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Research Letters

Effectiveness of community-based monitoring projects of terrestrial game fauna in the tropics: a global review

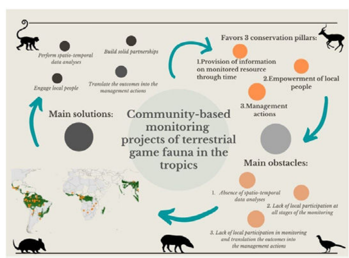
Yasmin Maria Sampaio dos Reis*, Maíra Benchimol

Applied Ecology and Conservation Lab, Programa de Pós-graduação em Ecologia e Conservação da Biodiversidade, Universidade Estadual de Santa Cruz, Rodovia Ilhéus-Itabuna, km 16, Salobrinho, 45662-000 Ilhéus, Bahia, Brazil

HIGHLIGHTS

- We identified 52 community-based monitoring projects on game terrestrial fauna in the tropics.
- Most of these initiatives (86%) were interrupted due the lack of funding.
- The absence of spatio-temporal data analyses prevented the provision of information on monitored resource.
- The empowerment and management actions were hampered by the lack of local participation.
- Community-based approaches will be more efficient if they engage local people at all stages of the monitoring.

GRAPHICAL ABSTRACT



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ABSTRACT

Biodiversity monitoring projects comprise key conservation strategies established to minimize biodiversity loss. Particularly, community-based monitoring projects have recently been implemented worldwide. This approach favors three conservation pillars: provision of information on monitored resource through time, local people's empowerment, and management practices. We conducted a systematic literature review to identify all past and current community-based monitoring projects of terrestrial game fauna in the tropics, and specifically examined seventeen of those projects in terms of costs, interruption and effectiveness. We identified a total of 52 projects, mostly located in the Amazon. We revealed an annual cost of US$0.24/hectare/project, with most of these initiatives interrupted due the lack of funding. We also noticed that the absence of data analyses comprised the main obstacle for the assessment on monitored game fauna through time, while empowerment was hampered by the lack of intensive local participation at different stages of monitoring. Finally, we observed that most management actions resulted in community rules and applications, including local bylaws governing resource use. We highlight that community-based programs can be more effective if they engage local people at all monitoring stages, build solid partnerships to ensure long-term funding and translate the outcomes into management practices for the monitored fauna.

Introduction

Biodiversity monitoring comprises a fundamental step towards species conservation worldwide, as it allows to detect popula-

* Corresponding author.
E-mail addresses: yasmin.sampaioreis@gmail.com (Y.M. Reis), mairabs02@gmail.com (M. Benchimol).

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tion changes over time (Lindenmayer & Likens, 2010). Those well elaborated monitoring projects, in which goals and study design are clearly defined (Yoccoz et al., 2003), can provide long-term information on the status and trends of target species and/or natural resources through time, and inform appropriate management actions (Danielsen et al., 2005). Specially in tropical forests, which hold the richest biodiversity on Earth, biodiversity monitoring is one of the main conservation tools established to detain the current biodiversity loss resulting from a myriad of anthropogenic activities, including habitat destruction, climate warming and the overexploitation of wildlife (Veiga and Ehlers, 2003). Assessing the main obstacles and contributions of monitoring projects throughout systematic review can provide useful information to enhance success for both existing and future programs across the tropics.

Over the last two decades, community-based monitoring projects (i.e., conducted by local people) have been implemented in several tropical ecosystems (Danielsen et al., 2021). This approach has been debated among researchers who question their ability to deal with sampling error and thus producing reliable inference to monitored populations (Yoccoz et al., 2003; Burton, 2012), and those who recognize the extensive knowledge of local people and defend its potential as could favor three conservation pillars — (i) provision of information on monitored resource through time, (ii) empowerment of local stakeholders and (iii) implementation of management actions (Danielsen et al., 2021). Empowerment can be defined as a participatory process through which local people gain greater influence over their lives and acquire improved management over used natural resources (Maton, 2008).

