

Foot Patrols Enhance Conservation Efforts in Threatened Forest Reserves of Coastal Côte d'Ivoire

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Source: Tropical Conservation Science, 12(1)

Published By: SAGE Publishing

URL: <https://doi.org/10.1177/1940082919872637>

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Foot Patrols Enhance Conservation Efforts in Threatened Forest Reserves of Coastal Côte d'Ivoire

Tropical Conservation Science
Volume 12: 1–10
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DOI: 10.1177/1940082919872637
journals.sagepub.com/home/trc



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Abstract

The Dassioko Sud and Port Gauthier Forest Reserves are important wildlife refuges in southern Côte d'Ivoire, harboring several endangered mammalian taxa. Between July 2012 and June 2016, foot patrols were conducted in these reserves by teams consisting of local villagers, Société de Développement des Forêts employees, law enforcement personnel, and the authors. The purpose of the patrols was to help curb poaching and illegal farming/logging and to collect information on wildlife. Over the length of the patrol period, both reserves experienced significant declines in illegal activities, including prior to the 2014 EBOLA outbreak. Both reserves continue to be pressured by persons living in surrounding villages; however, our results demonstrate that foot patrols involving local personnel can lead to significant declines in illegal activity inside such conservation areas.

Keywords

Côte d'Ivoire, patrol, poaching, encroachment, illegal activity, conservation

Introduction

Habitats designated as parks and reserves are intended as wildlife refugia, yet poaching and illegal farming within protected areas (PAs) continue to confound conservation efforts across the planet (Critchlow et al., 2016; Dinerstein et al., 2007; Hilborn et al., 2006). In parts of West Africa, the scale of illegal activity inside many PAs is staggering because in many cases, wildlife protection is nonexistent (Bitty, Gonedelé Bi, Bené, Kouassi, & McGraw, 2015; Gonedelé Bi et al., 2012, 2016). For example, forest cover inside numerous reserves (e.g., forêt classées) in Côte d'Ivoire has been entirely replaced by cocoa plantations and, in some cases, entire faunas have been extirpated (Bitty et al., 2015; Higonnet, Bellantonio, & Hurowitz, 2018). As the number of persons living adjacent to PAs continues to increase (Wittemyer, Elsen, Bean, Burton, & Brashares, 2008), the scale of illegal activity is likely to expand and areas of habitat set aside for wildlife conservation will come under greater pressure (Laurence et al., 2012).

If those engaged in illegal activities inside parks and reserves are able to act with impunity, there is little reason to believe protected habitats can safeguard

anything within their borders. Fortunately, there are relatively straightforward conservation mechanisms that can be highly effective at deterring illegal activity (Gandiwa, Heitkönig, Lokhorst, Prins, & Leevwis, 2013; Jachmann, 2008). Active monitoring is considered among the strongest deterrents to poaching and illegal farming inside reserves and parks. Perhaps the most straightforward means of active monitoring is to carry out foot patrols (Critchlow et al., 2016; Gray & Kalpers, 2005; Kablan et al., 2017; Nyirenda & Chomba, 2012). Foot patrols, or recce walks, are reconnaissance hikes

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Received 11 April 2019; Revised 30 July 2019; Accepted 6 August 2019

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made for the purpose of gathering information on wildlife and for disrupting/discouraging the actions of poachers, illegal farmers, loggers, miners, and so forth. These foot patrols may involve a range of personnel including wildlife officers, law enforcement officials, scientific researchers, and local villagers. Multiple studies have shown strong correlations between wildlife abundance and scale of illegal activity on the one hand, and the frequency, location, and size of patrols on the other (Bruner, Gullison, Rice, & Da Fonseca, 2001; Hilborn et al., 2006; Jenks, Howard, & Leimgruber, 2012; Kablan et al., 2017).

Patrols may serve several purposes and can collect a diversity of data. Geospatial data collected during patrols can be employed in a variety of contexts, many of which can enhance conservation (Challender & MacMillan, 2014; N'Goran et al., 2012; Tranquilli et al., 2014). Patrols increasingly use location data derived from GPS technology to identify and target so-called illegal activity *hot spots* where policing efforts can be concentrated (Hötte et al., 2016; Moreto & Matusiak, 2017). These efforts should lead to the apprehension and prosecution of more wildlife criminals. GPS information can also provide baseline data on wildlife which can be used to track changes in animal density, abundance, and range use over both time and space (Hoppe-Dominik, Kuhl, Radl, & Fischer, 2011; Jachmann & Billiow, 1997; Lotter & Clark, 2014). The overarching purpose of patrol activity is to establish a presence that monitors and protects wildlife by deterring ventures that threaten it.

