High-tech participatory monitoring in aid of adaptive hunting management in the Amazon

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A hunter and his family are instructed in the use of a phone app for monitoring hunting activity

A phone app is proving popular among Amazonian hunters in monitoring their offtakes, and it shows promise as a hunting management tool.

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Bushmeat (also called wild meat) consumption – defined as the use of any non-domesticated terrestrial mammals, birds, reptiles and amphibians harvested for food (Nasi *et al*., 2008) – is a reality in many tropical forest landscapes. Millions of people worldwide rely on bushmeat as a major source of protein, calories and micronutrients, and the sale of such meat supports the livelihoods of many forest-living people, who often have few other sources of income (Fa, Peres and Meeuwig, 2002; Bakarr *et al*., 2002; Mainka and Trivedi, 2002; Corlett, 2007; Nasi *et al*., 2008; Brashares *et al*., 2011; Golden *et al*., 2011). The overhunting of bushmeat species, however, can be a significant driver of defaunation in tropical forests (Gandiwa *et al*., 2014; Petrozzi *et al*., 2016). Wildlife hunting can be locally intense, threatening entire populations and contributing to the local extirpation of vulnerable species (Abernethy *et al*., 2013). Humans have been hunting wildlife for millennia, but the pressure exerted by hunting on wildlife today is being exacerbated by human population growth, improved hunting technologies, expanded market access, and extractive activities that bring people deep into tropical forests.

Unsustainable hunting not only creates empty forests and savannahs, it can affect ecosystem functioning because of the ecological roles played by wildlife in such environments (Abernethy *et al*., 2013; Effiom *et al*., 2013; Wilkie *et al*., 2011). Moreover, the modification of ecosystems caused by unsustainable hunting jeopardizes the culture, health and well-being of indigenous groups and poor rural families living within them (Bennett *et al*., 2007; Nasi *et al*., 2011).

Given the importance of unsustainable hunting for conservation and livelihoods, the 11th Conference of the Parties to the Convention on Biological Diversity (CBD), held in 2012, called for the development of appropriate plans for ensuring the sustainable hunting and consumption of bushmeat. This is a laudable aim, but attaining it is possible only in situations where local communities fully participate in hunting management governed by adaptive processes (Stuart-Hill *et al*., 2005). Recent experiences in adaptive management in temperate hunting systems provide inspiration for the sustainable use of bushmeat in tropical areas (Fiorini, Yearley and Dandy, 2011; Hunt, 2013; Carter *et al*., 2014; Brown *et al*., 2015).

THE IMPORTANCE OF MONITORING

Weinbaum *et al*. (2013) suggested that adaptive management is fundamental to achieving sustainable bushmeat hunting, and this requires efficient monitoring processes. An effective monitoring system requires indicators that represent and explain the condition of a monitored variable over time (Jones *et al*., 2011). Despite the CBD's call for more "appropriate monitoring systems of bushmeat harvest and trade" (CBD, 2012), however, only limited progress has been made in developing comprehensive indicators for the sustainability of wild animal offtakes, especially for terrestrial species. Monitoring should enable the detection of unexpected change, raise awareness among citizens and policymakers, and allow the timely development and evaluation of management interventions (Wintle, Runge and Bekessy, 2010; Jones *et al*., 2013).

Weinbaum *et al*. (2013) proposed the monitoring of harvested populations over time as one of the gold standards of sustainability monitoring. Understanding the impact of human hunting alongside the influence of exogenous factors, however, is also crucial for determining the fate of wildlife populations. Learning from the better-developed monitoring systems for fisheries, as suggested by Ingram *et al*. (2015), may help in building more robust approaches for monitoring the exploitation of terrestrial species (e.g. the use of mean body mass indicator to assess whether hunters are relying on increasingly smaller species over time, and the use of the "offtake pressure indicator" as a measure of harvesting pressure on groups of wild animals). Hunting sustainability can also be investigated directly by monitoring hunters' catch per unit effort (CPUE), which allows spatial and temporal comparisons (Puertas and Bodmer, 2004; Sirén, Hamback and Machoa, 2004).

