MANAGEMENT EFFECTIVENESS AND DEFORESTATION IN PROTECTED AREAS OF THE BRAZILIAN AMAZON

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ABSTRACT
The establishment and management of protected areas are critical strategies for biodiversity conservation and preventing tropical forest loss. We analysed 2020 management effectiveness data from Brazil's SAMGe evaluation platform in 133 areas of the Brazilian Amazon under varying deforestation pressures. We did not find any significant correlation between overall management effectiveness and deforestation, whereas distance to roads was negatively correlated. There is a higher occurrence of prohibited uses and fewer encouraged uses within highly deforested protected areas. Moreover, most of these areas also presented higher equipment expenditure scores, suggesting that resources are allocated towards protection actions. Most deforestation is likely driven by opportunity, as highly perturbed locations are generally much less isolated than those with very low deforestation scores. To avoid forest loss, complementary strategies that reduce the external forces leading to deforestation must urgently be implemented.

Key words: biodiversity conservation, environmental policies, management effectiveness assessment

INTRODUCTION
The creation of protected areas is a key strategy for biodiversity conservation worldwide (Hockings et al., 2006; Maxwell et al., 2020). Studies have evidenced their effectiveness as shields against deforestation (Joppa & Pfaff, 2011; Spracklen & Garcia-Carreras., 2015; Shah et al. 2021), although they vary in their protection capacity because of location characteristics, governance structure, local economic growth, and intensity of surrounding agricultural activity (Shah et al., 2021).

Recently, the creation of protected areas in Brazil has not only stalled, but there now is substantial political pressure for their reduction, downgrading or elimination altogether (known as the PADDD process; Pack et al., 2016; Tesfaw et al., 2018). The undermining of biodiversity conservation policies in Brazil during 2019 and 2020 saw a consequent advance in deforestation and setbacks in the implementation of multiple monitoring and law enforcement instruments (Amigo, 2020; Lovejoy & Nobre, 2019). This resulted in the highest rates of Amazon deforestation in the last 12 years, with more than 10,000 km² of cover lost in 2019 and similar rates in 2020 (INPE, 2021). This period has thus seen a substantial retrogression in comparison to the deforestation trends of the 2000s.

In the Brazilian Amazon, protected areas cover more than 2.4 million km² and serve as shields against the advancing deforestation frontier (Baragwanath & Bayi, 2020; Walker et al., 2020; Pfaff et al., 2015). These areas include two types of protected area recognised by Brazilian legislation: conservation units and Indigenous lands. The former have the fundamental objective of protecting biodiversity and are governed by the National System of Conservation Units, within the scope of environmental policy (Supplementary Online Material (SOM)). Indigenous lands have specific regulations within the scope of Indigenous policy and aim to preserve native ways of life (SOM text S1). Both are important to protect the forest and maintain climate stability in a global context (Walker et al., 2020; Nolte et al., 2013) and must be effectively managed to ensure they are fulfilling their role.

The impact and function of protected areas in conservation science and practice can be quantified using management effectiveness assessments (Maxwell et al., 2020), which have been incorporated into the international biodiversity conservation goals (Aichi Targets under the Convention on Biological Diversity, for 2011 to 2020). Post-2020 conservation targets are defined under the Global Biodiversity Framework, which recognises in its third target that the mere creation of protected areas is insufficient to guarantee the fulfilment of their conservation objectives (CBD, 2021). Thus, management effectiveness is a relevant indicator of protected territories' ability to adapt to land use challenges and effectively address pressures and long-term threats in addition to generating their expected benefits (Geldmann et al., 2015).

There are some 69 different tools applied around the world to assess the management effectiveness of protected areas (UNEP-WCMC & IUCN, 2021). Despite some similarities, this heterogeneity motivated the establishment of basic guidelines by IUCN that resulted in six primary indicators: context, planning, inputs, processes, products and results (Hockings et al., 2006). In Brazil, multiple management assessment tools have been introduced in recent years (Pellin & Ranieri, 2016). Recently, the Management Analysis and Monitoring System (SAMGe, in Portuguese) has stood out because of its institution-wide use by the Chico Mendes Institute for Biodiversity Conservation (ICMBio), the federal agency responsible for conservation units' management (ICMBIO, 2019; SOM text S1).