In southern Côte d'Ivoire, unchecked poaching and agricultural expansion stemming from an absence of monitoring and lack of law enforcement has been disastrous for wildlife in many PAs (Bitty et al., 2015). Within the last two decades, nearly every PA in southern Côte d'Ivoire that once contained tropical evergreen forest has been transformed into illegal plantations consisting largely of cocoa and, to lesser degrees, palm and rubber crops (Bitty et al., 2015). Much of this recent ecological destruction occurred in the wake of the Ivorian Civil war which began in 2002 and involved the southern migration of thousands of persons from northern regions of the country (Chirot, 2006; Collett, 2006; Woods, 2003). Many migrants settled inside PAs, encountered little or no resistance, and converted large portions of forest to cocoa plantations (Bitty et al., 2015; Woods, 2003). Two exceptions are the Dassioko Sud Forest Reserve (FR) and Port Gauthier FR which still contain areas of relatively undisturbed high canopy forest and which harbor several endangered taxa including forest elephants (*Loxodonta cyclotis*), Roloway monkeys (*Cercopithecus roloway*) and white-naped mangabeys (*Cercocebus atys lumulatus*) (Kouamé & Zoro, 2010). These reserves represent two of the last refuges for forest wildlife in

southern Côte d'Ivoire; however, both are threatened by illegal farming, logging, and hunting (Bitty et al., 2015; Gonedélé Bi et al., 2016; Yao et al., 2018). As part of ongoing efforts to preserve wildlife in Côte d'Ivoire, we initiated foot patrols inside both reserves with goals of documenting the extent of illegal activities and contribute to their cessation (e.g., destruction of new plantations, poacher camps, etc.). Our specific aims were to identify the most important illegal activities affecting the reserves and to measure the effectiveness patrols had over time at curbing illegal activities. Here, we present information on changes in illegal activity over the course of a 4-year period during which patrols were conducted inside the reserves.

Study Sites

Dassioko Sud and Port Gauthier FRs are coastal evergreen forests (Kouamé & Zoro, 2010) designated as conservation reserves and managed by the Société de Développement des Forêts (SODEFOR). The Dassioko Sud FR has a surface area of 12.5 ha, while Port Gauthier FR is approximately 11.2 hectares (Figure 1). The topography of the two reserves differs with Dassioko Sud having a higher average elevation (45.51 ± 1.32 m) than Port Gauthier (29.65 ± 1 m). The climate of the region is characterized by a wet and dry season: The wet season includes a long (April to July) and short (October–November) rainy season, while the dry season includes a long (December–March) and short (August–September) dry season.

Methods

Patrols were carried out in both reserves between July 2012 and June 2016. Patrol teams consisted of local community members, SODEFOR staff acting as law enforcement officials and researchers (the authors). Community members participating in patrols were recruited from villages adjacent to PAs and supported by funds obtained from several conservation organizations (see acknowledgments). The composition of each team remained constant during the survey period; however, the size and composition of the patrols (sub groups of teams) changed depending on the availability of individuals. The mean number of individuals on a given patrol in the Dassioko Sud and Port Gauthier FRs was 7.8 and 6.5, respectively. Patrol day was determined by the availability of SODEFOR staff since they are also in charge of the management of four to five additional forests.

The size and composition of the patrols changed depending on the availability of individuals, but patrols typically consisted of four or five men from local villages, a SODEFOR employee, and one of the authors. Law enforcement personnel were present in

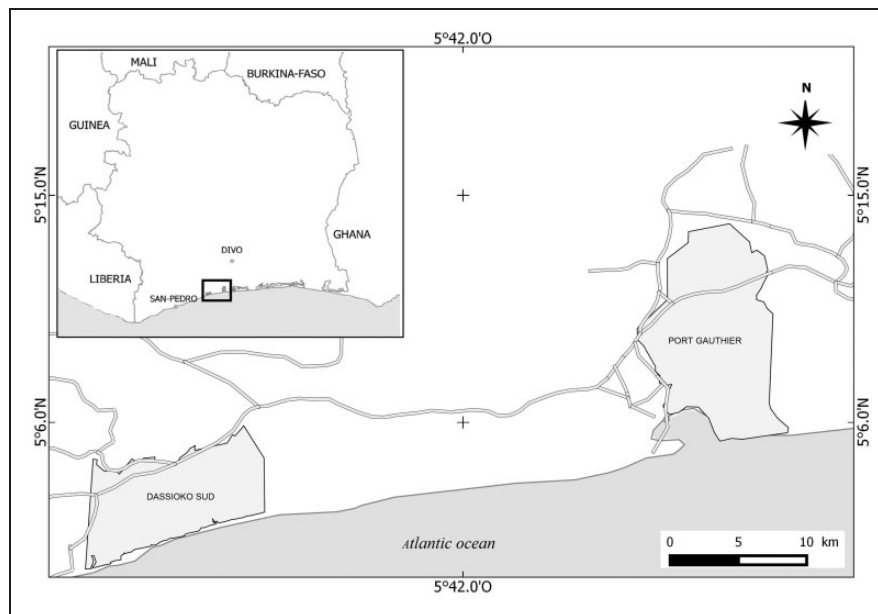


Figure 1. Location of Dassioko Sud and Port Gauthier forest reserve in coastal Côte d'Ivoire.

approximately one third of all patrols. During the study period, the mean number of individuals on patrol in the Dassioko Sud and Port Gauthier FRs was 7.8 and 6.5, respectively. Patrol walks typically commenced at 9:00 AM, ended at 16:00, and included a 1-hr rest period from 12:00 to 13:00 PM. We did not patrol reserves in systematic ways but instead randomized routes (e.g., changing direction frequently) to avoid becoming predictable. We attempted to cover as much of each reserve as possible during each walk; however, we did focus more at reserve entry points and on paths used by poachers in reserve interiors in order to increase the chance of encountering persons involved in illegal activity. Although we focused more on reserve entry points and on paths used by poachers in reserve interiors, the areas we surveyed between these points and paths were done so randomly.

