COORDINATED ACTION ACROSS ADMINISTRATION LEVELS AND ASSESSMENTS ARE KEY TOOL TO REVEAL BARRIERS TO THE EFFECTIVE MANAGEMENT OF PROTECTED AREAS

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ABSTRACT

We assessed protected area management effectiveness and identified attributes that limit the effectiveness of 21 protected areas in the State of Santa Catarina, southern Brazil. Of these, we assessed 10 areas under state-level administration for which a standardised assessment had not previously been conducted. For the 11 protected areas under federal administration, we obtained assessment data from the government. The protected areas were contrasted regarding the administration level and a list of attributes that could result in differences in management effectiveness between areas. We examined the relationship between protected areas' attributes and mean effectiveness using linear models. The same attributes were also related to management elements, namely context, planning, inputs, processes and outputs, using redundancy analysis. Management effectiveness and scores of management elements were found to be lower for areas either with unresolved land tenure, lacking management plans or updated ones, those under many pressures and threats, or those under state-level administration. Overall, we suggest that federal protected areas do better in at least these attributes or a combination of attributes not well-captured by single indicators than state-level protected areas. Reassessments should be regularly carried out across administration levels in order to effectively flag a barrier, clear it, and identify the next one to be tackled.

Key words: Atlantic Forest, land tenure resolution, management elements, State of Santa Catarina.

INTRODUCTION

Creating and maintaining protected areas (PAs) is an essential strategy in conservation (Rodrigues & Cazalis, 2020; Watson et al., 2014) and as a climate adaptation strategy (Carrasco et al., 2021), even though many barriers limit the fulfilment of PA conservation aims. PAs tend to improve biodiversity conservation (Le Saout et al., 2013) by both reducing threats to biodiversity (Andam et al., 2008) and maintaining ecosystem services (Watson et al., 2014). Global efforts towards biodiversity conservation have raised the coverage of PAs to ~16.6 per cent in terrestrial areas (UNEP-WCMC et al., 2023). However, habitat loss and biodiversity continue to decline in most PAs (Laurance et al., 2012). Such losses indicate that PAs have been unable to meet all the goals they had been created for, a fact in part related to management ineffectiveness (Coad et al., 2015).

To promote successful management, the International Union for Conservation of Nature (IUCN) has directed efforts towards the systematisation and assessment of PA management effectiveness. Such efforts produced a framework based on the principle of adaptive management (Biggs et al., 2011) and the assessment of six elements: context, planning, inputs, processes, outputs and outcomes (Hockings et al., 2006). Following this framework, different methods have been developed to assess PA management effectiveness. Of these methods, the Rapid Assessment and Prioritisation of Protected Area Management has been often used (RAPPAM; see Ervin, 2003). Thus far, management assessments cover only a small fraction of the global PA network (Coad et al., 2015) and indicate just a moderate effectiveness of ~50 per cent, which tends to be even lower in developing countries (Leverington et al., 2010). In Brazil, management effectiveness assessments

have been carried out mostly for PAs administered by the federal government; however, a substantial part of the Brazilian PA network is run under state-level administration.

Understanding attributes of PA management that influence results and defining actions that contribute to the most positive outcomes underlies effectiveness assessments and adaptive management, so that scarce resources are directed towards conservation gains. In addition, PA management effectiveness depends on attributes like the size and qualification of staff and available funds, with less than one-quarter of 2,167 PAs across the globe having adequate funding and staff (Coad et al., 2019). Such attributes often depend on administration levels – whether federal or state – and the appeal of the PA to the public, therefore we checked their influence on PA effectiveness. Specifically, we expected that PAs would score higher in effectiveness assessments when under federal administration (WWF-Brasil & ICMBio, 2012) and in more stringent protection categories (WWF-Brasil & ICMBio, 2012); with established management councils (Andrade & Rhodes, 2012), including co-management by relevant partners (Cundill et al., 2013); with large staffs and funds (James et al., 1999); with a management plan (Middleton & Thomas, 2003); and with substantial public appeal indicated by attracting many visitors (Steven et al., 2013). We also expected well-conserved ecosystems (Kauano et al., 2017) to show more effective management results due to fewer pressures and threats to biodiversity (Tranquilli et al., 2014). Finally, land tenure resolution was also expected to lessen many pressures and threats and thus lead to successful management outcomes (Nolte et al., 2010).

Thus, we estimated the relative importance of attributes related to management effectiveness outcomes that can aid PAs to achieve their biodiversity conservation goals. While our main aims were exploratory, we tested for effectiveness according to administration level (federal vs. state-level) because such governance differences can impact financial and human resources. To test these hypotheses, we considered a network of protected areas located in the State of Santa Catarina in southern Brazil.