In tropical protected areas, which are mainly located in emerging countries, the establishment of biodiversity monitoring projects has been hampered by low financial and human resources (Danielsen et al., 2009). In addition, there are cases where the government still cuts funding to scientific and academic endeavors, as recently seen in Brazil (Tollefson, 2019). In such realities, the community-based approach poses as a cost-effective conservation initiative that seeks to encourage the community involvement, meet local needs, and strengthen existing local systems for the monitoring and managing of natural resources (Danielsen et al., 2003). Indeed, community-based initiatives are gaining prominence in those protected areas managed collaboratively with local people, where understanding the main threats to species and/or natural resources used by residents is fundamental for proposing further mitigation actions (Luzar et al., 2011). In Tanzania, for instance, 181 management interventions were recommended based on outcomes provided by a community-based monitoring program focused on fauna and flora (Topp-Jørgensen et al., 2005). In western Amazonia, the community-based monitoring of the world's largest scaled freshwater fish (*Arapaima* cf. *gigas*) was reflected in the population recovery of the species even outside protected areas, revealing that management performed by local communities can effectively promote biodiversity conservation and empower local people (Campos-Silva et al., 2019).

Medium to large-sized mammals and birds comprise two of the main target groups in monitoring programs across tropical forests. Both represent most of forest vertebrate biomass (Peres, 2000), play key roles in forest functionality, and provide several ecosystem services (Bogoni et al., 2020). Yet they are also the main targets of hunters, with several species having succumbed locally until population depletion in hunted forest sites, mainly in Africa and Asia (Benítez-López et al., 2017). Indeed, mammal species diversity has been locally reduced in nearby villages of Gabon due to hunting, with large and hunted species being most frequently recorded far from the villages (Beirne et al., 2019). Conversely, studies in the Amazon have shown that terrestrial vertebrate populations can be more resilient to hunting (e.g., Iwamura et al., 2014), as humans have been intensively hunting for many years but animal populations are not extirpated. This is likely because many vast upland areas remain inaccessible to hunters, generating a positive source-sink dynamic that can rescue overharvested populations in heavily hunted areas (Antunes et al., 2016; Pereira et al., 2019). For this, Fragoso and colleagues (2016) emphasized the need to use robust and accurate methodologies to properly assess hunted vertebrate populations and propose adequate management actions.

Analyzing the extent to which community-based wildlife monitoring is effective in achieving the three conservation pillars (provision of information on monitored resource through time, empowerment of local people and implementation of management actions) is fundamental to identify both limitations and positive outcomes from already performed projects. We contribute to this discussion by conducting a systematic literature review to identify, map and examine both existing and previous community-based monitoring projects (i.e., minimum of one year of monitoring) of terrestrial game forest species in the tropics. In particular, we assess the main causes of monitoring interruptions, compared the annual costs and analyzed the effectiveness of each project through the analysis of strategies used to promote the three conservation pillars (see our objectives in the Table S1). In addition, we identify the obstacles faced by each initiative and discuss how community-based monitoring projects focused on terrestrial game fauna can be improved and therefore better achieve success.

Material and methods

Data source and analysis

We conducted a literature search to identify published and unpublished studies on community-based monitoring projects for terrestrial game fauna (i.e., frequently hunted medium to large-sized forest mammals and/or birds) in the tropics. We considered community-based monitoring projects, those occurring for at least one year, where local people (traditional groups or local rangers) were directly involved in data collection. Using Scopus and Google Scholar bibliographic databases, we performed searches until March 2022 using different keywords in English: program OR project AND participatory OR community OR community base OR citizen science AND monitoring AND mammal * OR vertebrate * OR bird * OR hunting. Subsequently, searches were made on Google Scholar using the same keywords translated into Portuguese and Spanish. Both scientific articles and grey literature (i.e., technical reports, dissertations and thesis) were searched. Given that the literature search failed in identifying some studies, we further included additional studies that we were previously aware of. As a criterion, the study needed to explicitly provide information on either existing or previous community-based monitoring projects focused on terrestrial game fauna (i.e., at least one game mammal or bird species). We thus carefully examined the title and abstract of each study and excluded duplicate references and non-related studies (Fig. 1). During this screening process, when more than one study for the same project was obtained, all were selected. Therefore, we ended up with 62 studies (55 publications, 2 book chapters, 1 technical series, 2 master dissertation and 2 PhD thesis) referring to 52 projects (Fig. 1). We thus extracted several information from the selected studies to achieve our objectives (Table S1).