Patrol members progressed slowly using routes that did not disturb the vegetation, natural corridors, and established pathways and game trails. During each walk, patrol members collected information on illegal activities (gunshots heard, snares encountered and deactivated, shotgun cartridges collected, poacher or farmer apprehended, hectares cocoa farms destroyed). A member of the patrol team recorded the patrol routes using GPS device. All locality information was recorded using handheld GPS Garmin Etrex 10. We noted the time and direction of all gun shots, collected discarded gun cartridges, and counted and dismantled all snares. We recorded the size and location of all logging and farming operations and destroyed all plantation crops, most of which were new cocoa seedlings. During day patrols that included law enforcement

personnel, any poachers, loggers, or illegal farmers encountered were apprehended and their firearms confiscated. Patrol is defined as an individual walk (i.e., *recce*) made for the purpose of collecting information within a given reserve. Information collected on patrols was used to determine the total number of signs of illegal activity per kilometer walked. Illegal activities include signs of poaching, illegal farming, logging, and grazing activities inside the reserves. Thus, total illegal activities included the sum of all possible wildlife crimes within a reserve. The poaching signs we recorded were the number of (a) gunshots heard, (b) snares encountered and deactivated, (c) shotgun cartridges collected, and (d) poacher apprehended. These signs were used to calculate a separate poaching index which is the number of poaching signs per kilometer walked. Change in (a) overall illegal activity (including poaching) and (b) poaching only over time (monthly) in each reserve was examined using linear regression.

We also examined the effect of patrol effort on illegal activity in both reserves. Patrol effort was defined in two ways: the number of visits per month (patrol frequency) and the total number of kilometers walked by patrols in each reserve. We compared patrol efforts in the two reserves using *F* statistics. Generalized linear model analysis was used to test correlations between variables measured inside the reserves. All statistical analyses were carried out in Stata 9 with a significance of $p < .05$.

Results

Data collected during patrols are summarized in Table 1. Between July 2012 and June 2016, we conducted 192 and

Table 1. Patrol Efforts and Number of Illegal Activities Encountered Inside Dassioko Sud and Port Gauthier Forest Reserves.

	Dassioko Sud FR	Port Gauthier FR
Number of patrols conducted	192	158
Mean no. of patrols/month	4	3.3
Mean no. of persons per patrol	7.8	6.5
Total length surveyed (km)	1,152	954
Mean annual length surveyed (km)	230.4	189.6
Total no. of illegal signs encountered	1,830	1,621
Total no. of illegal signs—wet season	805.25	667.5
Total no. of illegal signs—dry season	1,024.75	953.5
Total no. of illegal signs/km	1.6/km	1.7/km
No. of gunshots heard	158	144
No. of snares encountered and deactivated	554	494
No. of poachers apprehended	2	4
No. of shotgun cartridges collected	537	475
Total no. of poaching signs (Poaching Index)	1,251	1,117
No. of poaching signs—wet season	549	444
No. of poaching signs—dry season	702	673
No. of hectares cocoa farms destroyed	350	164

Note. FR = forest reserves.

158 patrols in Dassioko Sud and Port Gauthier FRs, respectively. Figures 2 and 3 illustrate the patrol routes used in each reserve during each year. Across the 48-month patrol period, an average of four patrols per month was carried out in Dassioko Sud FR (range = 2–6, $SD = 0.64$); 3.3 patrols per month were conducted in Port Gauthier FR (range = 2–6, $SD = 0.65$). This effort did not differ significantly across the two reserves ($F = 1.2$, $p = .526$). The average number of kilometers walked per month in Dassioko Sud (230.4 km) and Port Gauthier (189.6 km) did not significantly differ ($F = 1.64$, $p = .64$).

Monthly totals of illegal activity signs recorded in each reserve are presented in Figure 4. Both reserves experienced significant declines in total illegal activity across the study period (Dassioko FR: $R^2 = .703$, $n = 47$, $p < .001$; Port Gauthier FR: $R^2 = .624$, $n = 47$, $p < .0001$). The monthly poaching index calculated for each forest reserve is presented in Figure 5. Both reserves experienced significant declines in poaching activities over the length of the patrol period (Dassioko FR: $R^2 = .727$, $n = 47$, $p < .0001$; Port Gauthier FR: $R^2 = .650$, $n = 47$, $p < .0001$).

During the study period, patrols heard 158 and 144 gunshots, collected 537 and 475 shotgun cartridges, deactivated 554 and 494 cable snare traps for catching animals, and destroyed 350 and 164 hectares of cocoa

plantation in Dassioko Sud and Port Gauthier FRs, respectively (Table 1). Significantly more area of illegal plantations was destroyed in Dassioko Sud FR (350 ha) than in Port Gauthier FR (164 ha) ($F = 1.89$, $p = .033$). A total of 318 campsites of poachers and cocoa farmers were destroyed in both reserves. During the patrol period, patrols encountered and 164 intruders, including poachers and illegal farmers, in Dassioko Sud and Port Gauthier FRs, respectively (Table 1). Over this period, law enforcement officials arrested 107 and 144 offenders in Dassioko Sud and Port Gauthier FRs, respectively.