Government agencies can use management assessments to identify priority actions by analysing a given protected area's scores (Coad et al., 2015). The use of these assessments became commonplace in the early 2000s (Coad et al., 2015). Brazil's SAMGe online assessment (created in 2016) currently uses six indicators corresponding to the IUCN management elements. It is populated with data annually by protected area managers, ideally following a participatory process. Records combine field data relevant to the protected areas' goals, biodiversity status, management actions and identified threats (ICMBIO, 2019). Its score is based on attainment of the protected area goals, with consideration to the interaction of conservation targets (e.g. endangered species or habitats), societal use and management initiatives (SOM, Figure S1). Each indicator and the overall effectiveness score are calculated from 0 (worst) to 1 (best scenario). Thus, management can be classified as not effective (0 to 0.2), of reduced effectiveness (0.2 to 0.4), moderately effective (0.4 to 0.6), effective (0.6 to 0.8) or highly effective (0.8 to 1).

The SAMGe evaluation also requires the inventorying of encouraged, allowed and prohibited activities occurring within the protected area (ICMBIO, 2019). Encouraged uses are expressly described in the protected area system legislation or the management instruments/ strategies required to achieve conservation goals (ICMBIO, 2019). They include uses that are also conservation goals, such as sustainable tourism or research activities in national parks (ICMBIO, 2019). SAMGe shares a limitation with other tools in that it ultimately depends on managers' perceptions (Coad et al., 2015; Geldmann et al., 2021). Nevertheless, it is a valuable contribution to protected area metrics that otherwise would not be available and that, combined with ecological indicators, can inform the protected areas impact and promote effective area-based conservation strategies. This study evaluates whether deforestation within protected areas is related to management effectiveness scores and whether individual management indicators differed considering different deforestation intensities. We also identify patterns in protected area resource use that may be associated with the threat of deforestation.

METHODS

Protected areas

The Legal Amazon covers approximately 5 million km², including all states of Brazil's northern region (Acre, Amazonas, Amapa, Para, Rondonia, Roraima and Tocantins), Mato Grosso state and part of Maranhao state. This is equivalent to 59 per cent of Brazil's territory (Santos et al., 2021). Brazilian protected areas, in the form of conservation units, cover 22.17 per cent of the Legal Amazon, totalling approximately 1.3 million km² (CNUC, 2020).

Conservation units are divided into two groups. Strictly protected areas aim to preserve nature and only allow indirect use of natural resources (corresponding to IUCN protected area categories I, II and III). Sustainable use units incorporate nature conservation with the sustainable use of natural resources (corresponding to IUCN categories IV, V and VI). Herein, protected areas are analogous to conservation units, as they are the sole type of protected area evaluated by the SAMGe platform (see text S1 for Brazilian protected area types).

The criteria for inclusion were that the protected area be located within the Legal Amazon, have undergone a 2020 management effectiveness assessment with the SAMGe tool (this encompasses about 40 per cent of all Amazon protected areas), and have spatial delimitation data available in the public National Register of Conservation Units (CNUC, 2020). Protected areas meeting these criteria are listed in Table 1.

Deforestation and management effectiveness

Management effectiveness data from the SAMGe platform[1] consisted of assessments from 133 Amazon protected areas during 2020 (125 federal and 8 state managed areas) (SAMGe, 2020). We chose SAMGe for

Table 1. Protected areas included in the analysis

Brazilian management categories	Brazilian management group	IUCN category	Number of areas with SAMGe assessment	Area covered by category (in km²)	Governance regime
Biological reserve	Strictly protected	Category Ia	11	39,972.03	By government
Ecological station	Strictly protected	Category Ia	11	62,281.72	By government
Park	Strictly protected	Category II	21	176,846.81	By government
Area of relevant ecological interest	Sustainable use	Category IV	3	189.31	Shared governance
Environmental protection area	Sustainable use	Category V	7	22,732.21	Shared governance
Forest	Sustainable use	Category VI	34	196,144.53	Shared governance
Sustainable development reserve	Sustainable use	Category VI	1	8,735.77	Shared governance
Extractive reserve	Sustainable use	Category VI	45	126,140.10	Shared governance
Total			**133**	**630,494.92***	

* Total area discounting overlaps.

this study due to both the availability of current and accessible data and to the assessment structure having a clear link with each area's conservation targets. We evaluated the overall effectiveness scores, each of the six indicator scores (context, planning, inputs, processes, results, and outputs and services), and the types of use reported for each area (encouraged, allowed and prohibited uses).

