

Monitoring in Tropical National Parks: The Power of Knowledge

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Abstract

Monitoring is increasingly recognised as a key instrument for effective nature conservation. It attempts to provide quantitative knowledge to implement conservation actions upon scientific evidence. However, science studies have shown that monitoring is not only a simple technical choice but also carries a cognitive representation of the world and plays a social role. Based on a socioethnographic approach involving 94 semi-structured interviews in seven national parks in tropical Africa and Indonesia, the objective of this study is to analyse the different dimensions of the relation between expertise and power, in the context of postcolonial environmental policies. Drawing on the limitations of monitoring programmes to guide management, this paper shows their unexpected roles and indirect effects. Monitoring appears as a means to provide parks with an effective existence following two dimensions. First, it enacts and contributes to convey a cognitive representation of nature conservation in those areas. Overall, monitoring programmes concentrate predominantly on long term scientific knowledge rather than on pragmatic and action driven knowledge. The majority of programmes focuses on conserving charismatic species and banning illegal activities inside the park rather than on fostering sustainable human activities around the park. Second, the implementation of monitoring programmes gives the parks a material dimension. It provides human, financial, and logistical resources, it controls the parks' activities and structures the parks' governance and administration. Therefore, the day-to-day use of indicators and technical instruments relies less on their ability to drive action than on their capacity to shape power relationships and to produce a social reality. Our findings question the predominant place given to quantitative science and technique in nature conservation and the social conditions under which an evidence based policy can be implemented.

Keywords: monitoring, national parks, quantification, biodiversity conservation, knowledge, power

INTRODUCTION

Over decades, environmental practitioners, scholars, and funders have been seeking the most efficient strategies to

protect the earth's biosphere. In this context, Pullin and Knight (2001) suggested that conservation practices should be based on evidence rather than on "anecdote or myth" (Sutherland et al., 2004). Decision-making must be guided by rational understanding of socioecosystems (Mathevet and Mauchamp, 2005). Hence, biodiversity conservation has been increasingly supported by scientific knowledge and techniques (Granjou et al., 2010), and monitoring, as an instrument to inform management based on reliable indicators, has been widely used (Margoluis and Salafsky, 1998; Stem et al. 2005). Beyond management implementation, monitoring provides insights towards management efficiency. Monitoring

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programmes can answer various questions, mobilise a diversity of techniques such as transects, expert judgements or household surveys and rely on different scales and stakeholders (Stem et al., 2005; Mascia et al., 2014; Vimal, 2017).

However, several authors stressed that monitoring can fail to address conservation issues (Danielsen et al., 2005a; Gardner et al., 2008a; Burton, 2012; Lund, 2013). It turns out to be “data rich but information poor” (Ward et al., 1986) and reveals a paradox: biodiversity conservation does not necessarily benefit from a massive investment in knowledge production. Hence, instead of optimising their use, monitoring can divert scarce resources (Sheil, 2001; Nichols and Williams, 2006; Gardner et al., 2008b). This paper thus aims to understand how monitoring can persist although its capacity to drive action appears to be limited.

Monitoring programmes, as instruments to quantify human and nature activities in order to drive action, can be considered as governing techniques (Foucault, 1979, 1991). Designed to control the living (Braverman, 2014), they seek to implement a biopower: “a power that exerts a positive influence on life, that endeavours to administer, optimise, and multiply it, subjecting it to precise controls and comprehensive regulations” (Foucault, 1990: pp 137 cited in Braverman, 2014). Monitoring therefore contributes to ‘render technical’ the sociopolitical issues to be governed (Li, 2007). By promoting objectivity and transparency, it reflects the well known trust in numbers (Porter, 1996) and the increasing success of quantification in modern society. Nonetheless, as both, tools of knowledge and tools of power (Desrosières, 2014; Rottenburg et al., 2015), monitoring programmes raise the issue of the relation between knowledge production and decision-making. Indeed, constructivist approaches in science studies (Callon, 1984; Latour, 1987, 2005) and political sciences (Muller, 1985; Jobert and Muller, 1987; Lascoumes, 1994) have shown that, instead of being only a simple technical choice, instruments, data, and indicators are also socially embedded. They not only reflect the environment but also contribute to shaping it and producing a social reality (Asdal, 2011). Two main dimensions have been discussed: on one hand, governing techniques carry a cognitive representation of the world, a theorisation of action and a given perception of political values and perspectives (e.g. Desrosières and Naish, 2002; Lascoumes and Le Galès, 2005; Carolan, 2009; Cabane and Tanchou, 2016). On the other hand, governing techniques play a social role. Irrespective of the objectives initially being pursued, they produce other effects and contribute to structuring the social network in which they are processed (e.g. Charvolin et al., 2011; Edwards et al., 2011; Vimal and Mathevet, 2011; Granjou et al., 2014).

These social dimensions of science and techniques are assumed to be even more important in the context of biodiversity conservation. Indeed, the uncertainty and complexity related to the management of socioecosystems preclude the domination of a single top-down expertise and rather underline and foster micropolitics in which knowledge for nature is highly context dependent (Granjou, 2013; Mathevet et al., 2016).

The management of tropical national parks is often based on complex interactions between various organisations such as local governments, NGOs or research institutes and has a strong dependence on external funding and technical supports. Such areas appear to be relevant to study the role of technical infrastructures and metrics in nature protection. Indeed, in tropical areas, rational knowledge and scientific authority are known to be the main drivers of development initiatives (Bonneuil, 2000; Rottenburg, 2009; Tilley, 2011; Cabane and Tanchou, 2016). In a context of postcolonialism and neoliberalism, tropical national parks can reveal the relation between scientific expertise and power relationships towards biodiversity conservation (Adams and Hutton, 2007).