The growing field of public participation in scientific research includes citizen science, volunteer monitoring and other forms of organized research in which members of the public engage in the process of scientific investigation by asking questions, collecting data and interpreting results. In the long term, population monitoring will be most effective in ensuring sustainable hunting if it is an ongoing participatory process (possibly accompanied by adaptive harvesting strategies), which in turn empowers local people (Johnson, Kendall and Dubovsky, 2002; Singh and

A hunter checks a trap in the Ticoya Indigenous Reserve, Colombia

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Members of the hunters' association, Airumaküchi

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Gajadhar, 2014). Such monitoring programmes require long-term, intensive and repetitive monitoring of hunting effort and offtake by the individuals undertaking the hunting. Crucially, they require methods that can be replicated over time and that are efficient and transferable to different communities (Meijaard *et al*., 2011). To date, most offtake monitoring has involved the simple use of notebooks, in which hunters record information on their hunting trips, such as the type and numbers of animals killed, in a standardized format. But many hunters may be illiterate, filling out notebooks is time-consuming, and errors may arise due to research fatigue.

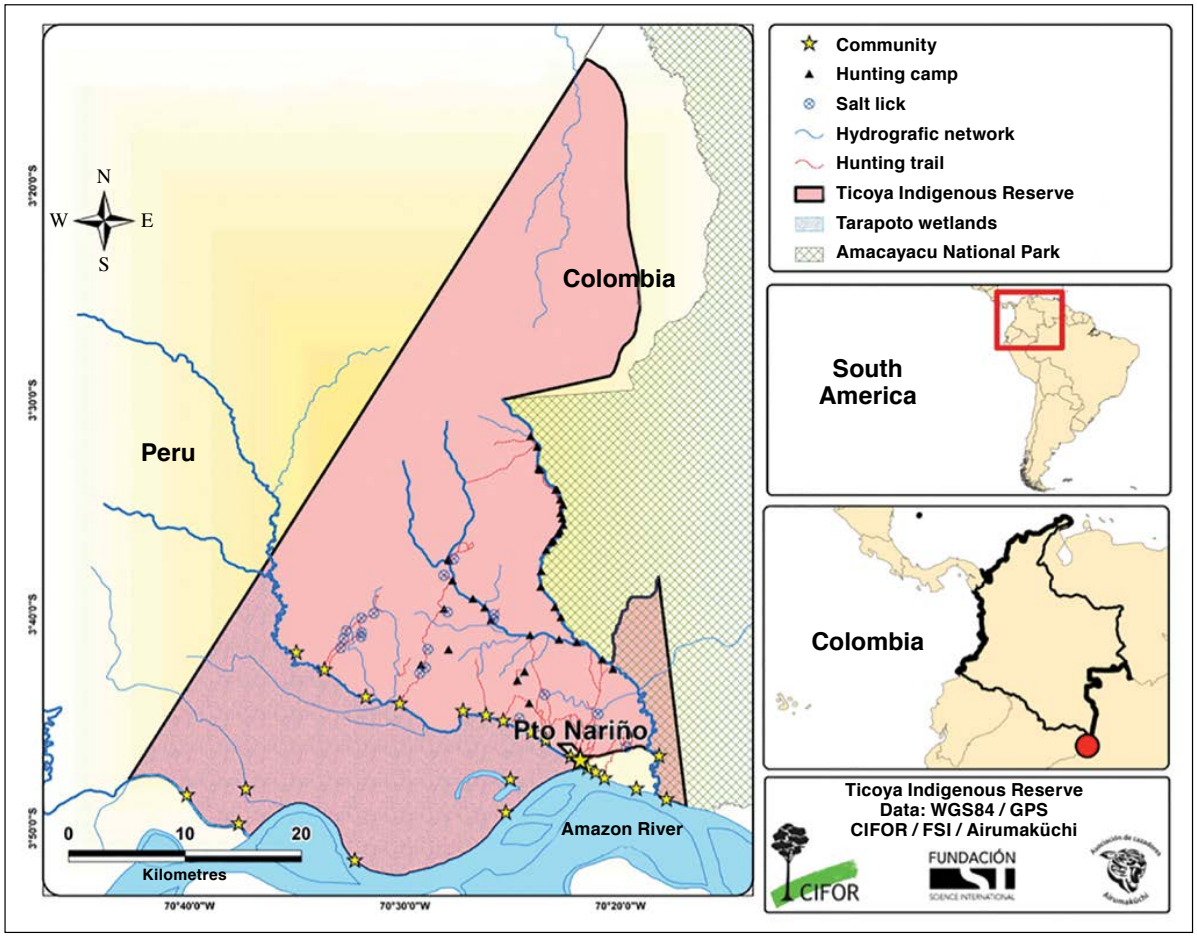
In this article, we present the results of a study on a new method for data collection, digitization and analysis based on a mobile phone application. Applications, commonly referred to as apps, are software programmes designed to run on mobile devices such as smartphones and tablets. We tested the method through a hunters' association, Airumaküchi, in Puerto Nariño, Amazonas, Colombia; we found that it is not only more efficient than traditional methods of note-taking, it also provides hunters with an opportunity to be data providers and to distinguish trends in their hunting activities. More importantly, the data generated using this more efficient method can increase the involvement of hunters in decision-making. Here we present data generated by 30 hunters during a 5-month trial and discuss the perceived advantages and disadvantages of the use of phone apps compared with traditional notebooks.