We finally contacted by e-mail the authors and/or professionals involved on each project to obtain further information (see form consisted of open and closed questions in the Table S2). Out of 52 contacted projects, we obtained responses from 17 monitoring programs. We then carefully examined these projects in terms of interruption, average annual cost US$/project, and effectiveness. We defined that a project was effective when it adopted strategies that promoted the three conservation pillars (see Table S1).

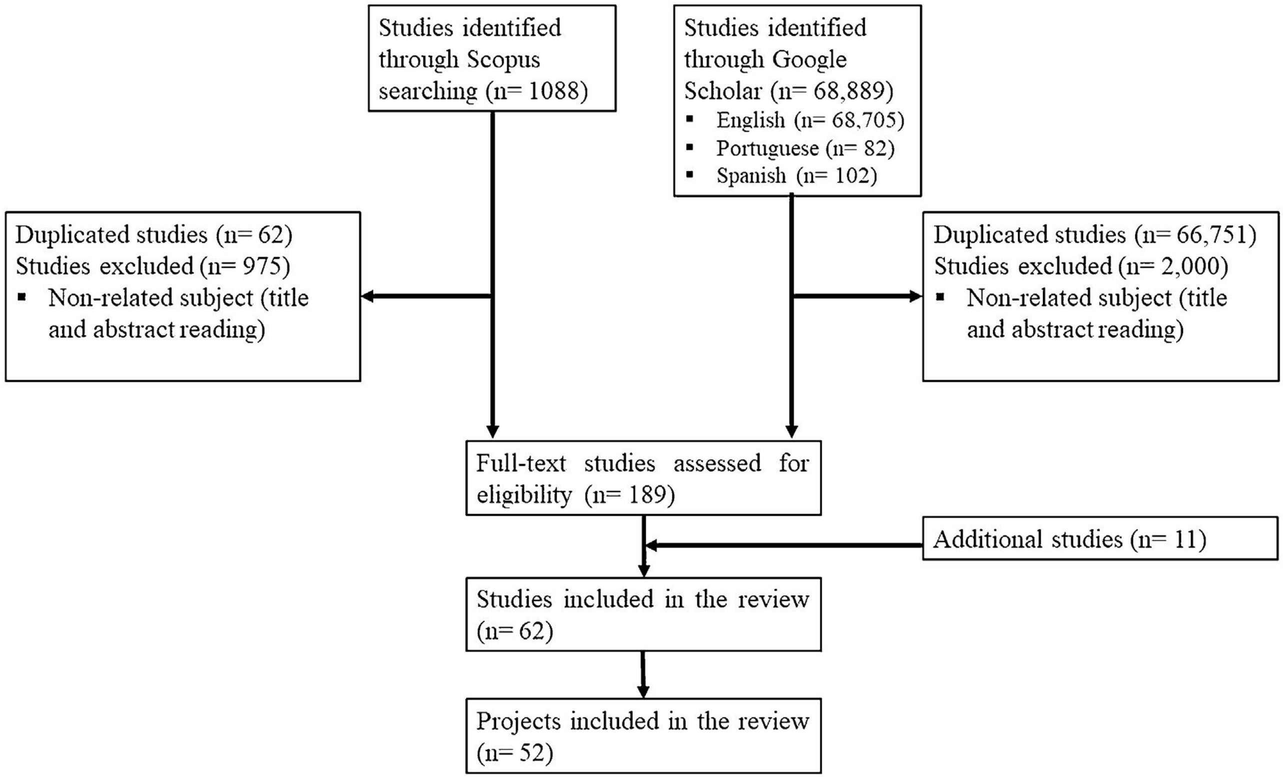

Fig. 1. Flow diagram of the dataset selection process used in our study to identify existing and past community-based monitoring projects of terrestrial game fauna in the tropics.

We are aware that both the definition and evaluation of 'effectiveness' were based on our perspective (i.e., researcher's viewpoint), which might not follow the conception of local people engaged on the monitored project.

Regarding the first pillar, we evaluated the following strategies adopted by the 17 projects: (i) spatio-temporal data analyses, (ii) percentage of tabulated data and (iii) percentage of data analyzed (using any type of analysis). The strategy (i) was scored as 1 if 'exists' and 0 if 'does not exist'. The strategies (ii) and (iii) were categorized into 4 classes (0–25%, 25–50%, 50–75%, 75–100%), and scored from 1 to 4, respectively. In addition, we evaluated the number of publications resulted from each project.