By focusing on monitoring in tropical national parks, this study questions the relation between quantitative knowledge and action, and analyses the unexpected social roles of expertise in nature conservation. It is often assumed that quantitative techniques drive action and enhance authority. In this paper, drawing on the limitations of the capacity of monitoring to inform decision, we provide insights to understand the conditions under which it is maintained as a fundamental instrument of national parks. Therefore, the aim of this paper is less to understand *whether* than *why* instruments, indicators, and knowledge are powerful.

Based on a socioethnographic approach over seven national parks in Africa and Asia, we first describe the nature and extent of monitoring programmes as well as their capacity to guide action and inform decision. Although monitoring appears to represent a massive investment in ‘knowing in order to conserve’, its managerial utility seems to be limited. We then assess the social roles of monitoring and explore the conditions under which it has effects. We first focus on the cognitive role of expertise. Monitoring as such, regardless of its capacity to inform management needs, enacts nature conservation. We show, however, that the monitoring programmes cannot be considered as neutral. They carry a representation of both the place given to quantitative knowledge in conservation and the human-nature interactions. We then assess the power of monitoring through the social processes of their implementation and their capacity to provide parks with a material dimension. Monitoring appears to be a way to supply human, financial, and logistical resources, to control parks’ activities and to structure networks of governance. The different sociopolitical contexts considered for the seven parks highlight the diversity and heterogeneity of monitoring programmes, and stress the importance of considering the social dimension of expertise.

METHODS

This study was conducted in the context of a larger project, which aims at analysing the role of science and knowledge exchange in the great ape habitat conservation network. For this purpose, we conducted semi-structured interviews with 94 people working in national park institutions, local and international NGOs, intergovernmental organisations, private companies and research institutes.

This study specifically focused on seven tropical national parks in Ivory Coast, Cameroon, Republic of Congo, Democratic Republic of Congo, Uganda and Indonesia (Figure 1).

Those parks were chosen according to a compromise between variability of management scheme, geopolitical context and similarity in terms of ecological and social issues, main threats on habitats and wildlife (Table 1).

All seven parks were visited for an average of two weeks between 2014 and 2016. We conducted interviews with various staff members of the parks' authorities and their partners (mainly NGOs and research institutes) including rangers, heads of programmes, deputy directors and administrators. In addition to bilateral discussions, we consulted different types of documents (management plans, monthly and annual reports of the services, business plans, etc.), participated in field missions (law enforcement, wildlife survey, primate habituation, etc.) and observed meetings (weekly team meetings, annual partnership sessions, etc.).

Our study focused on scientific monitoring programmes involving data collection related to ecosystems and wildlife, illegal activities and local communities. We included different types of programmes involving data collection i) on a permanent or regular basis, ii) still running, iii) inside or around the park in a 20km buffer zone, iv) oriented towards management and/or research. We did not include programmes related to human resources and staff management, accountability, administration, logistics as well as public attendance.

Even though most of the programmes focus on local management, some of them also aim to produce knowledge for research or assessment of global environmental trends. This study, however, discusses the capacity of monitoring programmes to orient action locally as well as their unexpected roles.

All monitoring programmes conducted in the seven national parks are listed in Appendix 1 and classified as 'ecological monitoring', 'law enforcement monitoring' or 'community monitoring'. The list provides information on the aim of the programmes, the method used for data collection, the output

in term of analysis, the organisation in charge and its partners. In order to simplify the presentation, monitoring programmes conducted in the context of a single project or of a permanent site run by an organisation were merged in a single line. They often correspond to research activities. A summary of this list can be found in Table 2.

These tables represent only part of the detailed information collected during our field missions. They provide a semi-quantitative and visual support for our analysis.

ARGUMENT

Over the seven national parks, we identified 50 monitoring programmes including seven projects that involve several monitoring activities each. Although each park has its own specificities, trends can be identified regarding the nature and role of monitoring programmes (Table 2, Appendix 1). These programmes can be implemented for the entire park or on a specific area, target single or multiple issues and reveal the use of various techniques, methods, and scientific backgrounds.

Three main kinds of monitoring programmes can be identified: 'natural resource' oriented programmes (58%), 'community' oriented programmes (16%) and 'law enforcement' based programmes (26%). The two main approaches involving data collection for the entire area of the parks are wildlife surveys and law enforcement patrols. Most of the national parks conduct a general survey of the park in intervals of one (e.g. Tai) to five (e.g. Odzala-Kokoua) years. Exceptions are Virunga and Gunung Leuser and, to some extent, Bwindi. All the national parks collect data while patrolling and use the Spatial Monitoring And Reporting Tool (SMART, www.smartconservationsoftware.org), although with different intensity, to store, analyse, and report such data. Both programmes (wildlife survey and law enforcement monitoring) focus on the same information i.e. illegal activities and large mammals. However, wildlife surveys are based on a systematic inventory across transects and produce density estimations for flagship species such as great apes or elephants and relative density (number of occurrences) for other species and illegal activities (Appendix 1). The collection of data based on law enforcement patrols relies on a more opportunistic approach, driven by the intervention of rangers, their random tracking, capacity to identify species, and willingness to collect data. Many other monitoring programmes are conducted in the national parks through single species survey, great apes habituation programme, community livelihood assessment, etc. (Table 2).