STUDY LOCATION

The study was carried out in and around the Ticoya Indigenous Reserve (TIR) in the municipality of Puerto Nariño, 87 km upstream of the Colombian Amazon's largest city, Leticia, on the Amazon River (Figure 1). Three types of forest are found in the municipality: *terra firme* forest (not subject to flooding regimes); varzea forest (subject to periodic flooding by white waters); and swamp forest (seasonally flooded by black waters) (Moreno Arocha, 2014). The climate of the area is warm and humid, with rainfall causing four distinct periods: 1) high waters (February to April); 2) decreasing waters (May to July); 3) low waters (August to October); and 4) rising waters (November to January). The average annual temperature is 26 °C (although it can reach 38 °C), and the relative humidity is around 87 percent (Rangel and Luengas, 1997).

The TIR, which was legally created in March 1990, covers 1 471 km^2 and represents 92.4 percent of the Puerto Nariño municipality. Twenty-three indigenous communities from the Ticuna, Cocama and Yagua ethnic groups live within the TIR, mostly along the Amazon, Loretoyacu, Boyahuazu and Atacuari rivers. In our study, we sought the participation of eight communities living within or bordering the TIR. The main livelihood activities are shifting cultivation (31 percent); fishing (24 percent); timber extraction (7 percent); hunting (4 percent); the collection of non-wood forest products (4 percent); livestock (4 percent); and salaried jobs (18 percent) (Trujillo, 2008, data from three communities). Tourism has recently become an important livelihood activity, providing jobs for guides, cooks, cleaning services in hostels, and handicrafts. Recent studies indicate the cultural importance of bushmeat and its contribution to food security, especially in situations where there is a tendency for nutritional transitions (van Vliet *et al*., 2015).

Hunters in the TIR have formed the Airumaküchi hunters' association, the main objective of which is to ensure sustainable hunting and the trade of surplus meat as a way of guaranteeing local food security and maintaining cultural values. We provided technical support for the development of a hunting monitoring system aimed at informing adaptive management processes for sustainability.



1
The Ticoya Indigenous Reserve, Colombia

THE MONITORING APPROACH

Six hunters from Airumaküchi have been monitoring their wildlife offtakes using traditional notebooks since 2013. Given that Puerto Nariño has access to the Internet via a 3G network and that most households already have access to technologies such as tablets, iPhones and computers, we investigated the possibility of using the KoBoCollect software downloaded onto mobile devices in a participatory monitoring process as an alternative to notebooks. KoboCollect is an Android/iOS app to facilitate data collection involving the use of smartphones or digital tablets and questionnaires created online (or offline and then uploaded onto the devices) according to user requirements. Data collected via mobile devices can be transmitted via the Internet (e.g. by 3G or Wi-Fi), stored on the KoBoCollect server (encrypted, if needed), and exported for analysis using software formats such as XLS, CSV, ZIP and KML. KoBoCollect can be used to produce, for example, summary tables, simple frequencies, and summary statistics (i.e. mean and median).