To identify deforestation rates in the 133 protected areas, the geographic databases of their locations were cross-referenced with data from the MapBiomas monitoring project. The MapBiomas system validates and refines deforestation alerts with high-resolution images for native vegetation in all Brazilian biomes (SOM text S1, MapBiomas, 2020). Deforestation alerts for 2020 are catalogued for areas greater than 0.1 km²; zero deforestation was considered for areas with lower levels. We also calculated the mean distance of each protected area from roads based on data from the Institute of Man and the Environment of the Amazon[2] .

To assess whether deforestation within protected areas in 2020 was related to overall management effectiveness scores or to road accessibility, we applied a Kendall partial correlation test considering deforestation levels in 2020, management effectiveness in 2020 and average distance from roads. The Kendall method is suitable for data with non-normal distribution and with a high incidence of repeated values (Akoglu, 2018).

To assess if management components differ between protected areas with differing levels of deforestation, we divided protected areas into three categories: areas without detected deforestation (76 areas); areas with below-average deforestation (< 2.08 km², 40 areas); and areas with above-average deforestation (>2.08 km²,

A deforested forest fragment © FreeImage

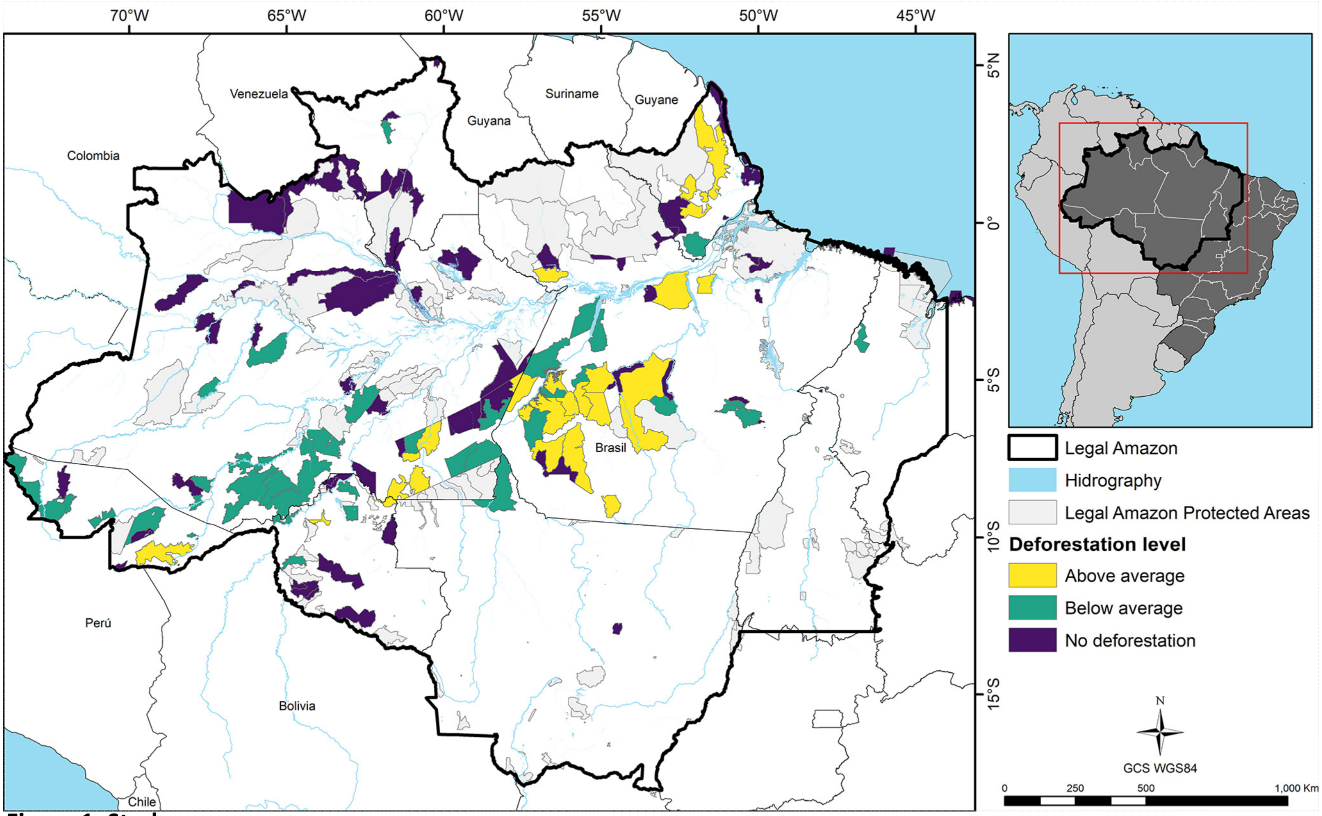

Figure 1. Study area

17 areas) (Figure 1). As deforestation varied strongly among protected areas, this classification allowed us to compare unthreatened areas and areas with two distinct levels of pressure: least versus most affected.

The effect of deforestation rate on each management effectiveness indicator was investigated in relation to the three classes of protected area defined above: without detected deforestation, with below-average deforestation, and with above-average deforestation. We used one-way ANOVA for data with normal distribution and Kruskal-Wallis for data with non-normal distribution to evaluate difference between groups. Data normality was verified through the Shapiro-Wilk test and the homogeneity of variances using Levene's test. For all tests, a significance level of 0.05 was considered.

Finally, we examined the frequencies of encouraged, allowed and prohibited uses in each of the protected area classes in order to identify patterns in reported protected area uses that might be associated with deforestation threat. All analytical procedures were performed using the R software (R Core Team, 2021).

RESULTS