The implementation of these monitoring programmes involve a number of different organisations (Table 1, Appendix 1). The partners of the parks, including local and international NGOs, as well as research institutions, are in charge of more than half (57%) of the monitoring programmes recorded in this study. They generally conduct programmes focusing mainly on natural resources or local communities in interaction with the related park's services (i.e. mainly 'research and monitoring' and 'community development' services). The managers

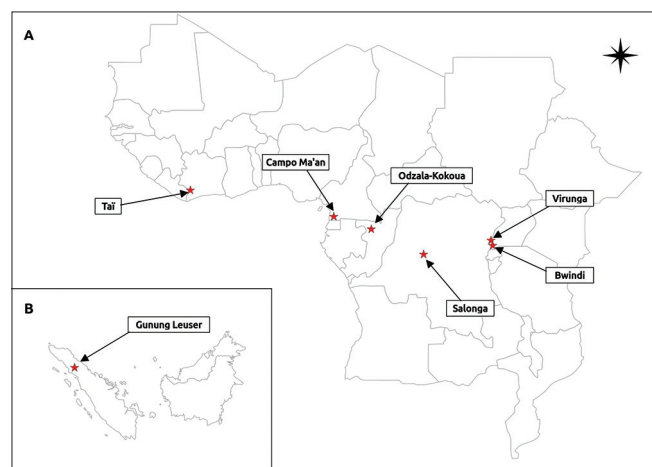


Figure 1
The surveyed national parks in Africa (A) and Asia (B)

Table 1
Main characteristics of the surveyed national parks

Name	Year of creation	Area (km ²)	Main threats	Management scheme	Main scientific partners
Taï (Ivory Coast)	1972	5300	Agriculture, gold washing, poaching	State (OIPR)	WCF, MPI
Campo Ma'an (Cameroon)	2001	2604	Industrial developments (harbor, dam), poaching	State (MINFOF) and NGO (WWF)	WWF, AWF
Odzala Kokoua (Rep. of Congo)	2001	13546	Commercial poaching, Ebola	Foundation (African Parks)	WCS, Univ. Rennes 1
Salonga (DRC)	1970	36000	Commercial poaching	State (ICCN)	WCS, MPI, WWF, ZSM
Virunga (DRC)	1925	7800	Agriculture, resources extraction, poaching	Foundation (Virunga foundation)	WWF, WCS, IGCP, MPI
Bwindi (Uganda)	1991	331	Agriculture, poaching	State (UWA)	ITFC, MPI, IGCP
Gunung Leuser (Indonesia)	1980	7927	Agriculture, palm oil	State (MEF)	WCS, FKL, SOCP, OIC

Table 2

Number of monitoring programmes implemented in the surveyed national parks. In 'Species presence, ecology, behaviour', 'Habituated species ecology, behaviour, health' and 'Community monitoring', we only included programmes that are not conducted in the context of a larger project (i.e. Ecological or Social monitoring site/project). Full information on programmes are presented in the Appendix 1

Monitoring programs	Method	Taï	Campo Ma'an	Odzala-Kokoua	Salonga	Virunga	Bwindi	Gunung Leuser
Wildlife survey	Transect	1	1	1	1	-	-	-
Single species survey	Transect	-	-	-	-	3	1	2
Habituated species ecology, behaviour, health	Tracking	2	1	1	-	1	2	1
Species presence, ecology, behaviour	Camera trap, bai observation, etc.	-	-	2	2	-	-	1
Community monitoring	Interviews, focus group, etc.	-	1	-	-	3	3	-
Law enforcement patrol	Patrol	1	1	1	1	1	1	1
Other law enforcement	Aerial survey, image analysis, others	-	-	2	1	2	-	1
Ecological monitoring site/project	Tracking, transect, camera trap, etc	2	-	-	2	-	1	1
Social monitoring site/project	Interviews, focus group, etc.	-	-	-	-	-	1	-

themselves, usually governmental authorities, are in charge of law enforcement and, accordingly, of the related monitoring programmes. Nonetheless, NGOs generally provide financial and technical support to collect, compute and analyse data, produce maps with the SMART programme and drive their interpretation. Rangers for law enforcement are always hired by park authorities whereas other field workers can be hired by the parks or by their partners.

Beyond their potential contribution to research and/or to the assessment of global environmental trends, most of monitoring programmes recorded in the seven national parks clearly aim to guide conservation action locally. In tropical national parks, such guidance is oriented towards increasing security, empowering communities and developing tourism. Using monitoring to implement conservation actions involves different steps including data collection, analysis, results interpretation and communication. Assessing the capacity of monitoring programmes to inform decision for management remains a challenge (see for example Danielsen et al., 2005b) often mobilising value judgements. Are collected data, analysis and interpretation reliable? Is the potential of a programme fully exploited? Is monitoring a priority in comparison with

other conservation action? What actions should monitoring programmes orient and in which time frame? Are the decisions based on the interpretation of monitoring results really implemented? And to which extent is the implementation of decisions correlated with structural reforming?

Our observations mainly suggest a lack of calibration. There is a gap between the quantity of data that is produced and used, as well as between the high precision of the analysis and the broad scale of their interpretation. For instance, wildlife surveys produce a number of indicators, often spatially displayed at a few square kilometer pixel level and for different taxonomic groups. Yet, most of the information used by managers relates to few general trends or estimations at larger scales. This becomes obvious with statements such as: "We focus our attention mainly on the eastern zone. We know that there are some impacts. So in the future, we will send some patrols. That's a dissuasive presence because we know that animals are more present in this area" (Taï, Park agent, Interview, April 2015).

While technical limitations have been widely discussed in the literature (MacKenzie and Vojta, 2005; Yoccoz et al., 2001), they are certainly not the most challenging issues for

monitoring to inform management. The parks seem to have difficulties in highlighting the interest of their monitoring programmes, to translate them in the daily management of their territory and to actually use them for decision-making (Danielsen et al., 2003). The following statements illustrate this difficulty of the parks to go beyond the collection of data and to properly use it to make informed decision.

"All we're doing is recording a disturbance but we're not doing anything about it... We're making data, but we're not making change" (Gunung Leuser, NGO agent, Interview, February 2016).

"I think we do a lot but capitalise nothing. If you look in the computers here, we have so many realised studies but we never had a pause to understand to which extent, this or that survey was useful for (...). We don't really pay attention to how such studies could contribute to management efforts" (Campo Ma'an, NGO agent, Interview, April 2015).

"Large quantities of data is collected (...) and is just stored. Little effort is made to analyse and disseminate the results for decision-making" (Management plan 2014, Bwindi national park, pp 37).

Our observations, however, suggest that monitoring programmes, irrespective of their capacity to provide guidance for management, can play other roles. In the following sections, we will show how monitoring can also be considered as a way to provide parks with an effective existence following both cognitive and material dimensions.