We developed a first version of the questionnaire based on the results of a meeting held with hunters, at which suggestions were made on the type of data to be collected to inform their decision-making. Each hunter was trained to use the questionnaire. Each also received a smartphone – the Samsung Galaxy Mini #4 model GT-I9195 (equipped with SIM cards, monthly 2-gigabyte Internet plans and physical protection) – and a printed and plasticized map of the territory of the TIR divided into an indexed grid; the purpose of the map was to provide the locations of hunting points in case the hunter could not fill in the form in the forest or obtain the location using the smartphone's global positioning system. The first version of the form was reviewed several times over the two-month testing period (March and April 2015) to take into account the suggestions and contributions of hunters. This period was key to identifying the difficulties that hunters might encounter

in handling the smartphones and understanding the questionnaire. Among others, these difficulties were as follows:

- Most senior hunters had trouble handling the phone's tactile screen.
- Of the ten phones delivered, one was lost in a river and two others were damaged by water.
- When the hunters returned home with no animals hunted, no form was filled out, resulting in the underestimation of effort.
- Some hunters used the whole package of 3G data in downloading games and other apps, meaning that no 3G data were available for sending the forms.

To correct these difficulties, we adapted the method in the second month of monitoring by:

- selecting young hunters familiar with the manipulation of smartphones and tactile screens and putting them in charge of monitoring offtakes for illiterate or older hunters in their communities;
- providing impermeable blisters to protect phones from humidity and water;
- insisting on the importance of collecting data with rigour because the collected data would be important in helping hunters decide on future actions; and
- providing access to the Internet for one day (or 200MB) four times per month, at the end of each week, rather than continuously, to ensure that all hunters had sufficient 3G data to send their forms to the server.

The final version of the questionnaire used multiple-choice questions and addressed the following:

- hunter's name and community;
- general information on each hunting trip, even if no animal was hunted (i.e. date of departure; duration of trip; places visited using the map of the territory; and other activities carried out);
- offtake data (i.e. species, using a pre-defined species list that includes pictures of the animals to assist identification; hunting tool used; place and type of habitat where the hunter killed the animal; sex and age of the animal; and, if female, whether the animal was pregnant); and
- the use of the animal (i.e. whether consumed, gifted or sold).

Hunters could also include photos of the animals caught and add comments. The following comments, among others, were entered into the database and used as sources of information for management:

"Migration and lack of prey due to the noise generated by the cutting of trees for new shifting cultivation plots."

"During my hunting trip, apart from the two animals I shot, I also saw a red deer and an agouti, but because I did not have any cartridges left, I let them go."

We monitored the hunting offtakes of the 30 hunters (but only 11 per month) over five months (May, June, November and December 2015 and January 2016) using the developed questionnaire. May and June correspond with decreasing waters (less rainfall) and November, December and January with increasing waters (more rainfall). The data were uploaded weekly to the KoBoCollect server and exported from CSV to a central Excel file. This file contained formulas that automatically analysed information in graphs, and these were presented to the hunters every two months. We built a wooden structure (shown in the photo below) in which to provide a tangible display of monitoring results to visitors to the Airumaküchi office, and we generated a map of hunting effort and hunting offtakes. A WhatsApp group was created among the hunters and project staff to enable rapid communication between them.

The data were analysed using descriptive graphs for ease of understanding by hunters. The analysis included the following simple indicators: number of hunting trips per month; biomass hunted per month; number of animals hunted per species and per month; number of unsuccessful hunting trips; CPUE in kg per hour; the proportion of small species (less than 20 kg) in the overall monthly offtake; the use of the meat (percentage sold versus other uses); and biomass per hunter per month.