In the 133 areas studied, total deforestation was 276.63 km² in 2020, with 226.37 km² occurring within 90 sustainable use protected areas (0.06 per cent of this group's total area) and 50.26 km² within the 43 strictly protected areas (0.01 per cent of this group's total area). Among the former, national and state forests experienced 160.90 km² of deforestation, environmental protection areas 37.79 km², and extractive reserves 27.54 km². Taking the total number of 330 Amazon conservation units, they registered 1,299.8 km² of deforestation in 2020 (MapBiomas, 2020). Thus, whereas our sample represents 40 per cent of Amazon protected areas, it only encompasses 21 per cent of protected area deforestation, suggesting that SAMGe may be applied primarily in less deforested areas. Moreover, the total deforestation in protected areas is a small fraction of the biome's entire deforestation of approximately 8,430 km², where private land comprises the majority (MapBiomas, 2020). Deforestation ranged from 0 (in the 76 areas) to 85.16 km² (SD = 9.15) in the 17 areas with higher-than-average deforestation (Table 2; 12.78 per cent of the total). The average rate of deforestation for protected areas overall was 0.03 per cent (SD = 0.11). Thus, most of the deforestation took place within a few protected areas.

The overall average management effectiveness score of the 133 protected areas was 54.09 per cent (SD = 8.46), 54.9 per cent (SD = 6.97) for strictly protected areas and 53.7 per cent (SD = 9.10) for sustainable use areas. Thus, most protected areas evaluated show similar and

Table 2. Effectiveness and deforestation values in the 17 most deforested Amazon protected areas

Area name	State	Effectiveness	Deforestation (km²)	Per cent deforestation
Jamanxim's National Forest	Para	51.65	85.16	0.65
Altamira National Forest	Para	61.24	42.90	0.59
Tapajós Environmental Protection Area	Para	50.51	37.43	0.18
Nascentes Serra do Cachimbo Biological Reserve	Para	47.88	22.32	0.65
Chico Mendes Extractive Reserve	Acre	59.41	17.21	0.18
Terra do Meio's Ecological Station	Para	47.13	10.33	0.03
Jamanxim's National Park	Para	56.67	9.52	0.11
Itaituba II National Forest	Para	51.86	6.88	0.17
Saraca-Taquera's National Forest	Para	50.48	4.24	0.10
Bom Futuro's National Forest	Rondonia	51.82	3.96	0.40
Campos Amazônicos's National Park	Amazonas Rondonia Mato Grosso	52.49	3.72	0.04
Amapa's State Forest	Amapa	52.79	2.85	0.01
Riozinho do Anfrísio Extractive Reserve	Para	60.90	2.78	0.04
Amana's National Forest	Para	46.42	2.51	0.04
Verde Para Sempre Extractive Reserve	Para	58.97	2.37	0.02
Caxiuana's National Forest	Para	52.68	2.32	0.07
Aripuana's National Forest	Amazonas	40.44	2.20	0.03

moderate effectiveness scores (SOM Figure S1), possibly because they are managed by the same federal agency and thus have the same institutional and legal structure and share the same management guidelines.