Monitoring programmes as Vectors of Representations and Values

We argue that, regardless of its impact on management, monitoring activity as such is a way to promote nature conservation. Although some studies showed how quantification and statistics have provided support to prioritise action (e.g. Hunsmann, 2016; Pinaud, 2016), here, we stress that the effect of monitoring is not related to its capacity to guide action, but to the representations and values it conveys. This capacity of techniques and quantification to enact nature conservation has been previously described by Kristin Asdal (2008, 2011). Indeed, using instruments, collecting data, or producing indicators in order to direct nature protection first of all promotes conservation issues. For instance, it is clear that monitoring programmes on elephants or tigers, regardless of their usefulness to plan management, contribute to fuel enthusiasm in people for these charismatic species. Observing how new programmes and techniques have highlighted new spaces for biodiversity also reveals this causal relationship between monitoring and the emergence of conservation issues. For instance, the increasing performance of molecular technologies allows scientists to track each individual of the mountain gorilla population in Virunga and Bwindi, thus promoting new aspects of their conservation needs. Tools such as camera traps or participatory mapping have opened new spaces for observing nature, human and their interaction, thus contributing to their conservation. We

would like to show, however, that this capacity of monitoring to enact conservation is not neutral. Rather, it contributes to shaping and legitimating given logics and forms of nature conservation.

The Persistence of a Fortress Approach

Monitoring produces numbers on both human activities (encroachments, snares, bullets, revenues, cropping area, fisheries, etc.) and wildlife (nest, faeces, peel, ivory, crop damages, presence of elephants, social behaviour of apes, etc.). It aims at providing reliable knowledge to increase security, empower and develop local communities and implement tourism. Hence, while all are targeting the same goal (i.e. protecting biodiversity), different monitoring programmes have different (non-exclusive) objectives and, accordingly, carry different representations of nature, humans and their interactions. Humans can be perceived as an entity to control (e.g. law enforcement monitoring in all parks) or to develop (e.g. fish stock assessments in the Virunga). Wildlife is the grail to protect (e.g. wildlife surveys in all parks), the source of conflicts (e.g. monitoring of wildlife damages on croplands in Campo Ma'an) or an income opportunity (e.g. mountain gorilla tracking in Bwindi). The data collected, the indicators produced and their associated goals show this constant duality in which human beings or wildlife play a role of either oppressor or oppressed.

The nature of monitoring programmes reveals preferences, choices, and priorities of park managers and their partners. Table 2 shows the frequency of the different monitoring programmes conducted in the seven national parks considered. There is a clear bias towards the collection of ecological and law enforcement data inside the parks in contrast to data collection focusing on the social context of parks and their surrounding areas (e.g. the use of resources, crop raiding, community livelihood and bushmeat trade). While 84% of monitoring programmes focus on illegal activities, wildlife and biodiversity issues, mainly inside the parks, only 16% focus on communities. Furthermore, there is a strong bias towards charismatic species, mainly mammals, and only few programmes focus on other biodiversity features such as vegetation, invertebrates or birds (Appendix 1). Overall, the extent and nature of monitoring programmes can be used as an indicator of the persistence of a "fortress approach" (Brockington, 2002; Adams et al., 2004) of nature protection in national parks: biodiversity conservation should mainly focus on what happens within the border of the area itself. Such bias towards the collection of data inside the parks can also reveal an emphasis on park security. Indeed we can easily assume that data on wildlife and illegal activities inside the parks are more often used to orient law enforcement patrols than to empower and support communities.

The fact that most of the 'community oriented programmes' are conducted in Bwindi and Virunga national parks (Table 2) is not a coincidence. Indeed, those parks face one of the highest human density in the tropics (Sanderson et al., 2002). More than anywhere else, the protection of these territories is highly dependent on the capacity of parks' authorities to control the activities of the communities around the park.

A Rationalist Approach

Monitoring also reveals the predominant place given to technical and quantitative knowledge in natural resource management. The recent implementation of SMART in all the surveyed parks is a symbol of such domination. Indeed, SMART provided a standardised method to collect data during rangers' patrols on both illegal activities and wildlife. Hence, rangers could be considered as scientific assistants. Their mission is not only to protect the park but also to produce knowledge. Therefore, SMART illustrates how the implementation of new technologies may transform daily park activities by emphasising on the role of knowledge.

Overall, monitoring, apart from being oriented towards the collection of data inside the parks, largely relies on programmes with high scientific profile such as wildlife survey, species census, clearing observation or gorilla tracking. These programmes generally aim to produce knowledge on the long term, based on precise and rigorous protocol, and do not necessarily target specific conservation actions *a priori*. This emphasis on the use of knowledge for conservation can also be assessed throughout the technical details of monitoring programmes and the differences observed across the surveyed parks. For instance, in Taï, in comparison with other parks, the wildlife survey relies on a much more precise protocol, provides a larger panel of indicators, details more taxonomic groups and is conducted every year.

Furthermore, the fact that part of the monitoring programmes not only targets local management, but also simultaneously the production of research and/or the assessment of global environmental trends, is also an indicator of this highly quantified approach of nature conservation: single knowledge, necessarily standardised and scientifically rigorous, can be suitable for different purposes. For instance, in Bwindi, one NGO monitors wildlife via camera traps following the protocol of the Tropical Ecology Assessment and Monitoring Network. Although this network attempts "to generate real time data for monitoring long term trends" associated with global change (TEAM, www.teamnetwork.org), the park authority clearly presents it as an opportunity to drive local management. In contrast, only few programmes such as the monitoring of elephant killing via necklaces or park encroachments via aircraft can be considered to be 'target oriented'. Such approaches focus less on the production of data on the long run than on its direct use for intervention. The fact that these programmes were mainly found in Odzala-Kokoua and Virunga (Table 2) might be explained by the type of organisations managing the areas. Indeed, those parks are managed as 'Public-Private Partnership' (see Hatchwell, 2014) and monitoring activities are partially organised by private foundations that generally claim a more pragmatic approach to nature conservation.