This display board is a local innovation by the Airumaküchi hunters' association to visualize hunting offtakes per month for a list of predefined species

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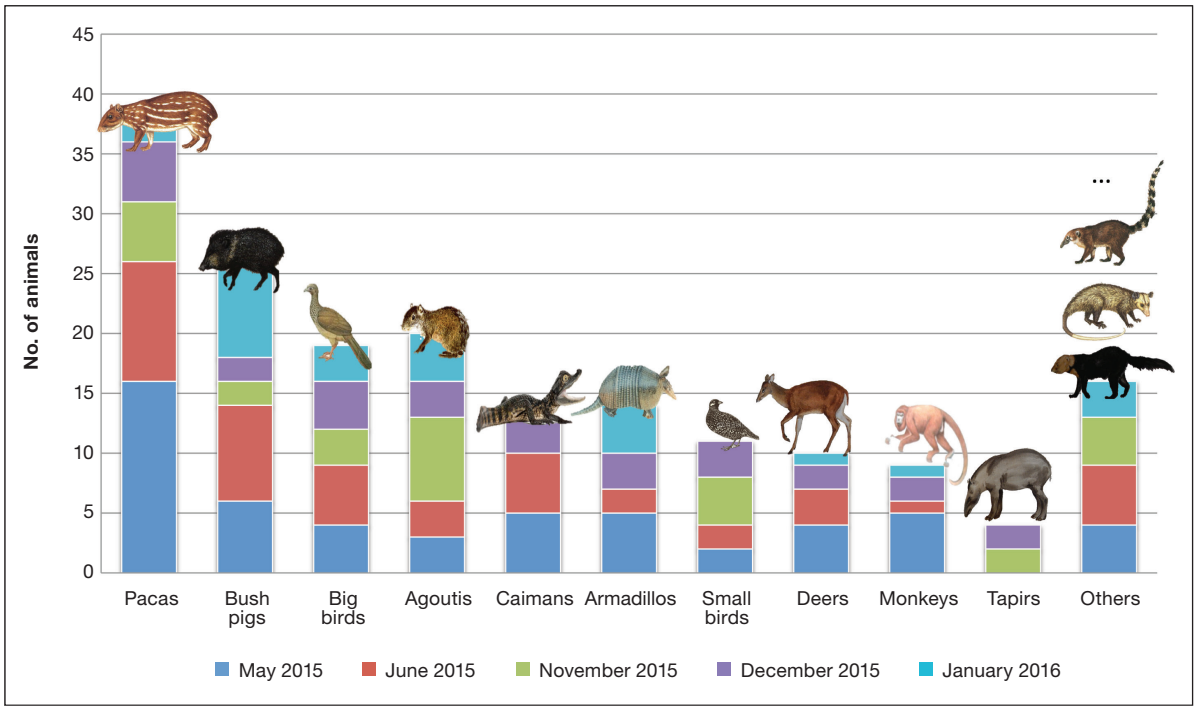
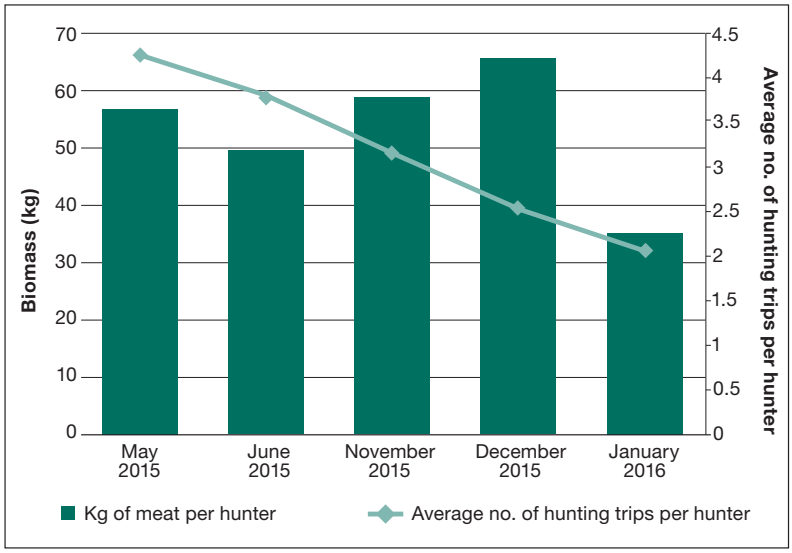