Discussion

Unrest in Côte d'Ivoire following the 2002 civil war was accompanied by significant changes in government resources and priorities (Hanson et al., 2009), and little formal conservation attention was given to Dassioko or Port Gauthier reserves for at least 10 years prior to our study. We therefore regard the date our patrol activities commenced—July 2012—as representing a point of minimal protection. Our data indicate that poaching and other illegal activities in Port Gauthier and Dassioko Sud FRs decreased immediately following initiation of patrols in both reserves and generally continued to decline over the course of the patrol period. The declines in illegal activity reached their lowest levels in early 2014, prior to the Ebola breakout.

Although their trajectories are similar, the pattern of decline in the two reserves is not identical and three factors may account for the difference. First, shortly after patrols began (February 2013), it was discovered that several local members of the Port Gauthier patrol team recruited by SODEFDOR had continued to carry out illegal activities inside that reserve.

Interviews revealed these men justified their actions because they felt they were the rightful owners of land (and fauna) inside both reserves. Following their discovery (and firing), SODEFOR recruited only nonlocal villagers to participate in Port Gauthier patrols, an adjustment not required for Dassioko Sud FR since no patrol participants were found to be involved in illegal activities. A second possible factor for a greater initial decline in illegal activity in Dassioko Sud is that several Dassioko Sud patrol members had prior biomonitoring experience inside the reserve. These individuals had previously worked with SODEFOR on several projects and likely had greater familiarity with signs of illegal activity.

Such experience could have facilitated greater detection of illegal activity in the early phases of patrols activity. A third possible factor is that more cocoa plantations were destroyed in Dassioko Sud FR than in Port Gauthier FR, resulting in more actors (i.e., illegal farmers) immediately losing incentive to enter Dassioko Sud FR because their primary reason for doing so had

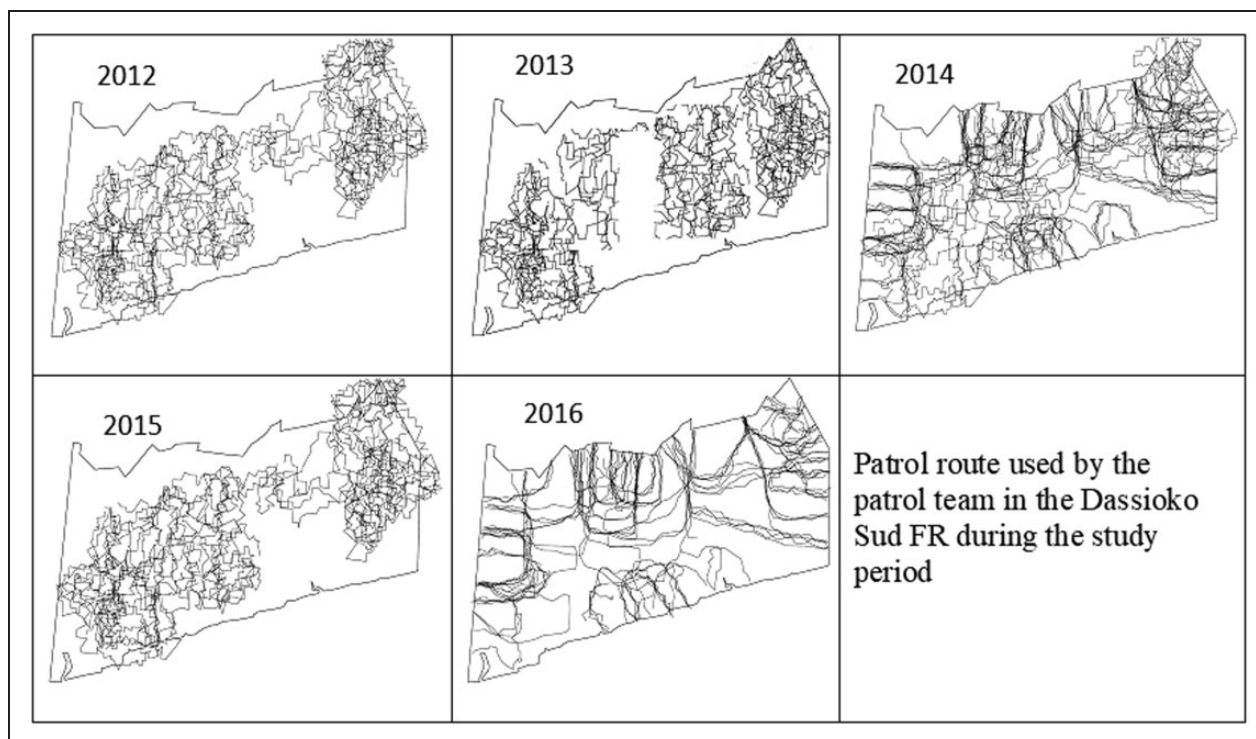


Figure 2. Patrol routes used by the patrol teams in the Dassioko Sud during the study period. The GPS devices were programmed to collect data at 5 min intervals generating a time series with associated x, y spatial coordinates. We edited the track data in GPS Track Editor.