Monitoring as a Way to Materialise Parks

In the first part of this paper, we showed the cognitive role of monitoring and its capacity to legitimate conservation. In

the second part of this paper, we would like to focus more on processes and demonstrate how the implementation of monitoring suggests practical transformations at the level of the parks following three dimensions: it supplies resources, it is used to control parks' activities and it structures the governance of parks.

Supplying Resources

Monitoring is directly linked to the provision of human, financial and logistical resources. Indeed, its implementation automatically implies raising funds, recruiting people and equipping parks logistically. Such resources, whatever the capacity of monitoring programmes to orient management, are vectors of practical materialisation of the parks. This materialisation obviously has an impact on biodiversity conservation. For instance, monitoring activities automatically involve the circulation and presence of parks' agents within and around the borders of parks and thus limit poaching and other illegal activities. In Africa, it is well known that, around research stations where field assistants collect data on a daily basis, poaching often happens less, hence making wildlife richer (Tranquilli et al., 2012). In Gunung Leuser national park, a local NGO runs a restoration site and monitors changes in vegetation, birds and mammals permanently. Based on this programme, the NGO obtained engagement from the park authority to improve the protection of the site and now supports the park to collect data during patrols.

Furthermore, monitoring programmes in African and Asian national parks represent a considerable source of funding for the different organisations involved and ultimately a non-negligible income for local communities. In some places such as Mbomo, headquarters of Odzala-Kokoua national park, the main source of revenue in the village is provided by the park through salary of the rangers or field assistants. The dependence is such that it can even lead to situations where programmes are not implemented for their potential contribution to management but rather for the opportunity they represent in terms of bringing funds to the park (Sheil, 2001; Garcia and Lescuyer, 2008).

"When [such organisation] is coming, we don't know for which purpose it is. Since they have come, I did not have any access to their data. We conduct this activity because they give a bit of money" (Campo Ma'an, NGO agent, Interview, April 2015). This role of monitoring can also follow more indirect ways in which funding opportunities appear as a consequence of an already run programme. The Taï national park authority was recognised and is legitimate at the international level by UNESCO because of its wildlife monitoring programme which is much more developed than in the other considered parks. This acknowledgement may facilitate future funding prospect and can ultimately serve conservation.

Controlling People and Parks' Activities

Evaluation is a major process of any bureaucratic system and generally takes place between different hierarchical levels of an administration and between organisations and their donors.

Such an approach is particularly important in developing countries where different organisations are increasingly challenged to demonstrate accountability, relevance and performance (Mueller-Hirth, 2012). From this point of view, implementing a monitoring programme automatically involves assessing it via reporting. Nonetheless, our observations suggest that although monitoring is originally meant to govern local communities and wildlife, paradoxically, it can also be used as an instrument to control the people implementing it. At a local level, monitoring can be used to control the agents' work during their missions in the park. For instance, several interviewees claimed that the implementation of the SMART programme has been fruitful to ensure that during their missions, rangers were actively looking for signs of illegal activities rather than "sitting all day long in the forest". This use of monitoring as a tool for evaluation and control can also be observed at broader levels of parks' organisation. In Taï, the heads of the seven 'districts' of the park provide a report every month to justify their activities. These reports are partly based on geolocalised observations (GPS coordinates) of illegal activities or patrimonial species, collected by field teams.

Irrespective of its usefulness to guide management decisions, monitoring is a strategic resource towards more efficient presence in the park and can ultimately increase conservation outputs. It is remarkable, however, that here the purpose is to assess the efficiency of a programme which itself aims to assess the efficiency of the park. In this 'monitoring monitoring' approach, data and analysis conducted are logical outputs to be reported. Donors usually want to see numbers and, for instance, like to have precise estimates of wildlife abundance. Nonetheless, there is a risk of confusion between 'performance measurement' which aims at monitoring project progress and 'impact evaluation' which assesses the changes induced by conservation actions (Mascia et al., 2014). The following intervention reveals this ambiguity: "*If there is trouble, at the end of the day, the patrols contact us directly, whereas with SMART, we need to wait one month before having encoded data. Here, we use SMART as a tool to report*" (Virunga, Park agent, Interview, November 2015). Ultimately, reporting can become the final aim of a monitoring programme instead of its ability to drive conservation actions as suggested by this interviewee: "*They don't do anything with it [the monitoring programme]; they use the data to justify the funds*" (Campo Ma'an, Park agent, Interview, April 2015). The preoccupation of the agent is to have something to show in his report regardless of its usefulness for management and its capacity to impact conservation on the ground.

Structuring Networks and Governance

The implementation of monitoring, independent of its usefulness in management, helps to structure the social relationship network, distribute responsibilities and organise parks' governance. In the parks that we studied, monitoring appears as a means to connect different stakeholders across different dimensions (e.g. between public and private organisations, research and management, local and global

issues, etc.). The capacity of environmental expertise to shape social relationship has also been studied in other contexts. For instance, Mauz et al. (2012) showed how platforms for long term socioecological research provided different partners involved with an opportunity to collaborate and learn from each other. More importantly, monitoring programmes contribute in building parks' administration and governance. Many studies have already shown how quantification and statistics are vectors of a neoliberal approach of government based on performance (Rose, 1991; Rottenburg et al., 2015). It is important, however, to understand that the structuring effect of such metrics is not necessarily based on their meaning and the results they provide, but primarily refers to the necessary conditions of their implementation. Again, the SMART programme is a good example to illustrate our argument. Indeed, SMART aims at providing support to organise law enforcement patrols via the collection of different kinds of data, running from stewardship (number of rangers, name, duration of stay, etc.) to geolocalised data on wildlife and human activities. Across all the parks we surveyed, SMART is promoted by international NGOs towards local governments. The implementation of this programme however calls for a given organisation: field teams, training sessions, centralisation and standardisation of the data, communication between hierarchical levels, etc. More than a tool to guide decision, SMART thus helps to establish a managerial governance of parks.