2
Numbers of animals caught, by species, May 2015–January 2016

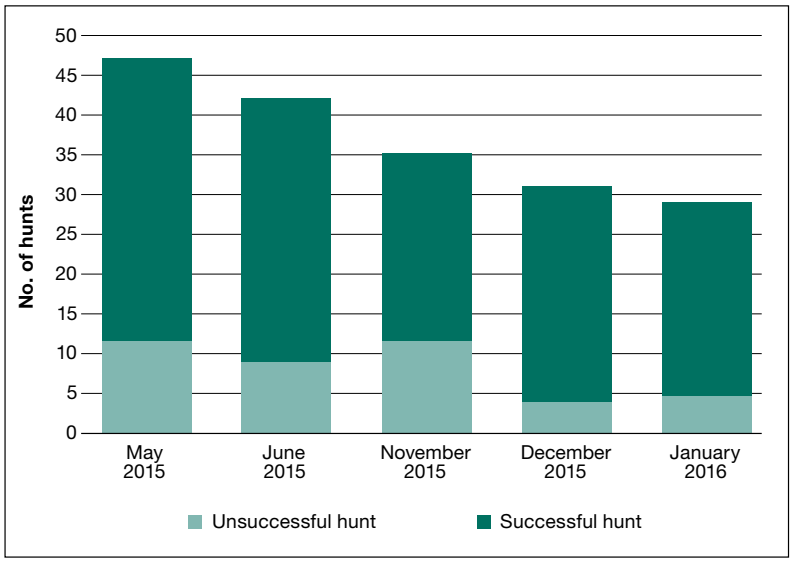
RESULTS

The hunters provided information on 175 hunting trips and 172 animals caught over the five-month monitoring period. The four most hunted species were paca (*Cuniculus paca*), bush pig (*Pecari tajacu*), big birds and agoutis (*Dasyprocta* spp.) (Figure 2). The average biomass caught per month by hunters was in the range of 32–63 kg (Figure 3). The percentage of biomass sold locally varied from 31 percent to 48 percent, depending on the month; the remainder was consumed by the families of the hunters or given as gifts to friends or family members.



3
Average biomass taken and number of hunting trips, May 2015–January 2016

The analysis shows seasonal variations in hunting patterns. Although the number of hunting trips was higher in the drier season (i.e. decreasing waters), the total biomass hunted per month did not vary significantly between seasons. Rain reduced the number of hunting trips in the rainy season but did not reduce the percentage of successful trips, which varied from 65 percent to 85 percent, depending on the month (Figure 4). About 75 percent of animals caught were from small-sized species (i.e. less than 20 kg), and this percentage did not vary significantly between months (Figure 5). The CPUE was higher in the rainy season (particularly in November and



4
Total number of successful and unsuccessful hunting trips, 30 hunters, May 2015–January 2016

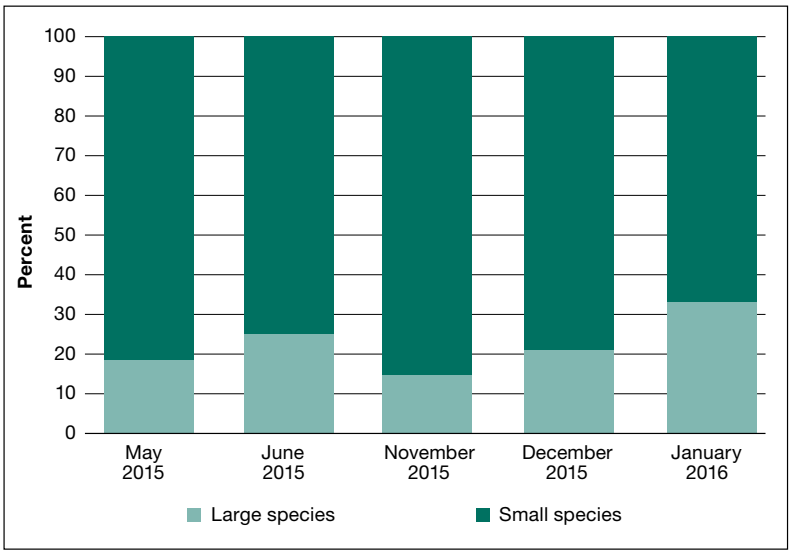
December) (Figure 6). Figure 7 shows the distribution of the catch and the number of pacas caught as an example of the output that the monitoring method generated to inform hunting management. The map, as well as the various indicators used in the monitoring process (i.e. CPUE, percentage of small-sized species, percentage of unsuccessful trips, and biomass per hunter), are useful for monitoring sustainability if used and compared over the long term.