In relation to the empowerment of local stakeholders, we examined if each of the 17 projects integrated the six main strategies related to empowerment according to the literature (see Constantino et al., 2012 and Costa, 2019) - if (i) local people participated in the elaboration of the project (species definition and criteria to select local monitors), (ii) the monitored resource is a source of meat and income, (iii) adequate training (i.e., theoretical and practices classes) was provided to the monitors and (iv) local people directly participated in data entry, (v) analysis and (vi) return of the results. Each strategy was scored as 1 if 'it was adopted' and 0 if 'it was not adopted'. Lastly, we evaluated if management actions were performed based on outcomes from each program (Danielsen et al., 2021). In this case, we scored as 1 if 'exist' and 0 if 'do not exist'. Finally, we ranked the 17 monitoring projects in terms of effectiveness, based on the sum of scores considering the three conservation pillars. To obtain the total effectiveness score, the score for each pillar received a weight of 1.

Results

Of the 52 projects identified, 58% monitored both the game fauna (including mammals and birds) *in situ* and harvest aspects (Table S3). Most of these initiatives are located in South America (n = 32; Fig. 2), especially in Amazonia (n = 24), whereas other 13 projects occur in Africa, three in Asia and four in North America. In particular, we highlight that 11 Amazonian projects were identified from 10 additional studies that we were previously aware of (Fig. 1). The majority of projects recorded in our study (83%) were established in protected areas, whereas eleven were identified within unprotected areas. Moreover, we found that all projects relied on the effort of local people in data collection and most started after 2000 (n = 37). Other details are shown in Table S3.

Interruption, annual costs and effectiveness

Considering those 17 projects for which we obtained further information (see Table S4), we found that most were interrupted (65%), either after the end of the project deadline (36%) or for unexpected reasons (64%). The lack of financial resources was the main reason for unplanned interruption (86%) and temporary suspension (67%) of projects. Other reported reasons were related to COVID-19 pandemic (14%), changes in priority of project managing (7%), conflicts between community and the project's managers (7%) and change of responsible technician (7%).

Fourteen of the 17 projects provided annual costs information (Fig. 3). The mean annual cost for collecting monitoring data was US\$0.24/hectare (SD ± 0.54) per project. Yet, the annual costs substantially varied among projects, ranging from US\$5,000.00 (e.g., HPA) to US\$300,000.00 (the case of ICB). We found no relationship between the annual cost of data collection (US\$) and the approximate extent of monitored area (ha). For example, the most cost-effective project (EBS) invested US\$60,000.00 to cover an area of 16,604,500 hectares (Fig. 3).

All 17 projects used strategies to provide information on the monitored resource through time (Table S5). In particular, we found that 53% performed spatio-temporal data analysis, and 94% and 65%