CONCLUSION

Despite the importance of protected areas' adaptive management, monitoring programmes are in general poorly evaluated from a social science perspective. Considering instruments, knowledge and techniques means "looking beyond the effects assumed by their leaders" (Cabane and Tanchou, 2016). It comes to understanding how quantification changes the way nature is governed, how it helps to administrate people, parks and wildlife, and how it distributes power and legitimacy. In this study we showed that, although its aptitude to guide management remains uncertain, monitoring is first of all a way to make parks exist following two dimensions: it shapes, enacts and legitimates nature conservation; and it contributes to materialise parks.

These implicit social roles of monitoring might explain why some programmes persist although they don't have a significant reforming impact. In this case, data can play a role even before being collected, analysed or interpreted. The dominant role of quantitative knowledge and techniques in environmental decision can be considered as paradigmatic. Our study highlights new dimensions of the relation between information and action beyond the commonly expected "path from truth to power" (Haas, 2004). It, therefore, questions the mechanisms under which such paradigm can be maintained (Kuhn, 2012). The legitimacy of an instrument is not necessarily related to its capacity to inform action but can be based on its indirect, strategic, and more or less conscious roles. This observation does not preclude an impact on conservation issues (also see

Asdal, 2011). In each of the related cases, monitoring can act as an intermediary (Vinck et al., 1996; Vimal and Mathevet, 2011) towards increasing nature protection. However, such mechanisms stress the need to consider expertise as socially embedded, reveal its subjectivity, highlight its strategic use and the power relationships it conveys, and raise the issue of the performance of parks.

In the first part of this paper, we showed that data, numbers, indicators contribute to shape categories among knowledge, nature, humans and to organise their interactions. Monitoring programmes are not uniform. Their ethnography across different national parks revealed a diversity of approaches. Therefore, rather than being objective, the implementation of monitoring programmes relies on a selective body of knowledge (Grundmann and Stehr, 2012). These choices might be guided by various factors such as geophysical context, management structure, historical partnerships or sociopolitical constraints. They mainly refer to two dimensions of what should be understood as a strategy for nature protection. First, monitoring programmes carry a representation of the relation to quantitative knowledge and its use towards the construction of action. Rather than being pragmatically oriented towards daily management, our case studies showed that the majority of monitoring programmes refers to long term projects, often curiosity driven and following scientific standards. Second, different monitoring programmes carry different representations of nature, humans and their interactions. Monitoring reveals some choices regarding *what* should be measured and *for which* purpose. Monitoring in tropical national parks mainly provides information on charismatic species and illegal activities inside the park rather than on human activities outside the park. Monitoring, therefore, contributes to the decision of what should we “make live and let die” (Foucault, 1997). Furthermore, it carries a duality between humans, as active proponents of attacks, and wildlife as victim, rather than a convergence of common interests. In such an approach, although data has a ‘liberating’ effect (Desrosières, 2014) for nature, it is mainly a means of control and policing for human populations.

In the second part of this paper, we showed the capacity of monitoring programmes to materialise parks through the provision of financial, logistical and human resources, the control of the parks activities, and the shaping of social relationships and parks governance. Therefore, regardless of the capacity of monitoring to inform management needs, the processes of its implementation primarily provide potential benefits. We showed, however, that these ‘side effects’ can turn out to be counter productive. Monitoring programmes can be implemented without any expectations regarding management orientation but only for the opportunity they represent in terms of attracting funds, controlling agents’ work, or ensuring human presence in the park. Although monitoring theoretically pretends to increase performance, these observations question its cost effectiveness (Vimal, 2017). For instance, an incremental capacity to get funds via monitoring independently of its management impact does

not necessarily fit with the urgent need for an efficient and reliable use of scarce resources. Furthermore, the capacity of monitoring to organise parks’ administration and structure social networks questions both the power relationships and the political perspective of the parks’ governance it underpins. The main issue at stake is the independence of the local authorities and their capacity to conduct their own expertise. Paradoxically, although the implementation of monitoring programmes implies capacity building and affords some level of independence to the governments in charge of law enforcement, it also imposes a given model of performance and creates a permanent dependence towards the technical skills held by expert NGOs (also see Bryant, 2002).

Our study questions the domination of quantitative knowledge in nature conservation and stresses the need to review the conditions under which a policy relevant conservation science can be implemented. Where exactly is the innovation and what are the conditions of its success? The different case studies in this paper illustrate how monitoring is both a social and scientific challenge towards the goals of biodiversity conservation (Vimal et al., 2012, 2013; Vimal, 2017). Framing conservation policies, based on a simplistic model of knowledge transfer, fails to consider the importance of the social dimension not only as a factor of success, but also as an output of the process of expertise, as success in itself.

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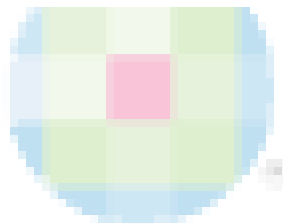
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LIST OF ABBREVIATION

WCS: Wildlife Conservation Society
WWF: World Wild Fund
ICCN: Institut pour la Conservation de la Nature
OIPR: Office Ivoirien des Parcs et Réserves
UWA: Uganda Wildlife Authority
TEAM: Tropical Ecology Assessment and Monitoring
AWF: African Wildlife Foundation
SMART: Spatial Monitoring And Reporting Tool
FKL: Forum Konservasi Leuser
OIC: Orangutan Information Center
SOCP: Sumatran Orangutan Conservation Project
MPI: Max Planck Institute
MIKE: Monitoring Illegal Killing of Elephants
IGCP: International Gorilla Conservation Project
MINFOF: Ministère des Forêts et de la Faune
MEF: Ministry of Environment and Forestry
DRC: Democratic Republic of Congo