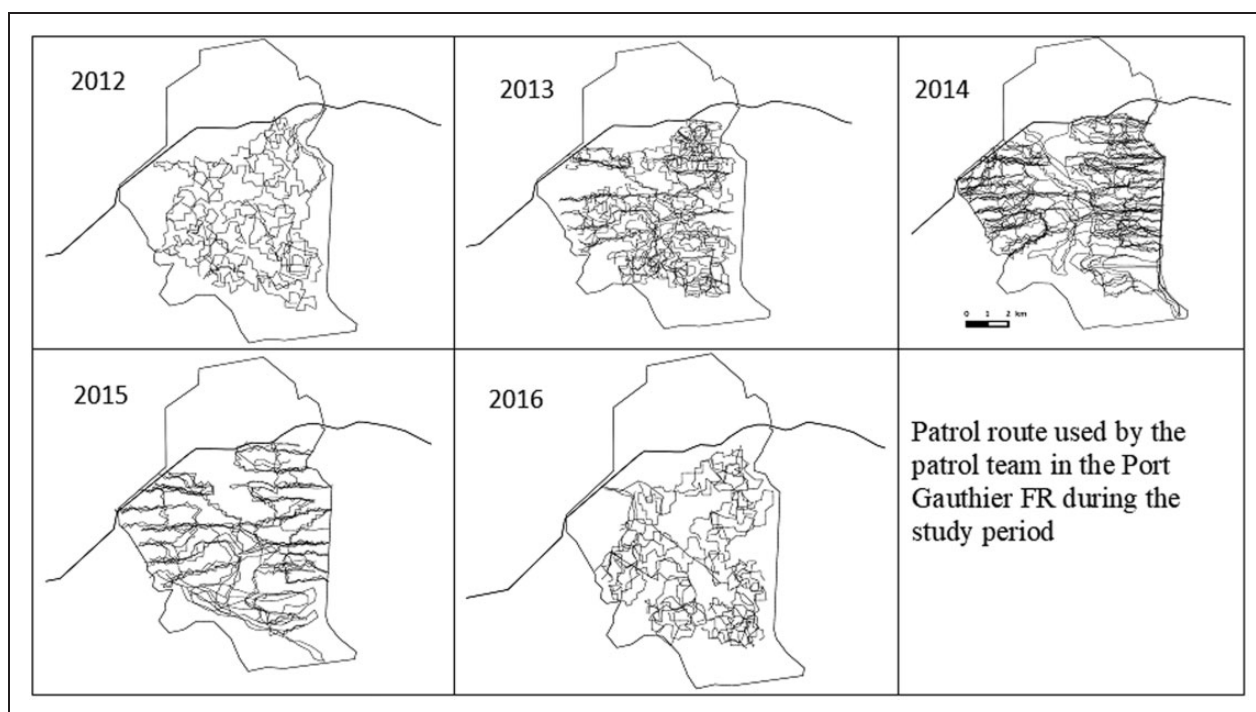


Figure 3. Patrol routes used by the patrol teams in the Port Gauthier FR during the study period. The GPS devices were programmed to collect data at 5 min intervals generating a time series with associated x, y spatial coordinates. We edited the track data in GPS Track Editor.