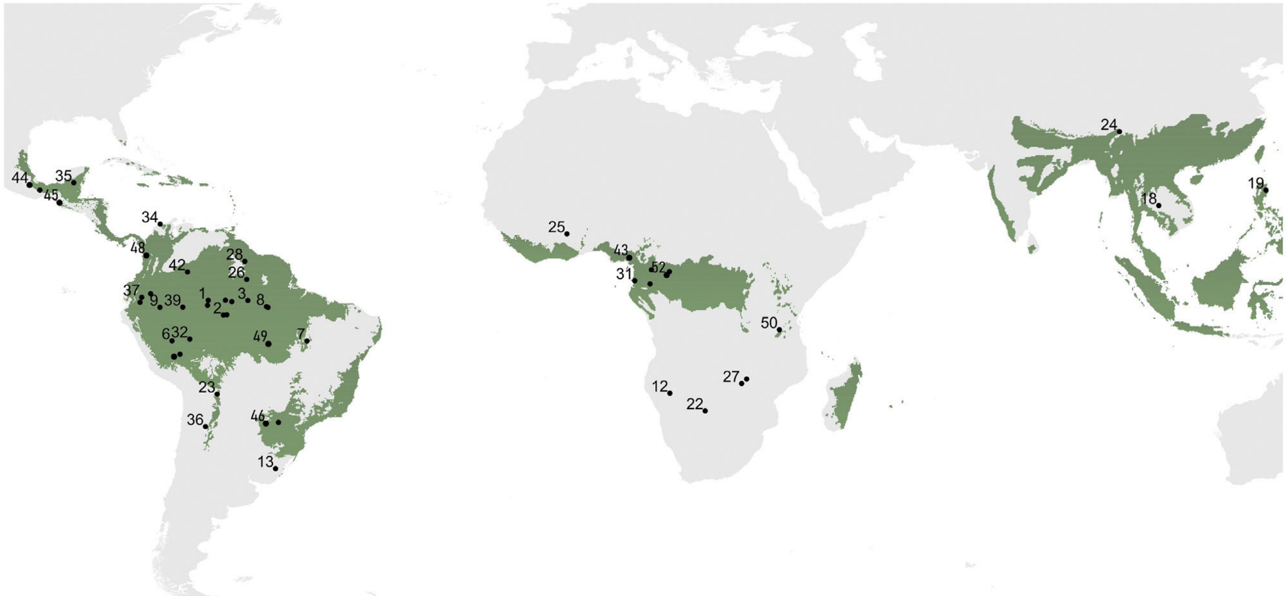

Fig. 2. Location for the 52 existing and past community-based monitoring projects (black dots) of terrestrial game fauna in the tropics (colored in green). Each number represents one project (the respective names are described in Table S3).

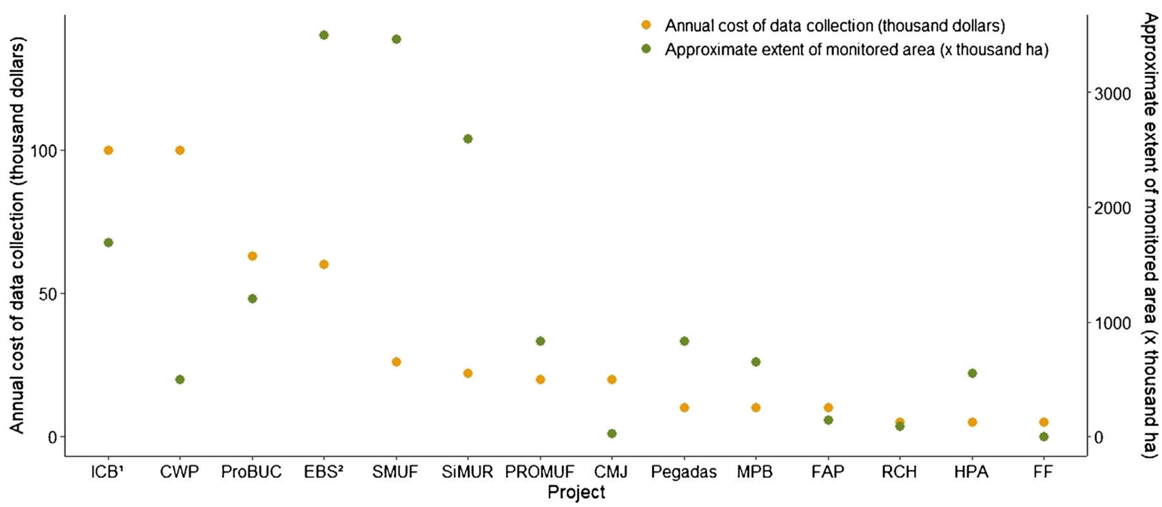

Fig. 3. Relationship between the annual cost of data collection (US$) and approximate extent of monitored area (ha) by each analyzed project. Data were not available for URIL, HXIL and Monitora. See Table S2 for a detailed description of each project.
ICB[1] – Annual cost of data collection (×3)
EBS[2] - Approximate extent of monitored area referring to 16,604,500 hectares

of projects had, respectively, performed data entry and analysis for at least 75% of data.

All 17 projects published scientific studies. A total of 200 publications, including articles, book or book chapters and gray literature were identified (Fig. 4). We observed that there is no relationship between the monitoring time and the number of published studies, although some long-term initiatives have published more (e.g., the HPA has been monitoring hunting for 30 years and published 92 studies), other short-term initiatives have published less (e.g., the CMJ monitored the fauna for a year and published one study) (Fig. S1).