METHODS

Protected area network

We assessed a PA network located in the Atlantic Forest domain, a region rated fourth for worldwide conservation priority (Myers et al., 2000). Despite the threats that contribute to this rating, the State of Santa Catarina has a high conservation potential, with

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~30 per cent of native vegetation cover remaining, even though vegetation cover varies across the state (Vibrans et al., 2012). The state has 99 PAs in several protection categories and management levels: federal (16 PAs), state (10), municipality (18) and private (56) (updated from MMA, 2017). In this study, we excluded private and municipality-managed PAs due to the high heterogeneity in the data available for these categories, difficulty in finding managers' contact details, and their smaller areas compared to federal and state PAs. Given these differences across the PA network, management effectiveness is expected to differ, providing grounds for checking which attributes lead to better outcomes.

Assessment of management effectiveness

We assessed management effectiveness using RAPPAM (Ervin, 2003) because it allows a standardised comparison between different contexts (Leverington et al., 2010) and emphasises effectiveness alongside pressures and threats. Pressures are forces, activities or events that have negatively affected PAs in the five years before the assessment. In turn, threats result from persisting pressures with detrimental impacts in the past are likely to continue over the following five years. Effectiveness assesses whether the management is leading the PA towards its aims, and considers the elements of context, planning, input, process and outputs. While it is important to check for relationships between management effectiveness and the mentioned elements with outcomes, the latter are harder to obtain and were not assessed here. RAPPAM uses several questions to characterise pressures and effectiveness. For each question about pressures and threats, the

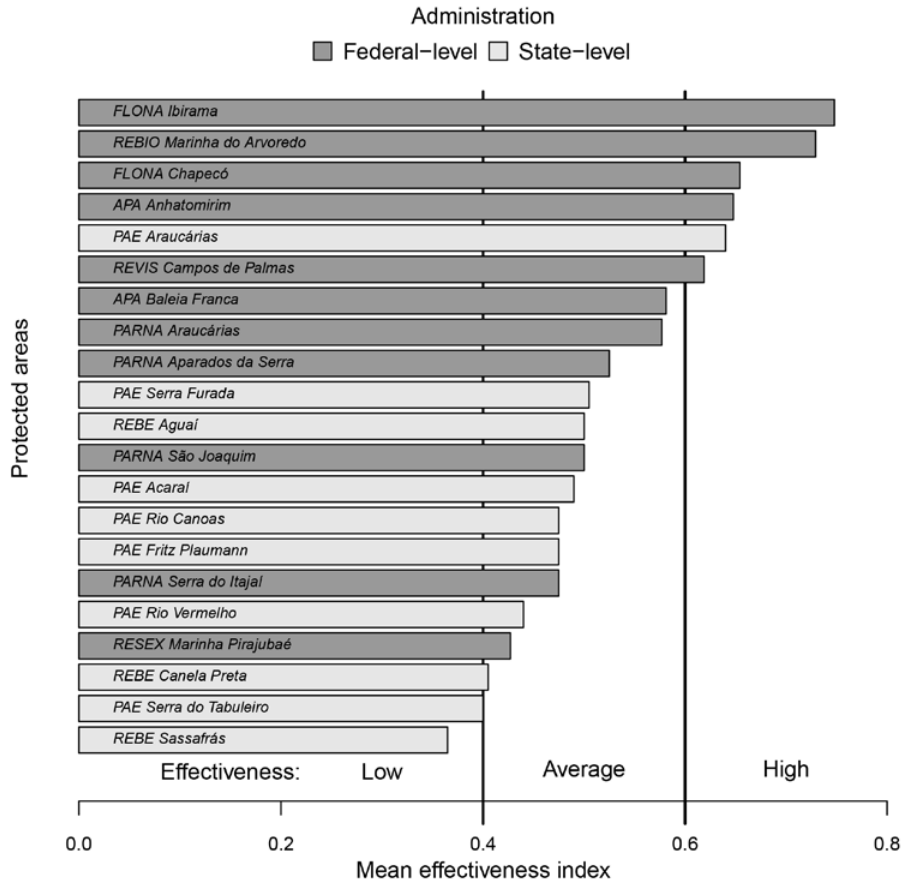

Figure 1. Management effectiveness of federal-level (dark grey) and state-level (light grey) protected areas. FLONA, National Forest; REBIO or REBE, Biological Reserve; APA, Environmental Protection Area; PARNA, National Park; PAE, State Park; RESEX, Extractive Reserve

manager provides an answer in a Likert five-point scale. For the questions related to effectiveness, the method uses a four-point scale. Combining scores assigned to effectiveness questions results in a management effectiveness index, which can be classified as low (<0.4), average (≥0.4 and <0.6) or high (≥0.6). For more detailed information on the RAPPAM method, see Ervin (2003).