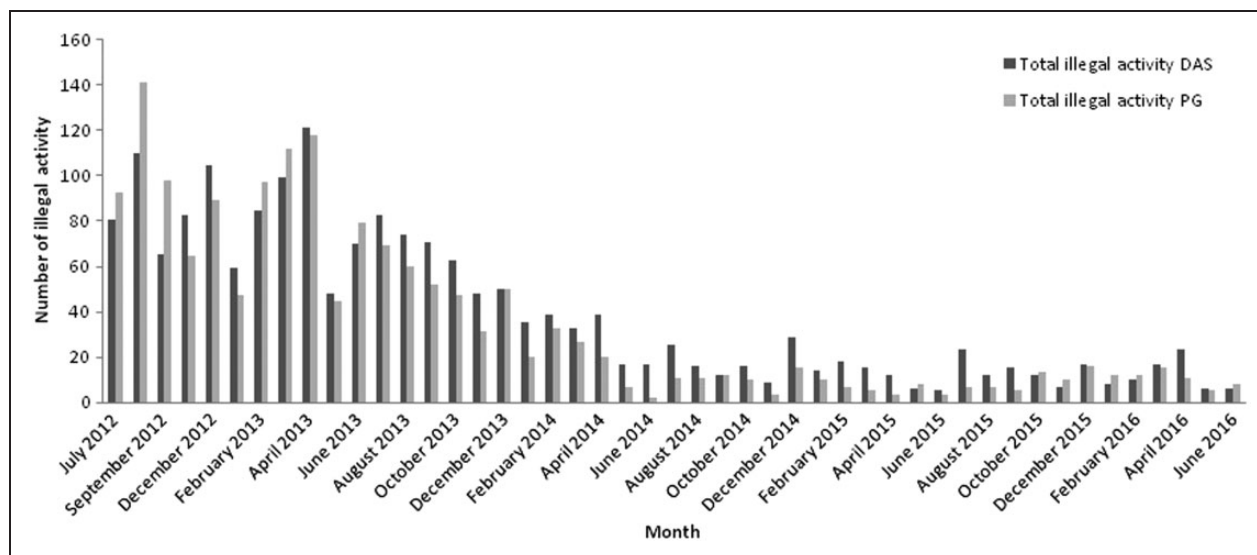


Figure 4. Plot showing monthly frequency of total illegal signs in Dassioko Sud and Port Gauthier forest reserves over the study period. DAS: Dassioko Sud; PG: Port Gauthier.

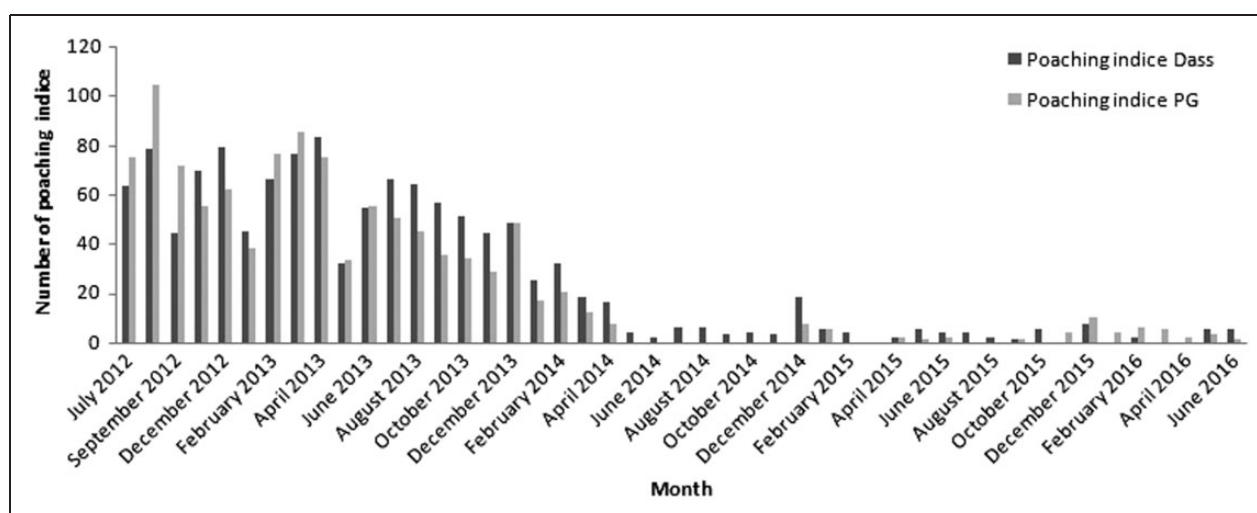


Figure 5. Plot showing monthly poaching indices in Dassioko Sud and Port Gauthier forest reserves over the study period. PG: Port Gauthier.

been eliminated. The destruction of farm crops also likely resulted in a decrease in poaching since many farmers are known to hunt opportunistically when working their field inside PA's. The lesson here is that aggressive and singular acts such of destroying illegal farms can result in significant declines in multiple forms of illegal activity.

It is tempting to conclude that patrol activity alone was responsible for reduction of illegal activity between 2012 and 2016; however, our results are accompanied by several caveats. It is possible that a portion of the poaching decline was attributable to fear of contracting disease

from bushmeat following the 2014 Ebola outbreak. The middle of our study coincided with the outbreak and spread of Ebola, a period during which aggressive anti-poaching and educational programs were enacted by Ivorian officials. Several studies have demonstrated that bushmeat hunting and bushmeat consumption were impacted by the epidemic in several West African regions (e.g., Akani, Dendi, & Luiselli, 2015; Bonwitt et al., 2018), and it is possible we sampled a behavioral change unrelated to patrol activity. We recognize awareness programs assisted in reducing hunting in Ivory Coast including, perhaps, in Dassioko Sud and Port

Gauthier FR; however, we note that the greatest decrease in illegal activity occurred well before the Ebola outbreak and the awareness campaign that followed (Figures 4 and 5). Subsequent to the poaching levels reaching their lowest points (Figure 5) at the end of 2014, education programs (e.g., Dinde et al., 2017) warning against the dangers of Ebola and bushmeat likely helped maintain low levels of illegal activity in 2015 and 2016.

Support for this idea comes from the slight uptake in poaching activity that has occurred since the Ebola *all clear* message sounded at the end of 2015 and despite patrol efforts which continued into 2016.

Another factor to consider when interpreting the effect of patrols on poaching is the possibility that poaching activity declined as the survey period progressed because the abundance of wildlife targets had been reduced. Lack of information on depletion rates of forest wildlife prevents us from stating unequivocally that our patrols were solely responsible for declines in hunting, and we are unable to associate changes in prey abundance with fluctuations in poaching pressure as has been done in other studies (Kablan et al., 2017; Keane, Jones, & Milner-Gulland, 2011; Linkie et al., 2015). Data on wildlife abundance and prey offtake by poachers during the study period would have been very helpful.

