco and puma, land cover of native forest, scrublands and vegetation types were obtained from the vectorial land cover map provided by Chilean Forestry Services Database at 1:50,000 resolution CONAF (2011). Polygons of espinal (*Acacia caven* silvopastoral savanna), native sclerophyllous forest and scrubland were considered suitable habitat for guanacos, which are generalists that used to live throughout Chile, including central Chile, until around 500 years ago when they were locally extirpated through overhunting. Pumas live in a variety of habitats including native forests, pine plantations, steppe, matorral (shrub habitat), and pampas; but prefer forested areas (Quintana et al., 2009). Suitable wild prey species can also be assumed to live in these habitats. Accordingly, for puma habitat we considered sclerophyllous forest and scrubland, plantations and *Acacia caven* savanna from CONAF (2011). Due to human-carnivore conflict and historical and potential illegal hunting pressure on puma in this region with high human activity, we decided to exclude highly populated areas. For this we extracted from the puma polygon distribution a buffer (exclusion zone) of 50 km from cities, towns and industrial areas, based on a range size of 100 km^2. After subtracting the buffer, remaining suitable habitat areas were considered to be relatively safe areas for puma reintroduction and/or protection. All analyses were carried out in ArcGIS 10.

Results

We found a scattered distribution of 704 sites containing all 7 of the 7 included flagship fleet species (which excludes the tarantula) (Fig. 1). The mean size of each site was 1.871 km^2 (SD 4.624) and the total area of these sites was 1317.183 km^2. We found a relatively small overlap between the identified flagship fleet sites and public and private protected areas in the region. In Rio Clarillo National Reserve we found 0.7 km^2 within the distribution of all 7 flagships, and in Las Palmas de Cocalan National Park 0.7 km^2. Private protected areas present in 2013 only protected a minimum of 7.6^{-10} km^2 with all 7 of the flagship species present.

We found an extensive area of 63,810 km^2 that could be suitable for reintroduction of guanacos, which includes 11,742 km^2 of *Acacia caven* (Fig. 2). These areas are less fragmented in the north and more so in the south, which is likely to impede or impose risks on animal movement. However, the majority of the identified areas were outside of existing public and private protected areas.

Because of the highly anthropogenic study area, the buffer used to exclude areas for puma reintroduction and protection occupies almost the entire habitat available for this species, leaving only 2142 km^2 in the north and 358 km^2 in the south of the region, coinciding with the area available for guanacos but almost entirely outside any kind of protected area (Fig. 3).

Discussion

The area in central Chile available for pumas where human–wildlife conflict could be low is unfortunately very small, by our analysis. Pumas were traditionally persecuted by local people in rural central Chile, in order to protect their livestock and themselves. In southern and central Chile, conflict with pumas remains problematic, and there are few positive perceptions of pumas or other wild felids (Herrmann et al., 2013). This option to promote awareness of habitat conservation in central Chile yields a larger total area than the priority flagship fleet areas, but includes fewer sites, found only at the extremes of central Chile, and with no overlap with existing protected areas. This reflects the balance

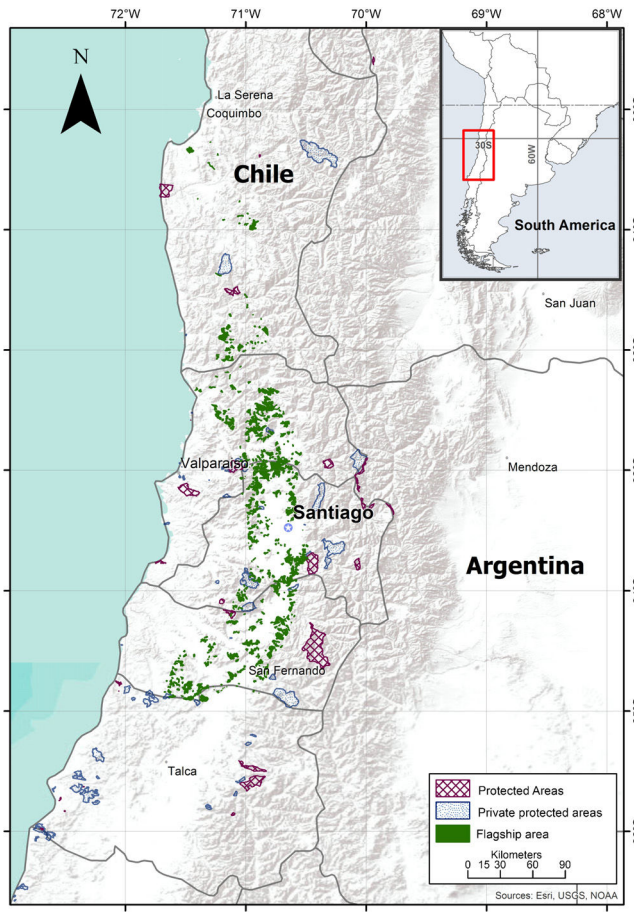

Fig. 1. Distribution of areas containing the flagship fleet species and protected areas.