For federal-level PAs, we used the most up-to-date RAPPAM assessment that was collected in 2015 (WWF-Brasil & ICMBio, 2017) and covered 11 of the 16 federal PAs in the State of Santa Catarina (5 PAs were not evaluated using RAPPAM). For the 10 state-level PAs, which never underwent such assessment, we applied the whole RAPPAM to PA managers and, in addition, the effectiveness questionnaire to a representative of the State Environmental Agency and two representatives of the management council of each PA. For state-level PAs with either no council or when councillors could not be contacted, we interviewed representatives of entities that were likely to take part in the council once it was established. The criteria for selecting representatives were their consent to participate in our study, basic knowledge of ecology or related fields, and sufficient knowledge about the PA. For each state PA, we calculated the effectiveness index as the median of the four questionnaires. Because the study involved talking to managers and councillors of state-level PAs, it was first authorised by the Ethics Committee of Universidade Federal de Santa Catarina (53996516.7.0000.0121).

Indicator attributes of protected area with management outcome

We assessed the key attributes that indicate effectiveness results in two ways. First, we built general linear models with attributes being included as fixed effects (e.g. PA administration level, protection category, funds and staff size, and so on; see full list in Table 1) and PA effectiveness index as the univariate response. To reduce multicollinearity, we fit preliminary models and removed variables with large variance inflation factors (VIF ≥ 4). Next, we chose which attributes were most strongly related to management effectiveness using a step-by-step removal process. This process was guided by values of corrected Akaike information criterion for small samples (AICc), and we stopped the selection when we reached the lowest AICc-values. Second, we used a multivariate approach to inspect for changes to the six elements underlying the effectiveness index. In this approach, the same 13 PA attributes were related to the six elements of effectiveness as the multivariate response using a Redundancy Analysis (RDA). To check for multicollinearity, we fitted a preliminary RDA and

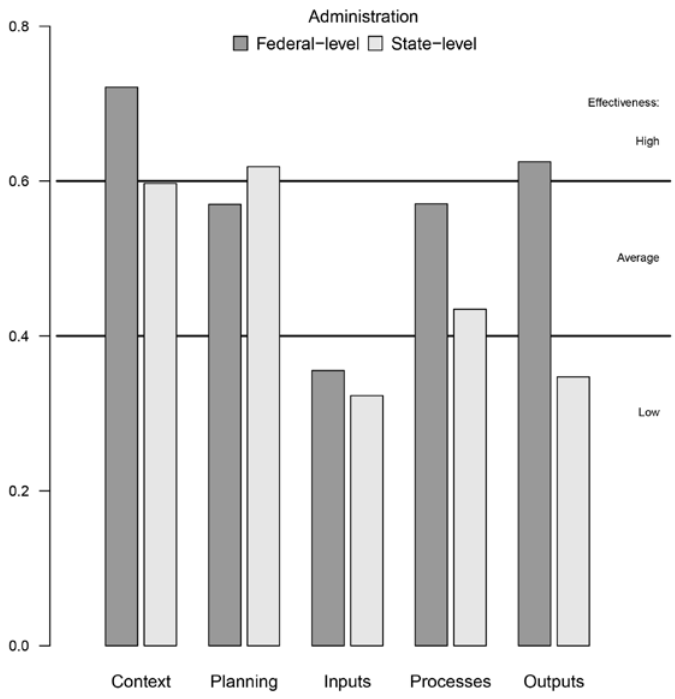

Figure 2. Protected areas management effectiveness per management element

removed indicators with VIF ≥ 10. Then, we reduced the full model in a step-by-step process using the highest adjusted-R^2 as the stopping criterion. We checked the overall predictor-response relationship of RDA and of each of the remaining predictors using permutation tests (9,999 iterations). Finally, we also conducted these analyses for the subset of state-level PAs to better explore the newly collected dataset. We computed all analyses in R (R Core Team, 2016) using the 'vegan', 'MASS' and 'car' packages.

RESULTS

Overview of management effectiveness and its elements

Two-thirds (14/21) of the PAs had average management effectiveness, whereas it was high in 6/21 PAs and low in one (Figure 1). The mean effectiveness index was 0.53 (min = 0.37; max = 0.75), which corroborates a medium overall management effectiveness. Based on mean indices, federal-level PAs showed a management effectiveness index that was 25 per cent higher than that of state-level PAs. Under federal administration, effectiveness was evenly distributed as either average (6/11) or high (5/11) ($\bar{x}$ = 0.59; min = 0.43; max = 0.75). At the state-level, 8/10 PAs had average effectiveness, while one had high and another had low effectiveness ($\bar{x}$ = 0.47; min = 0.37; max = 0.64).