We found no correlation between the overall effectiveness results and deforestation ($p = 0.57$), but a negative correlation between deforestation and distance from roads ($r = -0.2$; $p < 0.001$).

The overall management effectiveness score was not significantly different among our three deforestation categories. In areas without deforestation, the average was 54.92 per cent (SD = 7.73), in areas below-average 53.18 per cent (SD = 10.56) and in areas above-average 52.55 per cent (SD = 52.55). Among the latter, 15 have moderate management effectiveness (between 40 per cent and 60 per cent) and two have high effectiveness (> 60 per cent) (Table 2), suggesting that even well managed areas experienced deforestation in 2020.

The variance in the most deforested areas is smaller for the context indicator, oscillating close to the average of 44 per cent. Other indicators presented greater variability (SOM Figure S2). The indicator most associated with high and moderate effectiveness values in the 17 most deforested areas is inputs, which stands out as the best rating in 12 of the 17 areas. Among the 17 areas with the highest deforestation rates, 12 are in Para state.

There was no difference between the three deforestation classes and individual management indicators ($p > 0.05$ in all tests). Figure 2 and Table 3 present results for each group of management effectiveness indicators for the three deforestation categories. Table 3 presents the management indicator values with their respective averages for the three deforestation classes and specific values referring to the 17 most deforested areas in this study.

Considering the individual components of the input indicator (external support, technical capacity, equipment, staff number and financial resources), there was a statistical difference for the equipment value, Kruskal-Wallis test ($X^2(2) = 6.35$; $p < 0.05$) (Figure 3). For this indicator, areas without deforestation scored significantly lower than areas with above-average deforestation (Dunn's post-hoc test, $z = 2.36$; $p < 0.05$).

We found that in areas with above-average deforestation, prohibited uses accounted for 42.8 per cent of all uses, 37.9 per cent were allowed uses and 18.5 per cent encouraged uses. In other protected area classes, the most prominent are allowed uses (42.6 per cent), followed by encouraged (26.2 per cent) and prohibited (26.42 per cent) uses.

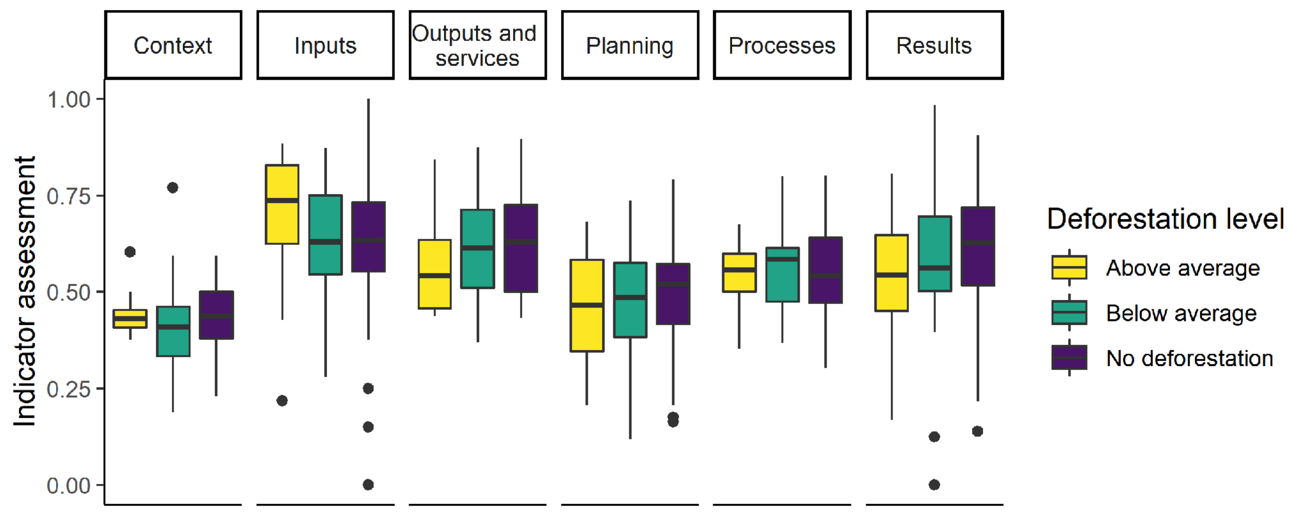

Figure 2. Results for each management indicator in the deforestation categories. There was no statistical difference between these indicators by deforestation category