between keeping pumas away from rural people with whom they are likely to be in conflict, while keeping them close enough to be relevant to target audiences who do not have to interact regularly with them (MacDonald et al., 2015). However, it is not clear that pumas in these remote locations will be salient enough to provide the bridge to experience that we are aiming for.

Guanaco reintroduction to suitable habitats in central Chile could follow a number of different conservation and management models (Lindon and Root-Bernstein, 2015; Root-Bernstein et al., 2016). At this stage, the institutional requirements for guanaco reintroductions are not firmly established, the threat from feral dogs has not been adequately controlled (Bonicic pers. comm.), and community-level dialogue throughout central Chile have not been undertaken; adding uncertainty to the proposal. However, the potential suitable habitat for guanaco reintroduction is larger than for pumas or the flagship fleet, and is widely distributed within the region. Ultimately, the strong cultural symbolism of the guanaco could be leveraged for environmental education if it were reintroduced into its original habitats across central Chile (Lindon and Root-Bernstein, 2015). However, this option may take decades to materialize.

By contrast, working in areas where the flagship fleet can be found may be a more practical starting point to promote conservation and environmental education in central Chile. The identified sites with all seven of the flagship fleet species for which we have distributional data were fairly numerous but small and well-distributed across most of central Chile. The mapped areas represent priority areas, given limited resources, and opportunities to experience maximum flagship species richness. The relatively small areas and patchiness that we found for the flagship fleet

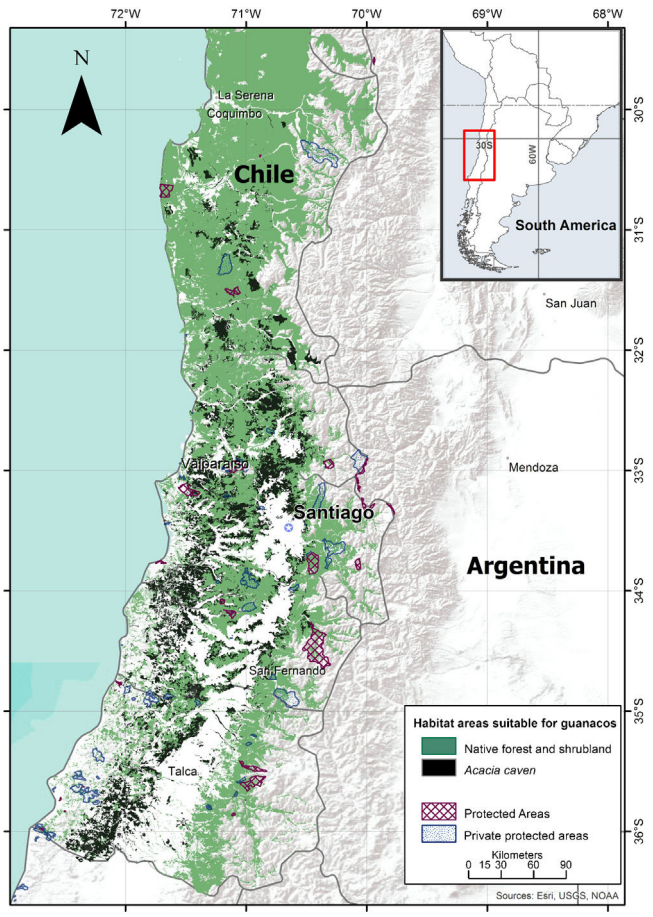

Fig. 2. Habitat areas suitable for guanacos (*Lama guanicoe*) and protected areas.