Appendix 1
The different monitoring programmes over the seven national parks

Type	Park	Mission	Aim	Area	Frequency	Collection method	Features of interest	Analysis	Who	Technical partners
Law enforcement	Campo Ma'an	Law enforcement patrol	Management	The whole park	Permanent	Patrol	Illegal activities and large mammals	Identification and distribution	MINFOF	AWF and WWF
Law enforcement	Tai	Law enforcement patrol	Management	The whole park	Permanent	Patrol	Illegal activities and large mammals	Identification and distribution	OIPR	
Law enforcement	Odzala-Kokoua	Law enforcement patrol	Management	The whole park	Permanent	Patrol	Illegal activities and large mammals	Identification and distribution	AP	WCS
Law enforcement	Odzala-Kokoua	Elephant tracking	Management	The whole park	Permanent	Patrol	7 elephants	Daily track and position, home range, ecology	AP	
Law enforcement	Odzala-Kokoua	Elephant killing	Management	The whole park	Permanent	Patrol	Ivory stock and carcasses	Quantity	AP	MIKE-CITES
Law enforcement	Salonga	Law enforcement patrol	Management	The whole park	Permanent	Patrol	Illegal activities and large mammals	Identification and distribution	ICCN	WCS, WWF, ZSM, MPI
Law enforcement	Salonga	Elephant killing	Management	The whole park	Permanent	Patrol	Ivory stock and carcasses	Quantity	ICCN	MIKE-CITES
Law enforcement	Virunga	Law enforcement patrol	Management	The whole park	Permanent	Patrol	Illegal activities and large mammals	Identification and distribution	ICCN	WCS
Law enforcement	Virunga	Elephant tracking	Management	The whole park	Permanent	GPS necklace tracking	15 elephants	Daily track and position, home range, ecology	Virunga foundation	
Law enforcement	Virunga	Invasion of the park (agriculture and rebels)	Management	The whole park	Permanent	Aircraft survey photography	Illegal logging, encroachment and rebels	Identification and distribution	Virunga foundation	
Law enforcement	Bwindi	Law enforcement patrol	Management	The whole park	Permanent	Patrol	Illegal activities and large mammals	Identification and distribution	UWA	
Law enforcement	Gunung Leuser	Law enforcement patrol	Management	The whole park	Permanent	Patrol	Illegal activities and large mammals	Identification and distribution	UWA	OIC, WCS, FKL, LIC
Law enforcement	Gunung Leuser	Invasion of the park (agriculture)	Management	The whole park	Permanent	Satellite image analysis, drones survey photography	Illegal logging, encroachment	Identification and distribution	SOCF, FKL	
Ecological	Bwindi	Mountain gorilla census	Management/Research	The whole park	Every 5 years	Transect	Gorillas, large mammals	Parasitology, genetic identification, density, distribution and family structure of gorillas; large mammals and illegal activities relative density and distribution	IGCP	DFGFI, Gorilla doctors, MPI, MGVP, ITFC

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Appendix 1
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Type	Park	Mission	Aim	Area	Frequency	Collection method	Features of interest	Analysis	Who	Technical partners
Ecological	Bwindi	Habituated mountain gorillas monitoring	Management	14 groups	Permanent	Tracking	Gorillas	Vital domain, number and health checking	UWA	MGVP, Gorilla doctors
Ecological	Bwindi	Global change monitoring	Management/Research	The whole park	Permanent	Camera trap, vegetation plots, climate station	Vegetation, wildlife, climate	Distribution, growth rate, temporal evolution	ITFC	TEAM
Ecological	Bwindi	Habituated mountain gorilla monitoring	Management/Research	3 groups	Permanent	Tracking	Gorillas	Vital domain, nutrition, behavior, genetic, parasitology, social structure, ecology	MPI	ITFC
Ecological	Campo Ma'an	Wildlife survey	Management	The whole park	Every 3 years	Transect	large mammals and illegal activities	Great apes, elephants, duikers (3sp) density and distribution; Other large mammals and illegal activities relative density and distribution	WWF	
Ecological	Campo Ma'an	Gorilla habituation	Management	<5%	Permanent	Tracking	Gorillas	Vital domain, food	WWF	
Ecological	Gunung Leuser	Restoration sites monitoring	Management/Research	<5%	Permanent	Transect, camera traps, plots	Planted tree species, birds, orangutans, mammals	Vegetation growth and phenology; Number of birds species; Species recolonization; Orangutan behavior	OIC	University of Nagoya, University of Liverpool
Ecological	Gunung Leuser	Mammals survey	Management	<10%	Permanent	Camera traps	Rhinoceros and other mammals	Species presence; Rhinoceros reproduction	FKL	
Ecological	Gunung Leuser	Tigers survey	Management	<10%	Every 2 years	Transect	Tigers and other mammals	Density, distribution	WCS	
Ecological	Gunung Leuser	Orangutans survey	Management/Research	The whole park	2004 and 2013	Transect	Orangutans	Density, distribution	SOCF	Liverpool John Moores University
Ecological	Gunung Leuser	Orangutan monitoring	Research	<10%	Permanent	Tracking	Orangutans	Vital domain, nutrition, behavior, social structure, ecology	SOCF, FKL	University of Aceh, University of Zurik, Liverpool John Moores University
Ecological	Odzala Kokoua	Clearing monitoring	Tourism	1 clearing	Permanent	Observation of the clearing	Gorillas, birds, large mammals	Frequencies of mammals and birds; Individual identification of gorillas, ungulates, elephants	AP	University of Rennes 1