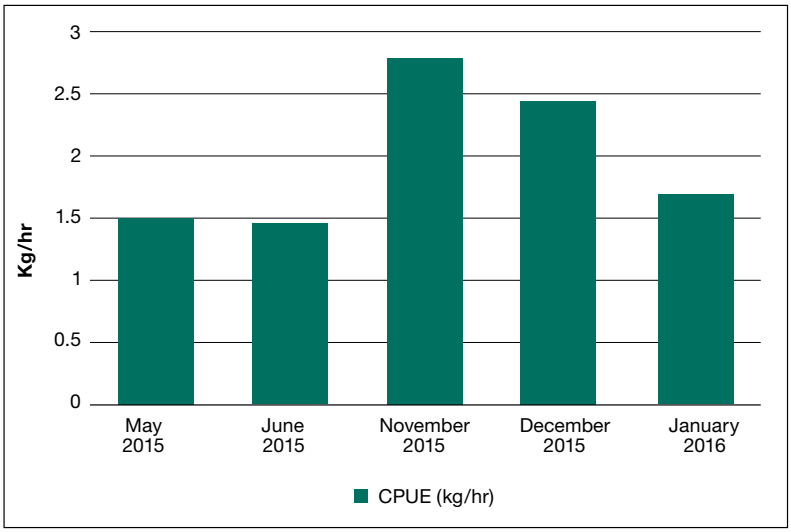
ADVANTAGES AND DISADVANTAGES OF THE METHOD

To assess the advantages and disadvantages of the use of the app in monitoring offtakes compared with notebooks, we developed a semi-structured questionnaire and asked 6 of the 30 hunters participating in the monitoring process (because those six had previously worked with paper notebooks) and two staff members in charge of coordinating the project's monitoring component to complete the questionnaire. The questions included a comparison between paper notebooks and phone apps in terms of the clarity of the questionnaire; the time spent filling out the form; the added benefits of being able to use a smartphone; and the disadvantages and advantages of using phone apps compared with notebooks.

Of the six hunters, four had never previously used a smartphone but found it very easy to learn. Only one of the hunters (the eldest) preferred to use a notebook after trying the phone app. The other five hunters preferred the phone app because it was easy to use and information could be entered more quickly; they also appreciated learning about new technologies and using their smartphones for other purposes, such as to check the time and date, use WhatsApp, take photos and play games. Among the disadvantages cited were that the smartphones could be damaged or stolen and that it was less easy to capture details about hunting trips because all questions were multiple-choice. For the two project staff members, the main perceived advantages were that the motivation of access to new technologies helped attract hunters to participate in the monitoring system and in understanding its importance. The use of the app was also seen as positive because the data could be uploaded directly to the server, saving the time required to digitize data from notebooks and avoiding transcription errors. The use of WhatsApp as a means of communicating among hunters and project staff was seen as very positive, helping create a sense of team within the group and enabling the sharing of experiences, photos and important information about the monitoring protocol.