PAs that are monitored are far more likely to remain intact and preserve wildlife than those that are ignored and unsupervised. Patrols carried out regularly send a strong message to communities near PAs that such habitats and their wildlife are valued and are being watched. The critical element in the message is that teams of individuals are actively and irregularly—but frequently—patrolling habitats. Our data suggest that such measures can be highly effective and can lead to sustained reductions in poaching and illegal farming; however, without a clear understanding of the factors contributing to these activities, as well as the mechanisms needed to counter them, it will be difficult to improve conservation in West African PAs (Nutakor, Marfo, & Tutu, 2011).

Forest loss continues to be a major problem in Côte d'Ivoire. Between 2000 and 2015, the country lost approximately 17% of its forest cover driven by an annual deforestation rate—2.69%—which was among the highest in the world (Global Forest Watch, 2019). PAs were not immune to degradation, and considerable forest inside Côte d'Ivoire's PAs has been eliminated, especially within the last 20 years. Given the government's concern with national security over much of the last three decades, safeguarding habitat and wildlife inside parks and FR was not likely a high priority. During the period following the 2002 civil war especially, thousands of migrants moved south and in to PAs with few, if any, law enforcement agents stopping them (Bitty

et al., 2015). The result was the rapid establishment of permanent human settlements, replacement of forest with illegal cocoa plantations, and an escalation of hunting within reserves, classified forests, and parks (Norris et al., 2010; Woods, 2003). These developments were facilitated by the behavior of local populations living adjacent to PAs, many of whom *sold* migrants their rights to work land within PAs. Local residents had exploited resources (forest products) within PAs for years prior to our patrol activity; however, the forests had become increasingly nonproductive owing to their degradation and reduction in size. This led to increasing feelings of detachment on the part of local persons who could no longer benefit from products secured from PAs. Many individuals sold their stake to migrants from the north who encountered virtually no resistance from forest authorities as they converted forest to cocoa plantations inside PAs (Bitty et al., 2015).

Lack of resources and personnel issues also contributed to the wave of illegal activity in both reserves, problems that continue to hamper conservation efforts today. A number of rangers we encountered lacked conservation-related training, adequate field experience, and reliable equipment. We were frequently struck by the limited forest knowledge of several SODEFOR workers and disturbed by how large an area they were responsible for patrolling but had never been visited. Much of the problem is a lack of man-power to adequately patrol—and protect—all area within these reserves. During the survey period, five men were assigned to Dassioko Sud FR as rangers. In addition to Dassioko (12,540 ha), these individuals were responsible for monitoring five other reserves: Bolo Est FR (10,174 ha), Bolo Ouest FR (6,605 ha), Dakpadou FR (300 ha), Haute Bolo FR (19,674 ha), and Okromodou FR (96,443 ha). Thus, these men oversaw a total of 145,738 ha for an average of one ranger per 29.15 km², a ratio far too small to offer effective coverage. Six rangers were assigned to Port Gauthier FR (10,694 ha) as well as four other FR: Dogodou FR (28,789 ha), Niouniourou FR (13,000 ha), Haute Dodo FR (196,733 ha), and Haute Bolo (19,674). These six individuals were responsible for overseeing a total of 268,887 ha or an average of one ranger for every 44.8 km². Both quotients fall well below the European average of 41 individuals/100 km² of PA and the global average of 27 individuals/100 km² (James, Green, & Paine, 1999).

Law enforcement is a central tenant of successful conservation, and the presence of rangers on the ground is the best way to control illegal forest activities (Covey & McGraw, 2014; Leader-Williams & Milner-Gulland, 1993; Ratcliffe, 2004; Tranquilli et al., 2014).

However, if individuals whose task is to locate, confront, and charge wildlife criminals are not supported by

a legal system that effectively punishes perpetrators, the reason for placing rangers in the field is lost. The threat of meaningful punishment is not an effective deterrent and the failure of authorities to prosecute wildlife offenders greatly hampers conservation efforts in Côte d'Ivoire. During our study, 48 of the arrested persons in Dassioko Sud were released shortly after their arrest and while still in the reserve; 62 of the arrestees in Port Gauthier were released immediately. Persons arrested in Port Gauthier FR and not immediately released were taken to the judiciary office in Divo, approximately 129 km away. Persons arrested in Dassioko FR and not immediately released were taken to the judiciary office in San Pedro, approximately 92 km away. Of these, 33 persons from Dassioko Sud and 32 persons from Port Gauthier were acquitted and released for various reasons, usually because of insufficient evidence. A total of 42 persons were indicted for environmental crimes, 27 in Port Gauthier and 15 in Dassioko Sud. Of these, 23 persons from Port Gauthier and 11 persons from Dassioko Sud were given prison sentences ranging from 2 to 4 months. The remaining persons were released with no penalty. Thus, many offenders apprehended inside the Dassioko Sud and Port Gauthier FRs were released immediately or soon after their arrests or sentenced to short prison sentences. Once released, it is reasonable to expect that many persons will resume activities inside the reserves, especially if they know they operate in what is essentially a consequence-free environment.