Context was the element that mostly indicated high management effectiveness values ($\bar{x}$ = 0.66), while input was associated with lower values ($\bar{x}$ = 0.35) (Figure 2). A similar pattern was found for PAs from either federal-level (context: $\bar{x}$ = 0.72; input: $\bar{x}$ = 0.38) or state-level administration (context: $\bar{x}$ = 0.61; input: $\bar{x}$ = 0.33). Mean scores of all elements were higher for federal than state-level PAs, except for planning, which was lowest for federal-level PAs.

We identified 22 pressures and threats across PAs (min = 4, max = 18 per PA) that can require management actions. Criticality levels ranged from 82 to 906. On average, there were ~11 pressures and threats per PA (criticality: $\bar{x}$ = 353). The overall top pressures and threats (with greater degrees of criticality) were hunting, invasive alien species, and construction or operation of infrastructure. For federal PAs, the top pressures and threats were external interference, invasive exotic species, and hunting, while for state PAs, they were hunting, construction or operation of infrastructure, and invasive alien species.

How do protected areas vary, and which attributes indicate successful management?

Most PAs were in the broadleaf evergreen rainforest but spanned over seven different ecosystem types (Table 1). Funds per km^2 differed by up to 2,022 times among PAs, but there was no significant difference between mean funding across administration levels. Only 2/21 PAs had > 1 employee/km^2 and 13/21 PAs had < 0.1 employee/km^2. Land tenure was resolved in 8/21 of the PAs, and most PAs had management plans. Of federal-level PAs, all had < 1 employee/km^2, but the trend towards smaller staff size than for state-level PAs was not significant. Regarding the protection category, 5/11 federal-level PAs had strict protection and 6/11 were managed for sustainable use. Land tenure was resolved in 6/11 federal-level PAs, and 3/11 lacked management plans. Under state-level administration, land tenure was resolved in 3/10 PAs, and 3/10 had no management plan. All state-level PAs were managed as strictly protected areas.

PA attributes added up to just over 50 per cent of overall management effectiveness (adj.-R^2 = 0.52; F = 4.65; $p < 0.01$). The most relevant indicators at this stage were the administration level, ongoing co-management arrangements, funds (negative relationship), management plan availability, tenure resolution, and criticality of pressures and threats (negative relationship). Because the model with the lowest AICc contained non-significant indicators, we further removed those with p-values > 0.05 up to the limit of ΔAICc < 4 from the above-mentioned model. After that,

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administration level ($p = 0.01$) and management plan availability ($p = 0.04$) were deemed the most relevant indicators, correlating most strongly with management effectiveness index values (adj. $R^2 = 0.52$; $F = 4.65$; $p < 0.01$). Adding back indicators in this model resulted in tenure resolution becoming significant ($p = 0.025$), but with $\Delta AICc > 4$. Thus, even though land tenure is always of concern, its relevance tends to be masked or related to the relevance of administration level and management plan availability.

Regarding the relationship between PA attributes and effectiveness, the protection category was removed from the redundancy analysis (RDA) because of multicollinearity. After step-by-step reduction, the final RDA explained ~50 per cent of the variation in the elements of management (Figure 3). Tenure resolution ($F = 12.48$, $p < 0.001$), administration level ($F = 7.01$, $p < 0.01$), degree of criticality of pressures and threats ($F = 5.72$, $p < 0.01$) and management plan availability ($F = 3.57$, $p < 0.05$) were the most important indicators of differences in the numeric values for the elements of management effectiveness, and tenure resolution was the attribute most strongly related to management success. PAs with tenure resolution also had the highest values for processes and outputs. In turn, being under federal administration was the second most important attribute in terms of its association with management effectiveness. Federal-level PAs also tended to have the highest values for both context and outputs. Criticality of pressures and threats was the third most important attribute and had mostly an inverse relationship with effectiveness. Criticality was highest in PAs with larger values of context and lacking management plans and lowest in PAs with larger input values.

