

Integration of Land-Sharing and Land-Sparing Conservation Strategies Through Regional Networking: The Mesoamerican Biological Corridor as a Lifeline for Carnivores in El Salvador

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Received: 24 October 2013 / Revised: 18 November 2013 / Accepted: 20 November 2013 / Published online: 28 December 2013

Abstract Nations with little remaining natural habitat and small extent are challenged when trying to achieve biodiversity targets. We show that the Central American nation of El Salvador cannot viably sustain populations of 87 % of its extant carnivores, especially in the case of large-bodied species with low population densities. Current land-sparing strategies will not suffice; therefore we propose that land-sharing strategies be implemented in tandem with protected areas to expand current conservation efforts via new regional networks. In Central America such a network can be established by linking international protected area systems in a way that implements the existing vision for the Mesoamerican Biological Corridor. Specifically, we propose a re-envisioning of the Mesoamerican Biological Corridor in which land-sharing practices are adopted throughout the agricultural matrix while ensuring formal protection of the remaining natural habitat. Such an integration of land-sparing and land-sharing could result in the creation of an effective network of protected areas, thereby increasing the probability of safeguarding species with populations that overlap national borders.

Keywords International cooperation · Conservation networking · Conservation targets · Agro-productive matrix · Spatial requirements

INTRODUCTION

Biodiversity does not stop at national borders, and neither should conservation strategies. Conventional conservation efforts embraced strategies based on sparing land from human development, thus protecting the wildlife contained therein. The question of how much land is enough for effective biodiversity conservation has been prominent in ecology ever

since MacArthur and Wilson's (1967) seminal Theory of Island Biogeography (TIB), which explained how species richness increased on large islands close to the mainland. Transferring the interpretation of islands to protected areas has allowed conservation scientists to estimate the minimum spatial needs of biodiversity, with some work suggesting that 30 % of the original area is often desirable (Svancara et al. 2005). However, more modest, politically convenient figures have been the norm for conservation targets on a worldwide basis, largely ignoring evidence-based targets, because of their lack of feasibility. The United Nations Convention on Biological Diversity (CBD) recently proposed to protect 17 % of terrestrial areas (Convention on Biological Diversity 2010). As many nations that have subscribed to this target ratified the first proposed figures of 10 %, considered bold at the time (Soulé and Sanjayan 1998), but which are now widely considered biologically meaningless. A particularly difficult problem arises when nations adhere to the CBD's 17 % target, but still do not have enough area to adequately meet the spatial needs of large species. Moreover, some countries may no longer have enough natural habitat remaining to meet the 17 % target. The issue is further exacerbated when these two situations arise at the same time, that is, in small countries where a lot of natural land has been converted. Here, we focused on the spatial needs of carnivores in El Salvador to show that it will be necessary to go beyond protecting land and illustrate how a comprehensive strategy for the conservation of carnivores could be implemented in Central America.

BIODIVERSITY RUNS OUT OF SPACE: LARGE CARNIVORES AS AN EXAMPLE

The Republic of El Salvador is the smallest country in Central America (21 000 km²), and currently holds 13 % of

its land as natural landscape while formally protecting 0.83 % (IUCN and UNEP-WCMC 2013). Focusing on carnivores, we used the well-known method of calculating the minimum area required to maintain a population of 500 individuals (Newmark 1985; Redford and Robinson 1991). For this purpose, we collated population density data from the PanTHERIA database (Jones et al. 2009), the IUCN Red List (2013) and Cervantes et al. (2002), to assess the suitability of the largest protected area in El Salvador for carnivores (Owen and Giron 2012). We calculated the ratio between minimum area (MA) and park area (PA), where an MA/PA > 1 indicates inadequate park size to sustain a viable population. Analyzing any protected areas smaller than the largest one would result in increasing ratios of MA/PA, indicating even less suitable areas for populations of 500 individuals.

The largest continuous protected terrestrial land area in El Salvador (34.6 km²), consists of three protected areas: El Imposible National Park, and the protected areas San Benito I and II and Las Colinas. However, even in combination this land is not enough to maintain viable populations of 87 % of the country’s extant carnivores (Table 1). Predictably, large-bodied species fared worse than smaller ones (Spearman’s $r = 0.57$, $p = 0.03$), with the largest already extirpated (*Panthera onca*) (Owen and Giron 2012), yet globally considered only as near threatened (IUCN 2013). Because size generally affects the spatial requirements of mammals (McNab 1963), species with greater body mass typically translate to higher MA/PA values.

These findings highlight two issues that hinder effective conservation management. First, conventional land-sparing strategies that rely on protected areas alone will not suffice (sensu Green et al. 2005). Second, because of the small size of El Salvador any conservation strategy cannot succeed without taking into account available habitat in neighboring countries. Illustrating this point through El Salvador and its carnivores as an example may seem exaggerated; however, it clearly shows that small nations alone are unable to accommodate the spatial needs of large biota, highlighting that regional cooperation is pivotal to successfully achieving conservation outcomes.