Table 3. Values of each management indicator for the 17 most deforested Amazon protected areas

Area	Context	Planning	Inputs	Processes	Results	Outputs and services
Jamanxim's National Forest	0.41	0.36	0.84	0.60	0.51	0.46
Altamira National Forest	0.47	0.61	0.87	0.60	0.63	0.54
Tapajós Environmental Protection Area	0.39	0.29	0.78	0.66	0.46	0.54
Nascentes Serra do Cachimbo Biological Reserve	0.40	0.29	0.70	0.57	0.41	0.58
Chico Mendes Extractive Reserve	0.50	0.68	0.52	0.68	0.80	0.45
Terra do Meio's Ecological Station	0.41	0.48	0.72	0.47	0.28	0.53
Jamanxim's National Park	0.50	0.45	0.84	0.63	0.54	0.49
Itaituba II National Forest	0.45	0.35	0.88	0.61	0.45	0.46
Saraca-Taquera's National Forest	0.42	0.47	0.74	0.45	0.56	0.44
Bom Futuro's National Forest	0.43	0.28	0.63	0.56	0.49	0.84
Campos Amazônicos's National Park	0.43	0.35	0.69	0.52	0.59	0.64
Amapa's State Forest	0.60	0.60	0.22	0.35	0.81	0.69
Riozinho do Anfrísio Extractive Reserve	0.38	0.58	0.83	0.52	0.75	0.68
Amana's National Forest	0.43	0.21	0.79	0.60	0.40	0.50
Verde Para Sempre Extractive Reserve	0.44	0.62	0.77	0.50	0.65	0.60
Caxiuana's National Forest	0.42	0.51	0.43	0.45	0.65	0.75
Aripuana's National Forest	0.43	0.47	0.50	0.52	0.17	0.44
Average for areas with above-average deforestation	**0.44**	**0.45**	**0.69**	**0.55**	**0.54**	**0.57**
Average for areas with below-average deforestation	**0.40**	**0.48**	**0.62**	**0.55**	**0.59**	**0.62**
Average for areas without deforestation	**0.43**	**0.50**	**0.64**	**0.55**	**0.62**	**0.63**

DISCUSSION

Amazon protected areas are bulwarks against the advancing deforestation frontier. The proportion of forest clearing in these regions is considerably lower than in unprotected areas (Pfaff et al., 2015; Assunção & Gandour, 2018; Alves-Pinto et al., 2022). Most protected areas analysed herein have negligible deforestation rates. However, those that are more