For the state-level data and after both checking for multicollinearity and model simplification, the number of employees per km² was the attribute most strongly related to differences in the effectiveness index, being followed by management plan availability (Figure 3; adjusted $R^2 = 0.74$; $F = 14.07$; $p < 0.01$). When assessing changes to the elements of effectiveness, the most relevant attributes were again the number of employees per km² (RDA, $p < 0.01$). In addition, tenure resolution and criticality of pressures and threats were also relevant, but to a smaller extent. The RDA, including only the number of employees per km² as a predictor, explained 42 per cent of the variation in effectiveness elements, whereas, with the three attributes, the explanation reached 63 per cent. The RDA with the three attributes was kept in order to explore the results further. This RDA showed larger staff sizes, indicating higher management effectiveness values in state-level PAs and linked to larger output values. PAs with tenure resolution had higher values for the elements of effectiveness. In turn, there was a negative association of management elements with the criticality of pressures and threats, with especially lower values for processes and planning under higher threats.

Table 1. Protected areas attributes and effectiveness results. ERF, Evergreen rain forest; MRF, Mixed rain forest; SEF, Semi-evergreen seasonal forest; MAR, Marine; MAN, mangrove; GRA, Grassland; H, High; A, average; L, Low; EI, Effectiveness Index

Protected Area	Administration level	Group	Category	Council	Human resources/ km²	Co-management
Acaraí	State	Integral	Park	yes	0.060	no
Aguaí	State	Integral	Reserve	no	0.013	no
Anhatomirim	Federal	Sustainable	Environmental protection area	yes	0.158	no
Aparados da Serra	Federal	Integral	Park	yes	0.053	no
Araucárias	Federal	Integral	Park	yes	0.008	no
Araucárias	State	Integral	Park	yes	2.614	yes
Baleia Franca	Federal	Sustainable	Environmental protection area	yes	0.005	no
Campos de Palmas	Federal	Integral	Wildlife refuge	yes	0.012	no
Canela Preta	State	Integral	Reserve	no	0.053	no
Chapecó	Federal	Sustainable	Forest	yes	0.249	no
Fritz Plaumann	State	Integral	Park	yes	1.116	yes
Ibirama	Federal	Sustainable	Forest	yes	0.578	no
Marinha do Arvoredo	Federal	Integral	Reserve	yes	0.035	no
Marinha Pirajubaé	Federal	Sustainable	Extractive reserve	yes	0.584	no
Rio Canoas	State	Integral	Park	yes	0.083	no
Rio Vermelho	State	Integral	Park	yes	0.849	yes
São Joaquim	Federal	Integral	Park	yes	0.004	no
Sassafrás	State	Integral	Reserve	no	0.019	no
Serra do Itajaí	Federal	Integral	Park	yes	0.007	no
Serra do Tabuleiro	State	Integral	Park	no	0.014	yes
Serra Furada	State	Integral	Park	yes	0.301	no

ERF, Evergreen rain forest; MRF, Mixed rain forest; SEF, Semi-evergreen seasonal forest; MAR, Marine; MAN, mangrove; GRA, Grassland; H, High; A, average; L, Low; EI, Effectiveness Index

Visitation	Financial Resources/ km²	Management plan	Ecosystem	Tenure resolved	Size (km²)	Pressure	EI	Effectiveness
0	4777.41	yes	ERF	no	66.67	111	0.49	A
0	10502.17	yes	ERF	no	76.72	347	0.50	A
12249	1350.50	yes	ERF	yes	44.37	434	0.65	H
111778	11240.56	yes	MRF	no	131.48	473	0.53	A
55	51246.22	yes	MRF	no	128.10	328	0.58	A
2414	206774.47	yes	MRF	yes	6.12	116	0.64	H
0	163.43	no	MAR	yes	1548.67	670	0.58	A
0	5690.14	yes	GRA	no	165.94	360	0.62	H
0	17352.56	no	ERF	no	18.99	400	0.41	A
1782	330491.85	yes	MRF	yes	16.04	244	0.65	H
4197	87379.37	yes	SEF	yes	7.17	75	0.48	A
0	48060.30	yes	ERF	yes	5.19	178	0.75	H
0	373.63	yes	MAR	yes	171.05	228	0.73	H
0	42432.26	no	MAN	yes	17.12	207	0.43	A
0	182603.78	yes	MRF	yes	12.00	362	0.48	A
0	94094.35	no	ERF	no	15.32	430	0.44	A
108148	8731.85	no	MRF	no	455.24	336	0.50	A
0	6091.22	yes	ERF	no	52.29	216	0.37	L
0	1577.56	yes	ERF	no	573.75	729	0.48	A
5350	427.69	no	ERF	no	843.00	906	0.40	A
0	44775.19	yes	ERF	no	13.30	259	0.51	A