LAND-SHARING AND REGIONAL NETWORKING

To address the first issue, an alternative to sparing land, such as land-sharing (wildlife-friendly farming practices, potentially at the expense of lower yields), could be implemented (Green et al. 2005). Both strategies have been compared (Phalan et al. 2011) and debated (Fischer et al. 2011), most recently at the 2012 European Section Meeting of the Society for Conservation Biology, but to date the debate continues without consensus being reached.

Table 1 Areas required to sustain viable populations of carnivores in El Salvador. MA is the minimum area (km²) required to sustain a population of 500 individuals; MA/PA is the ratio between the minimum area required to sustain a viable population (MA) and the area provided by the largest continuous protected land area in El Salvador (PA). *Spilogale angustifrons* and *Lontra longicaudis* were omitted for lack of data

Species	Body mass (kg)	Density (n/km ²)	MA (km ²)	MA/PA
<i>Mustela frenata</i>	0.19	0.76	658	19.03
<i>Bassariscus sumichrasti</i>	0.91	17.89	28	0.81
<i>Mephitis macroura</i>	1.20	1.34	373	10.79
<i>Potos flavus</i>	2.44	34.21	15	0.42
<i>Conepatus leuconotus</i>	2.55	0.91	552	15.98
<i>Leopardus wiedii</i>	3.25	0.05	10 000	289.27
<i>Urocyon cinereoargenteus</i>	3.83	2.41	207	6.00
<i>Eira Barbara</i>	4.13	1.77	282	8.17
<i>Nasua narica</i>	4.58	6.07	82	2.38
<i>Procyon lotor</i>	6.37	3.29	152	4.40
<i>Puma yaguarundi</i>	6.88	0.58	862	24.94
<i>Leopardus pardalis</i>	11.88	0.42	1190	34.44
<i>Canis latrans</i>	11.99	0.25	2000	57.85
<i>Puma concolor</i>	53.95	0.02	25 000	723.18
<i>Panthera onca</i> *	83.94	0.05	10 000	289.27

*Extinct

Notably, the apparent contest between land-sparing and land-sharing seems largely pointless when confronted with real-world problems such as those in El Salvador. Faced with the challenge of overcoming continuing decline of habitat and the inability to achieve CBD targets, reality requires that we protect all natural landscape left (land-sparing), while also expanding conservation efforts in surrounding land (land-sharing).

For the second issue, where populations of wide-ranging biota extend beyond national borders, we suggest that biodiversity targets need to be set regionally, rather than nationally. Since we now know that some countries are unable to extend the current size of their protected areas and thereby achieve CBD targets, setting regional as well as national targets may permit a larger window of success and thus offer a higher incentive for governments to comply. For trans-national protected area systems to succeed, intergovernmental communication needs to be established, and new networks of protected areas must be formed. Global efforts such as the newly created Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services (IPBES) could help to not only improve communication between the scientific community to policymakers, but also among governments (Turnhout 2012). This, in turn, could facilitate better coordination among protected area systems of adjacent countries.

AN EXISTING SOLUTION

A potential mechanism already exists in Central America that can deal both with extending protected area systems and improving international cooperation, namely the Mesoamerican Biological Corridor (MBC). In existence since 1997, the MBC has been the official conservation and rural development land-use planning system that spans Central America and southern Mexico (CCAD 2002). Although officially sanctioned by El Salvador, it has remained underused, as no more than a set of geographically defined connections among protected areas, without further governmental action. Its merit lies in that it embodies the legal framework for an integrated network of a regional protected area system (Ankersen 1994). What is needed now is research on the level of biological connectivity at different points of the corridor with respect to carefully chosen ecological indicators. Published findings could then swiftly spread horizontally throughout the MBC to neighboring countries, thereby assisting with allowing the on-ground interpretation that allows managers to choose a suitable course of action in different situations. Once the network is established and connectivity determined, governmental backing by officials to broker a deal with privately owned land must be done to ensure actual development of the corridor. By formalizing the corridor, land-sparing and land-sharing strategies would then coalesce into a single unit of conservation, allowing multiple protected area systems to form an international network capable of sustaining viable populations of even the lowest density mammals.