Despite two exceptions, 15 projects demonstrated that local citizens were likely empowered (Table S6), given that local people were directly involved in project elaboration (target species definition and criteria to select monitors) and provided adequate training for local monitors. Moreover, the effective participation of local people in returning project outcomes also promoted empowerment in some initiatives (29%). Conversely, three strategies were not usually adopted because they were not the focus of most projects — the effective participation of local people in data entry (12%), data analysis (12%) and the importance of the resource as a source of meat and income (18%).

Nine initiatives (53%) resulted in management actions (Table S7), mostly encompassed by community rules and applications, such as local bylaws governing resource use. We observed that 44% of projects created slaughter rules; for instance, the SMUF in Brazilian Amazonia contributed to the creation of a quota for the subsistence hunting of the lowland paca (*Cuniculus paca*). In addition, 33% contributed to the creation of management plans, 22% implemented a zoning of hunting areas within protected areas, 22% banned hunting of at least one game species and 11% put in practice the existing rules of the wildlife management plans. Out of the nine projects that endorsed management actions, 33% provided evidence that resulted in the monitoring of further species.

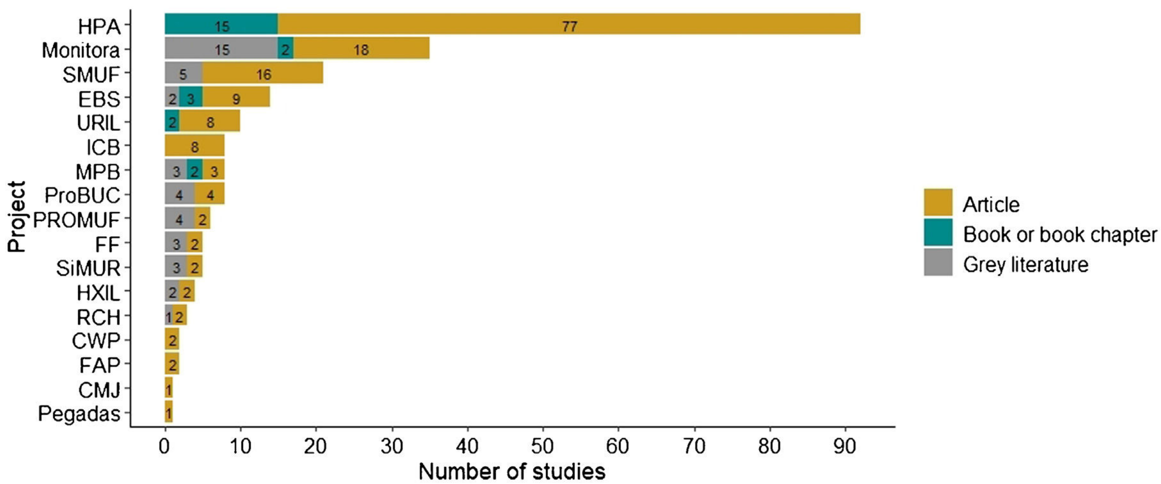

Fig. 4. Number of published studies (article, book or book chapter and grey literature) resulting from each of the 17 community-based monitoring projects of terrestrial game fauna in the tropics.

For instance, game species including the lowland paca and agouti (*Dasyprocta* spp.) started to be monitored through specific sampling programs in the SMUF, aiming to understand their life-history and ecology. Further, one initiative discouraged the creation of new human settlements aiming to improve the sustainability of hunting in the region. We finally observed that 22% of projects provided management actions at a wider scale. These included communitarian management of natural resources in Namíbia and the establishment of a protected area in the Paso Centurión region, in Uruguay.

By ranking the 17 projects in terms of effectiveness, based on the sum of scores obtained considering all conservation pillars, we noticed that almost half of projects were not fully effective because did not promote this triad (Table S8). The determining factor for this was the failure in conducting management actions (47% of initiatives). Still in terms of effectiveness, we showed no relationship between the average annual cost (dollars/ha) and project effectiveness, as costliest (e.g., FF and CWP) and cheaper (EBS and SMUF) projects were considered efficient (Fig. S2).