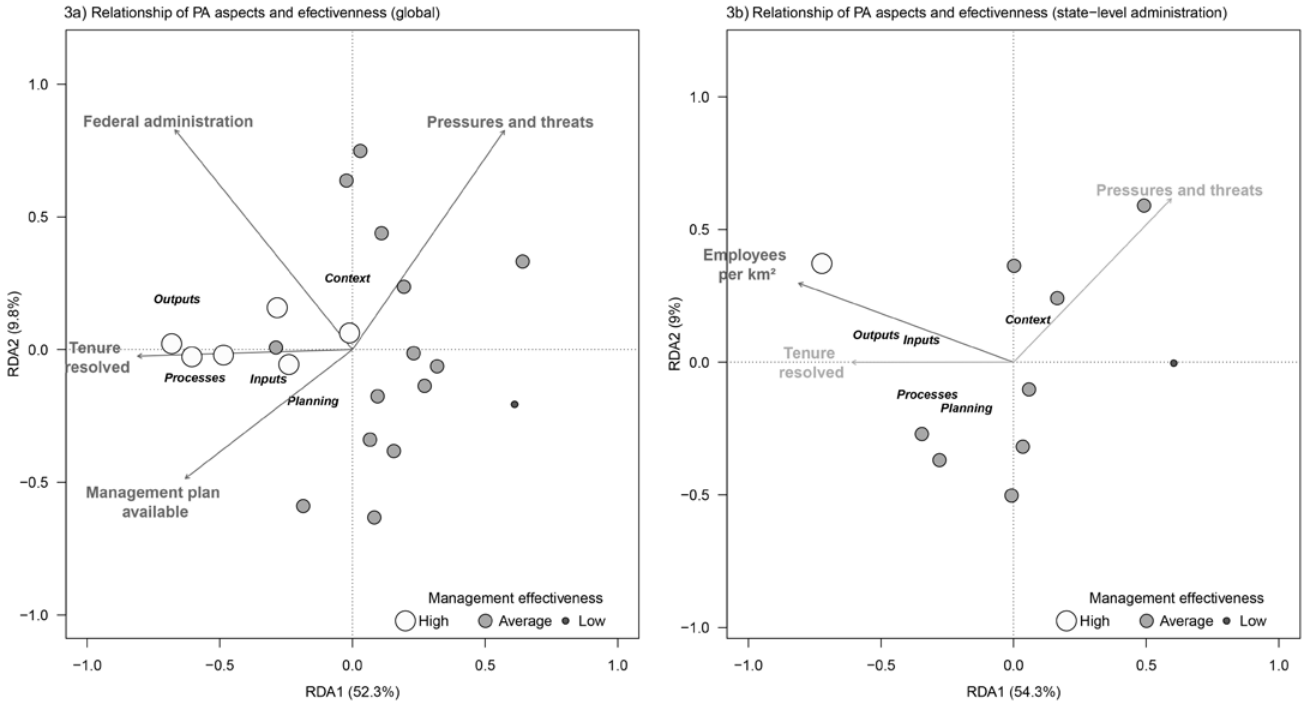

Figure 3. Relationship of protected areas' attributes and effectiveness for (3a) all areas, and (3b) state-level administration.

DISCUSSION

We found the protected area network to be of average management effectiveness. Effectiveness scores differed especially between PAs under different administrations, thus corroborating our expectation of an important role for governance in management effectiveness. In turn, staff and fund sizes were weakly related to better management effectiveness scores. Instead, land tenure issues seem to be the top barrier to more successful management in the studied PA network. The existence of management plans, and pressures and threats were additional attributes associated with differences in management effectiveness.

The average effectiveness score found here is comparable to the result of assessments across the globe (Leverington et al., 2010) and of all federal-level PAs in Brazil (WWF-Brasil & ICMBio, 2017). PA context was the element of management effectiveness with the highest values, suggesting good strategies are in use in prioritisation schemes and planning (Oliveira et al., 2017). High values in elements of both processes and outputs also correlated with high effectiveness. These findings can result from the practical aspect of both elements because processes include executing management actions, while outputs gauge action results (Hockings et al., 2006). The element with the lowest values was inputs, showing that staff and fund sizes – at least when considered independently – were weak indicators of management effectiveness scores, except for state-level PAs, where staff size correlated with higher management effectiveness scores. Put together, such results suggest that when overall inputs are low, management effectiveness tends to be limited. In addition, a shortage of resources is a problem that is worsening worldwide, and that relies on strong governance to be mitigated (Coad et al., 2019). PAs under federal administration were more effective than state-level PAs. Such results can be due to recurrent effectiveness assessments (WWF-Brasil & ICMBio, 2017), structure of the management body, and programmes developed at the federal-level, including access to funding. Federal-level PAs have already gone through three assessment rounds, and effectiveness indices improved along them, pointing to benefits along the process. It seems that at least some improvements result from information sharing and managers targeting the most serious issues after assessments (as suggested by Geldman et al., 2015), which is a pattern observed worldwide with ~70 per cent of PAs increasing in effectiveness scores in reassessments (Geldmann et al., 2015). In Brazil, the federal management body used to be more structured (Gerhardinger et al., 2011), with programmes developed at this level often maintained with international resources, a type of funding that makes reassessments more viable (Geldmann et al., 2015). Although international funding is scarce for state-level PAs, those of the State of Santa Catarina showed results above the average when compared to other Brazilian states (e.g. Lima et al., 2005), suggesting barriers to conservation goals to be distinct or more