FROM PAPER TO PRACTICE

There are challenges that need to be overcome to implement the vision we outline. First is a reintroduction of the MBC as an effective conservation project in Central America and Mexico. Some consider the MBC to have failed, yet in fact it never took off. A precursor to the MBC, the Paseo Panthera project, started in 1990 envisioning connectivity for the conservation of *P. onca* as an emblematic species, yet met with opposition from concerned indigenous and rural people uncomfortable with possible land-use restrictions (IEG 2011). Thus, the original mission grew to include conservation and development goals, adopted by Central American governments and formally commissioned as the MBC, where it is now largely stranded as a spatially explicit model of connectivity. El Salvador is generally in greater need of developing the MBC than the other parties because it harbors the least amount of protected land and therefore stands to gain the most for its biodiversity. It is the most densely populated

nation in Central America (294 p/km²) (UNSD 2013), 21 % of its employed population depends on agriculture (World Bank 2012), and 82 % of its land is comprised of agro-productive systems (Vreugdenhil et al. 2012), making it well suited for a strategy that relies on sharing as much as sparing land.

Presently, to seriously undertake its envisioned task the MBC would need to alter its wait-and-see approach which so far has not yielded recognizable success, and open up to external conservation proposals from both the scientific community and other research agencies, such as universities and NGOs, to garner more diverse and novel ideas of implementing the corridor. After 16 years, the MBC should now reevaluate how its goal could be achieved, and focus efforts on establishing efficient communication channels between the different international research groups that rarely interact and offer a more welcoming approach to these entities.

Moreover, land-sharing practices will need to improve. The MBC in El Salvador will need to mainly rely on wildlife-friendly practices, because natural habitat is in such low supply. Cultivated land on the Salvadoran MBC already consists of large tracts of shaded coffee which connects protected areas throughout the corridor, and coffee plantations have been shown to act as refuge for a large share of forest biodiversity (Perfecto et al. 1996). Introducing shade coffee plantations to farmland where applicable could lower the contrast between the agro-productive matrix and native forests. Conversely, sparing land by increasing agricultural intensification might lead to increased land rent because of the perceived higher productivity, creating new incentives for expansion (Phelps et al. 2013). Previous comparisons between land-sparing and land-sharing propose analyzing the tradeoff between commodity production and biodiversity to choose the correct course of action (Phalan et al. 2011; Tscharrntke et al. 2012). Because El Salvador cannot afford to lose more natural habitat, the remaining option is to protect all natural landscape that is left and simultaneously enact a land-sharing approach through the MBC. The current bias in land-sparing/sharing research is to assume a common species pool among habitat patches or homogenous landscapes (Grau et al. 2013). Under these assumptions, analyses at local scales may yield sound conclusions about the effectiveness of a strategy, but at regional scales (which are likely to include high rates of species turnover among habitat patches or heterogeneous environments) mixed approaches of these strategies may be required.

Offset mechanisms may also need to be adapted and employed to compensate biodiversity and local people where the use of the agricultural matrix is impractical (Kumaraswamy and Kunte 2013). As such, the economic necessities of local farmers that must continue to supply food to the growing human population should be taken into

account, especially in poor countries. Payments for environmental services should be sought out, which provide an incentive for farmers to opt for a potential lower yield that may be incurred by wildlife-friendly farming practices.

Fischer et al. (2008) provide policy guidelines for implementing a mix of both land-sparing and land-sharing strategies in agricultural landscapes, yet did not account for situations where natural vegetation was sparse. When there is no more land left to spare, cases where only protection of the remaining habitat and full implementation of land-sharing practices make sense are exceptions, but this fate may await many nations in the near future (Sala et al. 2000) and exceptions like El Salvador may become standard. Perhaps a long-lasting solution lies in the dual-motive behind the MBC: biodiversity conservation and sustainable development of the human environment.

PROSPECTUS

International participation in conservation programs has been high, with targets set and many nations eager to comply; but the implementation of strategies crossing national borders has not had the same luck, with situations arising where nations are willing, but unable, to achieve conservation targets. Fortunately, countries can cooperate with their neighbors, such as El Salvador which shares borders with Guatemala and Honduras, who have also signed up to the MBC. Their joint effort since 1998, the Trifinio Biosphere Reserve, located where the countries meet and included in the MBC, is a model framework for its parties' decision making and stands as a testament of Latin-American cooperation demonstrating that such cooperation is entirely possible (Miranda et al. 2010). After a reexamination, this existing mechanism could provide the means for El Salvador to overcome the spatial restrictions that human land-use has set upon its biodiversity. Combined with a land-sharing strategy, the MBC could allow populations of wide-ranging species which overlap with neighboring countries to benefit from the increased communication among conservation biologists that a protected area network can provide through better international cooperation. This kind of rapid integration needs to occur on a regional scale in Central America, and similarly worldwide, to enable networking of protected area management in small countries and aid in choosing the best conservation strategies for ensuring the survival of viable populations. As for El Salvador, too long has the MBC lain dormant, and the larger carnivores may not survive much longer unless conservation action is taken urgently. The wait is over.

Acknowledgments S.J.C. is a fellow of the Chilean International Cooperation Agency (AGCI), as well as fellow of the Faculty of Science, University of Chile. Their support is appreciated. We also

thank two anonymous reviewers for careful reading of our manuscript and insightful suggestions which helped improve the quality.

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