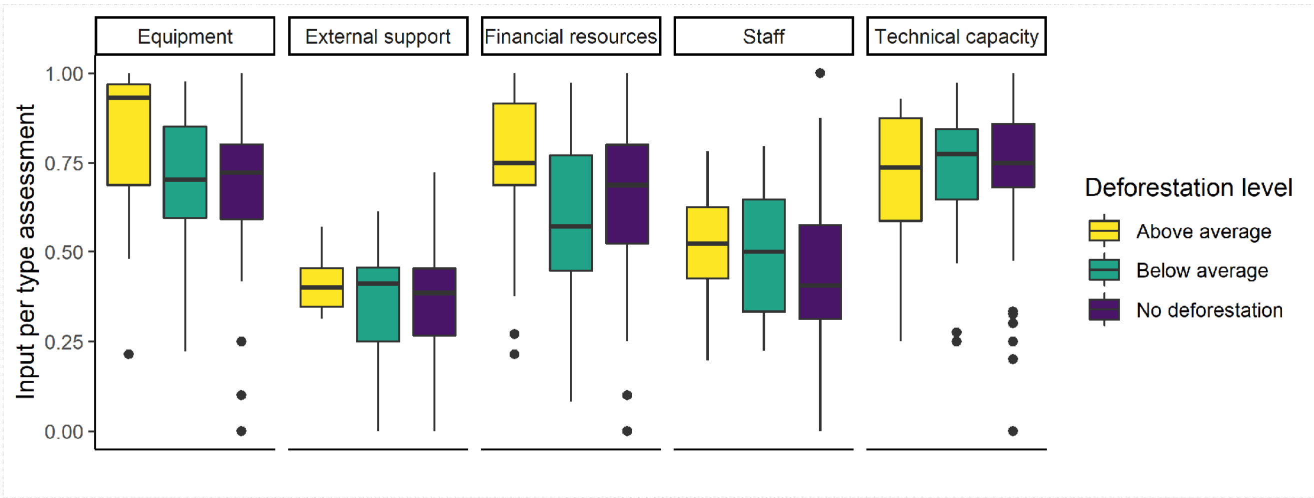

Figure 3. Results for each component of the input indicator in deforestation categories. There is a statistical difference only in equipment between areas without deforestation and with above-average deforestation.

impacted may still have moderate or high management effectiveness scores. Even in the most affected areas, we postulate that potential for perturbations would be substantially greater in the absence of protection (Baragwanath & Bayi, 2020; Walker et al., 2020; Alves-Pinto et al., 2022).

The analysed protected areas presented mostly moderate overall management effectiveness regardless of their status as either strict protection or sustainable use. Thus, management indicators were not related to deforestation, whilst accessibility by roads had a positive correlation. Deforestation levels are likely associated with specific combinations of territorial and management characteristics in each protected area, such as the influence of large infrastructure projects and advancement of the agricultural frontier (Gullison & Hardner, 2018). Thus, external forces may be more determinant of forest loss than attributes expressed in management effectiveness assessments, explaining the lack of correlation found in this and previous studies (Nolte & Agrawal, 2013). For example, 12 of the 17 most

Discussions with residents of a Brazilian protected area © IPÊ

deforested protected areas are in Para state, the most deforested of Brazil's Amazon states (MapBiomas, 2020).

In addition to improving protected area management, complementary policies, such as inspection and monitoring via satellite, are crucial. Monitoring and law enforcement effectively reduce illegal logging, as they quickly identify deforested areas and increase financial penalties (Gandour & Assunção, 2019). The strategic performance of surveillance monitoring has already avoided the loss of 27,000 km² of forest per year in the Brazilian Amazon (Gandour & Assunção, 2019).

Our results reinforce the tenuous relation between management effectiveness and tangible conservation outcomes (Geldmann et al., 2021; Coad et al., 2015). In our analysis, deforestation was detected in only a few areas and management indicators did not vary strongly between protected area categories. Thus, we did not identify differences in management indicators that reflected deforestation levels. Moreover, the most deforested areas generally still had moderate effectiveness scores. A similar pattern was found in Mexico, where areas with high effectiveness scores also presented higher deforestation because of their location (Powlen et al., 2021). Whereas Mexican protected areas with high management effectiveness had more success in reducing forest clearing, in the Brazilian protected areas evaluated herein, deforestation is likely determined by opportunity.

Protected areas with higher deforestation rates also presented higher rates of prohibited uses and lower rates of encouraged uses. While some uses may not impact conservation goals, some have the potential to decrease habitat ecological integrity, for example, livestock, farming and land grabbing. This demonstrates that law enforcement is not only failing to combat deforestation, but also other illegal activities. Moreover, these areas also presented a lower rate of uses that directly contribute to the achievement of management goals, such as scientific research and ecological tourism. This may be related to management efforts being focused on combating threats rather than producing benefits.

Protected areas with higher deforestation rates also presented higher scores in the input element of equipment. This may indicate that, in some cases, essential attributes for management are a consequence of the pressures within the territory, rather than reflecting its performance in containing forest loss. Thus, increased threats from deforestation would pressure managing agencies to allocate equipment to face those pressures. Many of the areas analysed receive long-term funding from the Amazon Region Protected Areas Program (ARPA), which does not provide resources for technical staff (a responsibility left to the public managing agencies) (Silva & Bueno, 2017). We thus found a significant difference between the components of the input indicator, which had higher values for equipment and financial resources, and lower values for technical staff. According to 2020 data from the ICMBio Workforce Panel (ICMBIO, 2021), only 219 employees were allocated to 125 federal protected areas covering more than 620,000 km² in northern Brazil. This translates to a ratio of 1.75 employees per protected area, or more than 2,840 km² per employee, and highlights the shortage of human resources within Amazon protected areas. Despite the low number of employees per area, the input indicator revealed that the available employees had adequate technical capacity to meet protected area management needs. This conclusion deserves special attention since technical capacity has previously been associated with the ecological functioning of protected areas (Geldmann et al., 2018).