detrimental in other PA networks. Further investigation on how such differences could be reduced is needed, given that appropriate governance is a key requirement for biodiversity maintenance (Leverington et al., 2010; Watson et al., 2014). We suggest that coordinated action across administration levels would lead to better conservation outcomes, particularly as many conservation goals can only be achieved by the whole PA network (Rodrigues & Cazalis, 2020). In this context, the use of tools such as RAPPAM that allow for the comparison of PAs in terms of individual performance across administration levels is a strength of the method. However, the limitations in using this method are the low flexibility, especially with different contexts of PAs, under different governance regimes; the limitations in capturing outcome-level data (Coad et al., 2015); and the subjectivity inherent in filling out the RAPPAM questionnaire. This last element can be minimised by using alternative ways to consider information about outputs, such as collective assessments.

The relationship found between pressures and threats with context is worrisome. While PA management should address and reduce pressures and threats to biodiversity to be effective (Rodrigues & Cazalis, 2020), just listing pressures and threats can be too simplistic, given ongoing and intensifying anthropogenic pressures worldwide. Dealing with the impacts of threats depends especially on staff (Tranquilli et al., 2014) to monitor, mitigate or bar their effects, as well as funds to mitigate them. Although hunting and deforestation are top threats to PAs globally (Kauano et al., 2017; Laurance et al., 2012), deforestation was of little concern, at least as an ongoing threat at the time of assessment. Conversely, hunting, invasive species, and impacts of infrastructure – such as roads – , were critical. There is also likely a synergic effect of both threats. For example, roads lead to direct impacts such as roadkills (Garriga et al., 2012), but can also lead to deforestation (Barber et al., 2014), access by hunters, and dispersal of invasive alien species. Here, we found staff size to be important, at least within PAs under state-level administration, which suggests that inputs tend to be limited to dealing with a large list of threats and pressures and cannot be overlooked.

Land tenure and development of management plans are of special concern for this PA network. Resolving land tenure has already been identified as a priority (Nolte et al., 2010), although it was suggested as a problem for a minority of PAs elsewhere (e.g. Leverington et al., 2010). Tenure issues can trigger conflicts (Robinson et al., 2017) because of the large budget needed to accomplish it in most cases, administrative difficulties, and the fragility of land tenure structure (Robinson et al., 2017). Moreover, threats and pressures are unsuccessfully mitigated where land tenure is poorly defined (Hausner et al., 2015). Management plans, in turn, are very likely both important and meaningful for management (Middleton & Thomas, 2003). Management plans lead to the implementation of actions and define guidelines for the optimisation of resources, and, when revised in a timely manner, allow for the adoption of a framework of adaptive management. Although the need for plans is obvious and plan development is considered urgent under current legislation, many PAs in the network still lack such plans, while others have them but they are not being regularly updated , thus contributing to poor management effectiveness. In addition, despite most federal PAs having management plans, which contrasts with just a few under state-level administration, the latter had somewhat higher values in the process element of management effectiveness. This suggests not every plan is making the difference it is expected to or that other barriers further limit management effectiveness when management plans are available.

The situation we describe here has been worsening following pressure to simplify the assessment (Fonseca & Rodrigues, 2017), evidence of corruption (Williams & Dupuy, 2017), and strong and coordinated political interference in the decision-making process (McCullough, 2017). Moreover, checking for an effect of PA management on threat and pressure abatement, for instance, depends on contrasting PAs to counterfactual scenarios in which adequate protection had not been established (Geldmann et al., 2019; Rodrigues & Cazalis, 2020). In such a type of counterfactual assessment, pressures within PAs seem to be increasing at a slower pace (Geldmann et al., 2019). Management effectiveness assessments must thus be linked to details about anthropogenic pressures and how they impact biodiversity; otherwise, such assessments tend to be of little significance by being unrelated to true improvements in ecological and social outcomes (Coad et al., 2015). In this study, however, the way in which information has been obtained for the PA network limits a more profound evaluation of the impacts of threats and pressures on biodiversity within and across the PA network.