5
Percentage of large (>20 kg) and small (<20 kg) species in total catch, May 2015–January 2016



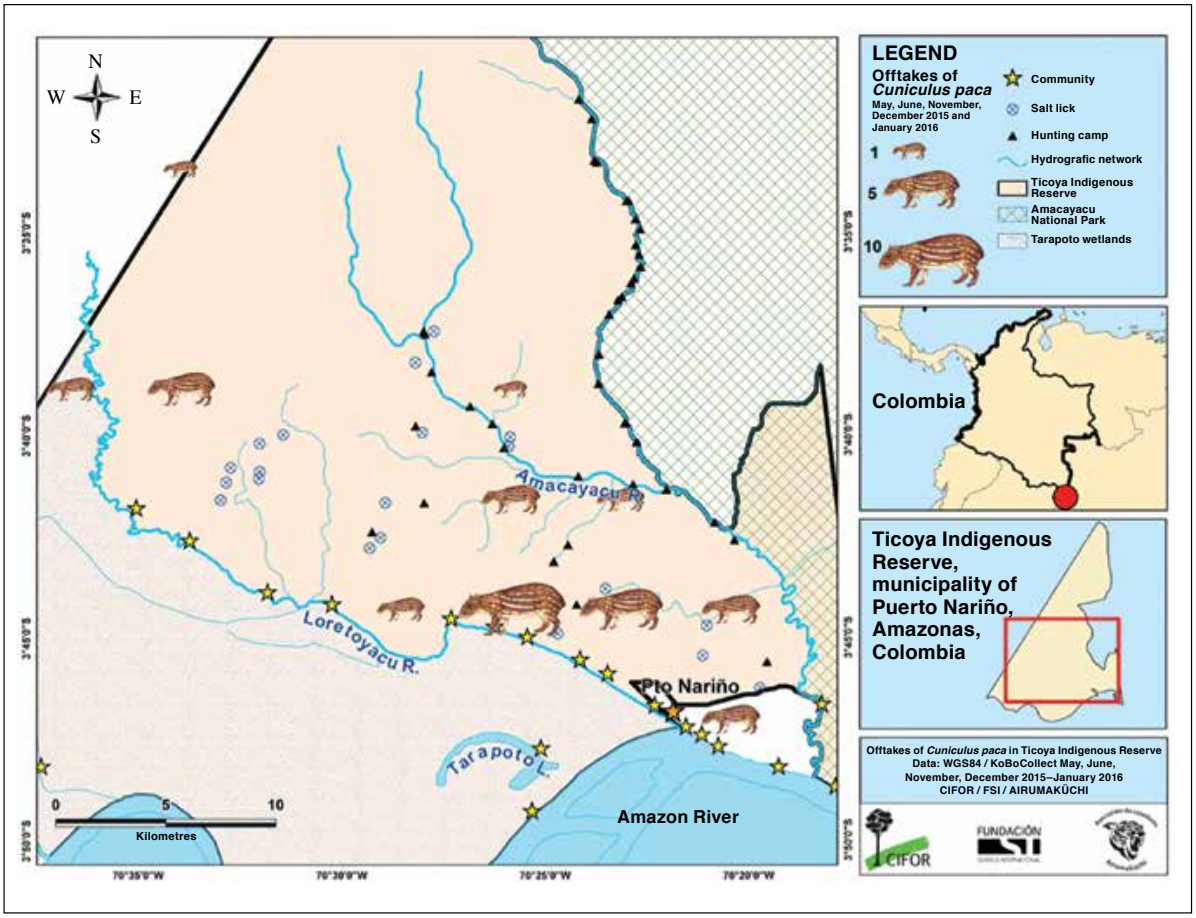


6
Average catch per unit effort, May 2015–January 2016

CONCLUSION

Our study tested the use of a smartphone app for the participatory monitoring of hunting in the context of sustainable hunting initiatives. The results show that the app can generate information on hunting on a monthly basis that, in the long run, can be used to inform decision-making. Hunters perceive smartphones to be easier to use and less time-consuming than paper notebooks, reducing the risk of research

7
Offtakes of* Cuniculus paca*, Ticoya Indigenous Reserve, May 2015–January 2016, obtained through the KoBoCollect app



Hunters share experiences and help each other in the use of the monitoring app

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fatigue; moreover, there may be more motivation to engage in monitoring over time because the results are readily available to users. This is not to say that smartphone apps are necessarily the solution in all contexts. Our pilot was successful partly because the area in which the project was conducted already had access to the Internet and phone technology was present in the community. The project, therefore, did not bring new technology with it; rather, it used an existing technology as a way of encouraging sustainable hunting; in other contexts, smartphone apps may not be so readily adopted. Despite a continuous decline in the prices of smartphones and Internet access, initial costs reduce the potential for many communities to use the methodology in the absence of external financial help.

Even though our study was preliminary and covered only seven months (a two-month trial and five months of implementation), it has shown the potential of using key indicators and modern technologies in participatory monitoring as a way of improving hunting management practices. ◆

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