Discussion

This study provides the first systematic literature review of community-based monitoring projects of terrestrial game fauna across the entire tropical region. These initiatives have been expanding over the last two decades to provide management strategies toward species conservation in the long-term (Danielsen et al., 2021), yet an evaluation of their effectiveness has never been assessed. We identified 52 projects, which mostly monitored both game fauna and harvest, and relied on the effort of local stakeholders in data collection. We revealed an annual cost of US$0.24/hectare/project, with most of these initiatives being interrupted or suspended due to the lack of funding. Finally, we observed that the absence of management actions precluded most projects to be fully effective. Based on our data compilation, we provide recommendations for ongoing monitoring projects in addition to highlight which aspects should be prioritized when planning monitoring projects focused on terrestrial game species across the tropics.

Spatial distribution of monitoring projects

Most community-based monitoring projects are located in South America, mainly in Amazonian protected areas. Although the Amazon faces an under-sampling of terrestrial vertebrate inventories carried out in protected areas (Bogoni et al., 2021), with a noticeable knowledge gap especially for carnivores and xenarthras (Cruz et al., 2022; Feijó et al., 2022), this biome hosts about half of the tropical forests on Earth (Hansen et al., 2013) mainly concentrated in Brazil. In addition, the Amazon is also home to a great number of indigenous and local people who rely on forests to survive (Lima and Pozzobon, 2005). Government institutions and collaborative networks between researchers/managers/participants of NGOs and OSCIPs are also frequent, which also explains this result. Indeed, the Amazon has been an example of community-management, where local people have been monitoring faunal species and playing a central role in management (e.g., Castello et al., 2009; Petersen et al., 2016). For instance, the community-based monitoring program focused on the pirarucu fish (*Arapaima gigas*) along the Juruá River has resulted on its population recovery and contributed to the development of traditional *ribeirinho* communities (Campos-Silva et al., 2020).

A great number of projects was also recorded in Afrotropical forests, which was expected given the high biodiversity in this continent and the annual meat harvests, higher than in other tropical areas (Fa et al., 2002). In contrast, only three programs were identified in the Brazilian Atlantic Forest. This biome, one of the global biodiversity hotspots, has been historically deforested and transformed into urban and agricultural environment – almost 75% of the Brazilian population inhabits this biome, most in urban centers. This explains the lower number of recorded community-based projects, with monitoring data coming essentially from scientists (e.g., Chiarello, 2000; Kaizer et al., 2021). Finally, the small number of initiatives recorded in Asia, probably caused by the low research effort for mammal species threatened by hunting (Ripple et al., 2016), calls attention to the importance of establishing novel programs in this region. In fact, this continent retains several threatened species, and illegal hunting constitutes the greatest current threat to wild vertebrates in Asia (Harrison et al., 2016).

Interruption and annual costs

Our results revealed that several projects were interrupted. Although interruptions in some projects were planned, the majority were stopped unexpectedly when funding had finished or due to changes in project management and conflicts between the community and the project's managers. Moreover, the absence of solid partnerships to ensure long-term funding is currently the main threat to the interruption of ProBUC and MPB. For example, the MPB in Brazil has always received funding from a nongovernmental organization (IPE) and the Amazon Region Protected Areas Program (ARPA), but the former is no longer contributing financially from mid-2022 on. As a result, the project will become exclusively dependent on ARPA and therefore vulnerable to government's temporarily suspension, which has already occurred in early 2021. Indeed, our findings reveal that the scarcity of ongoing financial support poses as the main obstacle to the continuity of community-based monitoring projects, which has also been shown in other studies (Van Rijsoort & Jinfeng, 2005; Costa, 2019). Moreover, we also recognize that other barriers can directly affect the progress of projects. For instance, the COVID-19 pandemic was responsible for the total or partial suspension of activities of some investigated projects (e.g., Monitora).

There is a wide range of total cost among the investigated projects (from US$5,000.00 to US$300,000.00/project or from US$ 0,004 to US$ 2,000/hectare), regardless the monitored area. Moreover, we found no relationship between the annual cost x extent of monitored area, and annual cost x project effectiveness. It is likely that other factors substantially influence costs, including the sampling methods used and the payment for services (Bucheli and Marinelli, 2014).

Effectiveness of monitoring projects

Similar to other studies (e.g., Danielsen et al., 2014, 2021), our results reveal that community-based monitoring provides useful information about monitored game fauna.