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Type	Park	Mission	Aim	Area	Frequency	Collection method	Features of interest	Analysis	Who	Technical partners
Ecological	Odzala Kokoua	Gorilla habituation	Tourism	<5%	Permanent	Tracking	Gorillas	Vital domain, food	AP	University of Barcelona
Ecological	Odzala-Kokoua	Wildlife survey	Management	The whole park	Every 4 years	Transect	large mammals and illegal activities	Great apes, elephants density and distribution; Ungulates, illegal activities relative density and distribution	WCS	
Ecological	Odzala-Kokoua	Gorillas/ Clearing monitoring	Management/ Research	3 clearings permanently, 4 others	Permanent	Observation of the clearing	Gorillas (+ birds, large mammals)	Group composition, behavior, ecology, epidemiology, social and genetic structure, sympatric species	University of Rennes 1	
Ecological	Salonga	Wildlife survey	Management	The whole park	2004 and 2015	Transect	large mammals and illegal activities	Great apes, elephants density and distribution; Ungulates, illegal activities relative density and distribution	WCS, MPI, ZSM	
Ecological	Salonga	Elephant monitoring around a clearing	Management	1 clearing	Permanent	Camera traps	Elephants	Presence	WCS	
Ecological	Salonga	Carbon monitoring	Research	3 parcels	Permanent	Vegetation plots	3 forest types	Biomass and botanical composition	WCS	CTFS, University of Leeds
Ecological	Salonga	Bonobo monitoring	Research	1 sites; <5%	Permanent	Tracking, camera trap, transect	Bonobos	Vital domain, nutrition, behavior, genetic, parasitology, social structure, ecology	MPI	
Ecological	Salonga	Ecological and law enforcement monitoring	Management/ Research	<10%	2 times a year	Transect (+ patrol)	Bonobos, elephants, large mammals, vegetation, IA	Distribution and temporal evolution of bonobos and elephants; Impact of law enforcement, data quality of patrols; Relation between wildlife and vegetation; genetic structure of bonobos; Ivory trade tracking	ZSM	Kyoto University, Michigan State University

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Appendix 1
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Type	Park	Mission	Aim	Area	Frequency	Collection method	Features of interest	Analysis	Who	Technical partners
Ecological	Tai	Wildlife survey	Management	The whole park	Every year	Transect	large mammals, birds and illegal activities	Great apes, elephants, bovidae, tale apes density and distribution; Birds, other large mammals, illegal activities relative density and distribution	OIPR	WCF
Ecological	Tai	Chimpanzee habituation	Tourism	<5%	Permanent	Chimpanzee tracking	Chimpanzee	Vital domain, food	OIPR	WCF, MPI
Ecological	Tai	Mangabey and Red Colobus habituation	Tourism	<5%	Permanent	Tracking	Mangabey, Red Colobus	Vital domain, food, behaviour	WCF	MPI
Ecological	Tai	Ecological and law enforcement monitoring	Research	<5%	Permanent	Transect	Large mammals, vegetation change, illegal activities	Distribution and temporal evolution of wildlife; Impact of law enforcement	WCF	MPI
Ecological	Tai	Tai Chimpanzee and Monkey projects	Research	5 sites; <5%	Permanent	Tracking, camera trap, transect	Chimpanzees and other primates	Vital domain, nutrition, behavior, genetic, parasitology, social structure, ecology	MPI, University of Neuchatel	CSRS
Ecological	Virunga	Mountain gorilla census	Management/Research	<10%	Every 5 years	Transect	Gorillas, large mammals	parasitology, genetic identification, density, distribution and family structure of gorillas; large mammals and illegal activities relative density and distribution	IGCP	DFGFI, Gorilla doctors, MPI, MGVP, ITFC
Ecological	Virunga	Hippopotamus survey	Management	<40%	2011, 2015	Transect (aerial and pedestrian)	Hippopotamus	Density, distribution, relation with law enforcement effort	WCS	
Ecological	Virunga	Savannas wildlife survey	Management	<70%	Every 5 years	Aircraft transect	Large mammals (7 sp)	density, distribution	WCS	
Ecological	Virunga	Habituated mountain gorillas monitoring	Management/Tourism	8 groups	Permanent	Tracking	Gorillas	Vital domain, number and health checking	ICCN	MGVP, Gorilla doctors

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Appendix 1
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Type	Park	Mission	Aim	Area	Frequency	Collection method	Features of interest	Analysis	Who	Technical partners
Community	Campo Ma'an	Human/Wildlife Conflict	Management	All around the park	Permanent	Villagers report	Damages of wildlife on human activities	Number, distribution, wildlife involved, and type of damage	WWF	CIRAD, OFAC, FAO
Community	Virunga	Edouard Lake fishing activity	Management	Edouard Lake	Permanent	Interviews and field survey	Fishes stock	Fisheries statistics, delimitation of spawning areas	WCS	WWF
Community	Virunga	Monitoring Community forests	Management	<10%	Permanent	Field survey, focus group	Land use	Delimitation of area for cropping, conservation and resource use	WWF	Local communities
Community	Virunga	Delimitation of community plantations	Management	<10%	Permanent	Field survey	Cropping area	Delimitation of cropping area; Monitoring conflict with park boundaries	WWF	
Community	Bwindi	Multiple resources use monitoring	Management	2km buffer zone inside the park	Permanent	Resources users report	Honey, medicinal and handicraft materials	Amount harvested, revenue generated per parish	UWA	Local communities, ITFC
Community	Bwindi	Local community monitoring	Research/Management	All around the park	Permanent	Interviews, focus group, household surveys, Participatory 3D modeling	Women, Batwa culture, resources users, local communities	Profiling resources users; Mapping local cultures; Impact of ICDs and multiple use on livelihood; Role of women in conservation	ITFC	IIED, JGI, ACOS
Community	Bwindi	Revenue sharing assessments	Management	All around the park	Permanent	Analysis of UWA data	Community projects	Location, nature and amount spent	UWA	ITFC
Community	Bwindi	Human/Wildlife Conflict	Management	All around the park	Permanent	UWA and HuGo (human and the gorilla people) records	Damages of wildlife on human activities	Number, distribution, wildlife involved, and type of damage	UWA	ITFC