We provide evidence that expanding management effectiveness does not necessarily translate into reduced short-term deforestation as the allocation of resources can initially result in increased effectiveness before the results of management actions are observed. In addition, external forces beyond the control of managing agencies have a significant impact on protected areas' capacity to confront deforestation and can be more decisive than management aspects (Shah et al., 2021). Nevertheless, the literature reinforces the importance of management quality in generating conservation impacts and ensuring socio-economic benefits (Oldekop et al., 2016; Geldmann et al., 2018). In addition, monitoring and surveillance policies are essential to ensure an effective reduction in deforestation driven by opportunity in the Amazon biome.

CONCLUSION

Although protected areas are essential for Amazon conservation, we did not find a significant correlation between management effectiveness and deforestation in the areas studied. Deforestation occurred in few areas and management effectiveness scores were generally low regardless of deforestation level. In other words, where outside pressures are high and opportunity exists, protected areas are not able to withstand deforestation. Resources do seem to be allocated to address deforestation, suggesting that management action may translate into conservation results only after a longer period of time. Most deforested areas were also more impacted by illegal resources uses other than deforestation and reported fewer activities related to their main goals (i.e., the delivery of results to conservation and to society).

Finally, we show that allocating resources is important to the effectiveness of the Amazon protected areas system. However, in order to assure the effective fulfilment of its creation goals and the provision of services to society, the most deficient elements of the management cycle must be improved. Furthermore, containing deforestation rates requires monitoring and surveillance actions to reduce external forces that threaten these territories.

ENDNOTES

[1] http://samge.icmbio.gov.br/#resultados
[2]Imazon; https://www.imazongeo.org.br/#/

SUPPLEMENTARY ONLINE MATERIAL

Supplementary text and figures

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RESUMEN

El establecimiento y la gestión de áreas protegidas son estrategias fundamentales para la conservación de la biodiversidad y la prevención de la pérdida de bosques tropicales. Analizamos los datos de eficacia de la gestión de 2020 de la plataforma de evaluación SAMGe de Brasil en 133 áreas de la Amazonia brasileña sometidas a distintas presiones de deforestación. No encontramos ninguna correlación significativa entre la eficacia general de la gestión y la deforestación, mientras que la distancia a las carreteras estaba correlacionada negativamente. Hay una mayor presencia de usos prohibidos y menos usos fomentados dentro de las áreas protegidas altamente deforestadas. Además, la mayoría de estas áreas también presentaron puntuaciones más altas en cuanto a gastos de equipamiento, lo que sugiere que los recursos se destinan a acciones de protección. Es probable que la mayor parte de la deforestación esté motivada por la oportunidad, ya que los lugares muy perturbados suelen estar mucho menos aislados que los que presentan puntuaciones de deforestación muy bajas. Para evitar la pérdida de bosques, es urgente aplicar estrategias complementarias que reduzcan las fuerzas externas que conducen a la deforestación.

RÉSUMÉ

La création et la gestion des zones protégées sont des stratégies essentielles pour la conservation de la biodiversité et la prévention de la disparition des forêts tropicales. Nous avons analysé les données sur l'efficacité de la gestion en 2020 provenant de la plateforme d'évaluation brésilienne SAMGe dans 133 zones de l'Amazonie brésilienne soumises à diverses pressions de déforestation. Nous n'avons pas trouvé de corrélation significative entre l'efficacité globale de la gestion et la déforestation, alors que la distance aux routes était négativement corrélée. Il y a une plus grande occurrence d'utilisations interdites et moins d'utilisations encouragées dans les zones protégées fortement déforestées. De plus, la plupart de ces zones présentent également des scores de dépenses d'équipement plus élevés, ce qui suggère que des ressources sont allouées aux actions de protection. La majeure partie de la déforestation est probablement due à l'opportunité, car les endroits fortement perturbés sont généralement beaucoup moins isolés que ceux dont les scores de déforestation sont très faibles. Pour éviter la disparition des forêts, il est urgent de mettre en œuvre des stratégies complémentaires qui réduisent les forces externes conduisant à la déforestation.