CONCLUSIONS

The protected area network we assessed currently has an average management effectiveness. This suggests the management of the PAs within the network is able to deal with only part of the issues involved in achieving the goal of biodiversity conservation. We identified four main attributes as indicators of the differences in

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effectiveness: administration level, existing and up-to-date management plans, potential impacts caused by threats, and tenure resolution. These attributes are related to measures that can be addressed by management actions and by a greater alignment with the legislation related to PAs, which demonstrates the low application of this legislation. We suggest systematising these attributes in a management model that treats them as top priorities and that coordinated action across administration levels would lead to better conservation outcomes, particularly as many conservation goals can only be achieved by the whole PA network. We caution that tools such as RAPPAM are likely to fail if used as the sole gauge of PA management effectiveness and without on-ground measures of conservation outcomes, although the method was found to be a useful tool to compare PAs across administration levels. Moreover, any benefits of assessments can be easily lost following changes in governance. Despite such limitations, we suggest that there is a great opportunity to improve the management effectiveness of PAs by means of regular assessments and information exchange across administrative levels as a guideline to adaptive management strategies, as suggested by Geldman et al. (2015). Only in this way will it become clear when a barrier to effective management has been cleared and which one is to be tackled next, and thereby accomplish solid positive conservation outcomes.

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RESUMEN

Evaluamos la eficacia de la gestión de áreas protegidas e identificamos los atributos que limitan la eficacia de 21 áreas protegidas del estado de Santa Catarina, en el sur de Brasil. De éstas, evaluamos 10 áreas bajo administración estatal para las que no se había realizado previamente una evaluación estandarizada. Para las 11 áreas protegidas bajo administración federal, obtuvimos datos de evaluación del gobierno. Las áreas protegidas se contrastaron con respecto al nivel de administración y a una lista de atributos que podrían dar lugar a diferencias en la eficacia de la gestión entre áreas. Examinamos la relación entre los atributos de las áreas protegidas y la eficacia media utilizando modelos lineales. También se relacionaron los mismos atributos con los elementos de gestión, a saber, contexto, planificación, insumos, procesos y resultados, mediante análisis de redundancia. Se observó que la eficacia de la gestión y las puntuaciones de los elementos de gestión eran inferiores en las áreas cuya tenencia de la tierra no estaba resuelta, que carecían de planes de gestión o de planes actualizados, que estaban sometidas a muchas presiones y amenazas o que estaban bajo administración estatal. En general, sugerimos que las áreas protegidas federales obtienen mejores resultados en al menos estos atributos o en una combinación de atributos no bien captados por indicadores individuales que las áreas protegidas de ámbito estatal. Deberían llevarse a cabo reevaluaciones periódicas en todos los niveles de administración con el fin de detectar eficazmente un obstáculo, eliminarlo e identificar el siguiente que debe abordarse.

RÉSUMÉ

Nous avons évalué l'efficacité de la gestion des zones protégées et identifié les caractéristiques qui limitent l'efficacité de 21 zones protégées dans l'État de Santa Catarina, au sud du Brésil. Parmi celles-ci, nous avons évalué 10 zones administrées au niveau de l'État pour lesquelles aucune évaluation standardisée n'avait été réalisée auparavant. Pour les 11 zones protégées sous administration fédérale, nous avons obtenu des données d'évaluation de la part du gouvernement. Les zones protégées ont été comparées en fonction du niveau d'administration et d'une liste d'attributs susceptibles d'entraîner des différences d'efficacité de gestion entre les zones. Nous avons examiné la relation entre les attributs des zones protégées et l'efficacité moyenne à l'aide de modèles linéaires. Les mêmes attributs ont également été mis en relation avec les éléments de gestion, à savoir le contexte, la planification, les intrants, les processus et les résultats, à l'aide d'une analyse de redondance. L'efficacité de la gestion et les scores des éléments de gestion se sont avérés plus faibles pour les zones dont le régime foncier n'est pas résolu, qui n'ont pas de plans de gestion ou qui n'ont pas été mis à jour, qui sont soumises à de nombreuses pressions et menaces, ou qui sont administrées au niveau de l'État. Dans l'ensemble, nous suggérons que les zones protégées fédérales obtiennent de meilleurs résultats que les zones protégées au niveau de l'État pour au moins ces attributs ou une combinaison d'attributs qui ne sont pas bien pris en compte par des indicateurs uniques. Des réévaluations devraient être effectuées régulièrement à tous les niveaux d'administration afin de signaler efficacement un obstacle, de le supprimer et d'identifier le prochain obstacle à franchir.