We demonstrated that more than half of the projects performed spatio-temporal data analysis and were successful in providing information on the monitored resource through time (e.g., the case of EBS, SMUF and SiMUR). Conversely, failures in spatio-temporal data analyses of some projects comprised the main obstacles for providing these information (e.g., Pegadas, PROMUF and FF). This might be related to the prioritization of investments and human efforts to perform data collection, overlooking the post-collection data management and analyses (Bucheli and Marinelli, 2014). As already pointed out by several researchers, we emphasize the importance of carefully planning each stage of the monitoring project, including the spatial and temporal delimitation of the resource to be monitored (Yoccoz et al., 2003). Although data entry was prioritized by most programs, we noticed that many data sets have not yet been analyzed for some projects, which therefore hampers the assessment of species trends over time.

Our findings evidence that most projects adopted strategies intended to empower local people, demonstrating their importance in strengthen communities. In particular, these strategies allowed empowerment to occur mainly in the psychological or cognitive dimension (Maton, 2008). Individuals engaged in project elaboration feel proud to get involved in building relationships with external researchers (Constantino et al., 2012). Furthermore, the adequate training led monitors to acquire technical and biological knowledge about the monitored resources (Danielsen et al., 2009). Their participation in data entry, data analysis, and in returns of the results, relevant to psychological and social empowerment, was not often in most projects. These strategies are important to build trust with communities (Luzar et al., 2011), increase the alignment between community and project goals (Noss et al., 2005), and increase the sense of ownership of the project and outcomes, thereby enhancing the local influence on faunal recourse decisions (Danielsen et al., 2021). This was likely the case of the CWP and URIL.

Finally, our results reveal that almost half of the initiatives failed to subsidize management practices, although the recognition of its potential (Villaseñor et al., 2016; Danielsen et al., 2021). Specifically, the duration of projects can be decisive for the creation of management actions, as longer projects implemented more management strategies. In addition, the degree of involvement of local members can determine how information will be converted into management actions (Fernandez-Gimenez and Ballard, 2008; Danielsen et al., 2010), because it may lead to ownership of the natural resource management process (Marrocoli et al., 2018). Moreover, some projects failed in performing spatio-temporal data analyses, which would be able to subsidize management practices. Conversely, projects such as Monitora and FAP were able to provide findings about monitored species through time, but local managers of their respectively protected areas did not use the information to implement management actions. In this sense, Danielsen et al. (2005) emphasize that decision policy makers should be directly involved in all stages of monitoring, and therefore establish management actions towards wildlife conservation.

Although not all projects have contributed to the management of wild fauna, we noticed that important management actions were conducted, including the establishment of local hunting grounds and slaughter rules, creation of management plans, temporary or permanent ban of hunting on vulnerable species and support for national policies. Overall, our study shows that management actions are based on rules and applications in the community, such as local statutes governing the use of resources (Van Rijsoort and Jinfeng, 2005) and zoning of hunting areas. In particular, when discussing with local people, these actions become encouraging management strategies, locally respected (Oliveira and Calouro, 2019), and aim not only to protect species, but also to ensure long-term benefits to local communities (Danielsen et al., 2014).

Conclusions and recommendations

Although an emerging number of community-based monitoring projects has been established in tropical forests over the last two decades, several obstacles are hampering their effectiveness in promoting the three pillars of conservation. These include the lack of funding, intensive local participation at different stages of monitoring, spatio-temporal data analyses and management actions for game fauna associated with the projects. We therefore recommend that on-going and novel programs should (i) build solid partnerships with universities, research centers, conservation NGOs or community associations that guarantee long-term funding, solving the problem of project interruption due to lack of financial resources; (ii) engage local people in all stages of monitoring, as empowering people can enhance their interest to continuing monitoring the fauna, even in limited financial circumstances; (iii) invest in human resources to perform spatio-temporal data analysis, which are fundamental to evaluate species fluctuations through space and time. We particularly emphasize the importance of building partnerships with universities, higher education institutions and research centers, specialized in research design, statistics course and article writing, to assist in both data analyses and dissemination of the results to the academia. Finally, we recommend (iv) translate the program outcomes into management actions and thus effectively contribute to safeguard species and, in those sustainable use protected areas, guarantee their long-term sustainability.

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Conflict of interest

The authors declare no conflict of interest.

Declaration of Competing Interest

The authors report no declarations of interest.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.pecon.2023.03.005.

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