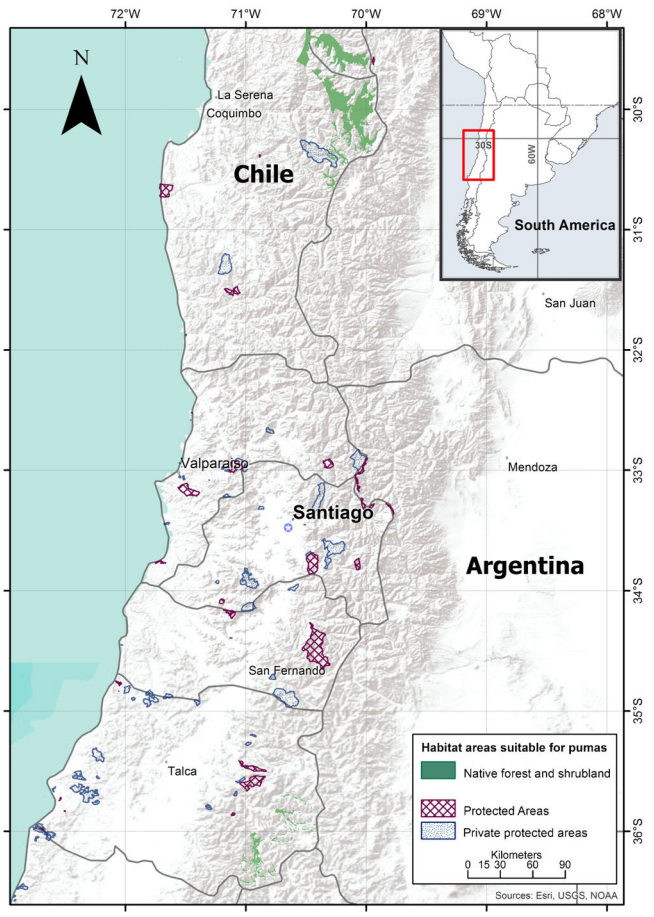

Fig. 3. Habitat areas suitable for pumas (*Puma concolor*) and protected areas.

is not necessarily a weakness, since they are at a scale at which local NGOs or individuals could feasibly operate. The small areas obtained both confirm the basis for urban Chileans' impression that attractive and recognizable wildlife is scarce in central Chile (Root-Bernstein and Armesto, 2013), and underscores the need to protect these priority areas for their exceptional value as sites for facilitating environmental education. Compared to using the guanaco as a flagship species, this option appears to be easier to implement in the short term, and in the event of widespread guanaco reintroduction, would have laid the environmental education groundwork to explain why the iconic guanaco should be reintroduced into the "empty wasteland" that central Chile is currently perceived by many people to be (Root-Bernstein, 2014).

The identified priority flagship fleet areas are likely to be on private landholdings, since the majority of landholdings in Chile are private. Three means to promote environmental education and conservation while providing access for flagship fleet observation, include (1) creating new private protected areas (PPAs), (2) developing citizen science programs, in partnership with local landowners who may be convinced to provide access to their landholdings for specific activities, and (3) developing nature tourism companies providing experiences on private landholdings (which might not be PPAs). Environmental tourism is underdeveloped in central Chile, but the creation of a network of flagship fleet sites could contribute to its development. For example, since most of the sites are within easy driving distance of the capital, Santiago, local tourists could be encouraged to spot all of the flagship species in all of the flagship sites. The risk of habitat degradation from excessive visitation can be controlled through management plans at individual sites. Citizen science relating to the collection of nature observations is in its infancy in Chile (see http://chilecientifico.cl), with the most established forum being the Chilean Network for Bird and Nature Observation (Red de Observatores de Aves y Vida Silvestre de Chile, ROC). Funding programs such as EXPLORA and the Nucleo Milenio, and the outreach department of the Natural History Museum in Santiago also bring natural science to the public. These opportunities could be leveraged in partnership with landholders to create site-based nature observation programs.

One of our assumptions is that seeing many flagship species together at the same site provides an optimal experience. Experienced nature observers are reported to show greater interest and satisfaction when seeing rare species and a wider variety of species (Lindsey et al., 2007). Collecting multiple observations of many species is a proximate motivation for activities such as bird watching and citizen science, and these activities may increase pro-conservation attitudes (Cosquer et al., 2012; Cooper et al., 2015).

Conclusion

The relationships between species, their observation, and engagement with habitats and landscapes is only beginning to be understood and operationalized for conservation purposes (Folmer et al., 2013). The assumption, based on studies of experienced nature observers and citizen science volunteers, that viewing multiple flagship species will increase support for conservation, has not directly been tested, and is an area for future research. How or why multiple species are presented together (e.g. with ecologically-based narratives, Root-Bernstein and Armesto, 2013) as well as the number and diversity of flagship fleet species, and the conditions of observing them, may all be important variables in determining

the social agency of flagships. We propose that mapping areas rich in flagship species can be a step toward helping people to discover and care about habitats in need of broad conservation efforts.

Conflicts of interest

The authors declare no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.pecon.2017.05.004.

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