Implications for Conservation

Ivorian laws pertaining to habitat and wildlife are weak and subject to (mis) interpretation and abuse. The legal framework governing wildlife crimes in Côte d'Ivoire is largely geared to forestry issues (e.g., illegal logging) and the language governing animal crimes is confusing. The harvesting—but not hunting—of forest resources, including the collection of nonendangered animals and insects for consumption (vs. commercial purposes) is permitted (Article 46 of the Ivorian Forest Code) even inside PAs, leading to a ambiguity between what can and cannot be extracted from a forest and by what means. Hunting of any animal has been prohibited throughout Côte d'Ivoire since January 1st 1974 by the decree no. 003/SEPN/CAB, yet many persons we have encountered are unaware of such prohibitions. Such confusion and misinformation does little to promote wildlife protection. Moreover, penalties for wildlife crimes are small: According to Article 127 of the Ivorian Forest Code, individuals found guilty of forest crimes, even in the most extreme case, face either a prison sentence of one to six months or a fine of 50,000 to 250,000 CFA francs

(88–439 \$US). Such punishments are unlikely to be effective deterrents.

If laws designed to conserve wildlife are weak and rarely enforced, and if wildlife criminals who are caught are released quickly and/or rarely prosecuted, it is little surprise that Côte d'Ivoire's reserves, classified forests, and parks are not providing the wildlife protection they were intended to. We appeal to the Ivorian authorities to take a stronger stand against illegal activities in the country's PAs and to hand down sentences of sufficient length that they serve as legitimate deterrents to illicit activities. Additional measures could also increase the likelihood of convictions and meaningful penalties with which could lead to fewer repeat/serial offenders. For example, the court closest to Dassioko and Port Gauthier FRs is approximately 90 km away, a distance which does not encourage arresting officers who have little incentive to make such a trip. A magistrate closer to these reserves would likely have a significant effect on the scale of illegal activity. Such ideas and efforts, combined with activities such as foot patrols that can monitor both wildlife and the threats to it, are needed to conserve two of the last coastal FR in southern Côte d'Ivoire as well as other PAs in West Africa.

Acknowledgments

We are grateful to Société de Développement des Forêts for permission to work at Dassioko Sud and Port Gauthier forest reserves. We also thank the Centre Suisse de Recherches Scientifiques en Côte d'Ivoire for logistical and assistance.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical standards

We obtained research permit from Société de Développement des Forêts and Ivorian Wildlife authorities. All field procedures were approved by these authorities.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research was funded by Conservation International (Primate Action Fund), Primate Conservation Incorporated and Rainforest Rescue.

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References

- Akani, G. C., Dendi, D., & Luiselli, L. (2015). Ebola virus effects on the bushmeat trade in West Africa. *African Journal of Ecology*, 53, 613–615.
- Bitty, E. A., Gonedélé Bi, S., Bené, K. J. C., Kouassi, P. K., & McGraw, W. S. (2015). Cocoa farming and primate extirpation inside Cote d'Ivoire's protected areas. *Tropical Conservation Science*, 8(1), 95–113.
- Bonwitt, J., Dawson, M., Kandeh, M., Ansumana, R., Sahr, F., Brown, H., & Kelly, A. H. (2018). Unintended consequences of the 'bushmeat ban' in West Africa during the 2013–2016 Ebola virus disease epidemic. *Social Science & Medicine*, 200, 166–173.
- Bruner, A. G., Gullison, R. E., Rice, R. E., & Da Fonseca, G. A. (2001). Effectiveness of parks in protecting tropical biodiversity. *Science*, 291, 125–128.
- Challender, D. W. S., & MacMillan, D. C. (2014). Poaching is more than an enforcement problem. *Conservation Letters*, 7, 484–494.
- Chiro, D. (2006). The debacle in Cote d'Ivoire. *Journal of Democracy*, 17, 63–77.
- Collett, M. (2006). Ivorian identity constructions: Ethnicity and nationalism in the prelude to civil war. *Nations and Nationalism*, 12, 613–629.
- Covey, R., & McGraw, W. S. (2014). Monkeys in a West African bushmeat market: Implications for cercopithecoid conservation in eastern Liberia. *Tropical Conservation Science*, 7(1), 115–125.
- Critchlow, R., Plumptre, A., Andira, B., Nsubuga, M., Driciru, M., Rwetsiba, A., ... Beale, C. (2016). Improving law enforcement effectiveness and efficiency in protected areas using ranger-collected monitoring data. *Conservation Letters*, 10(5), 572–580.
- Dinerstein, E. C., Loucks, E., Wikramanayake, E., Ginsberg, J., Sanderson, E., Seidensticker, J., ... Songer, M. (2007). The fate of wild tigers. *BioScience*, 57, 508–514.
- Dinde, A. O., Mobio, A. J., Konan, A. G., Fokou, G., Yao, K., Easo, E. L. J. C., ... Bonfoh, B. (2017). Response to the Ebola-related bushmeat consumption ban in rural Côte d'Ivoire. *Agriculture and Food Security*, 6, 28. doi:10.1186/s40066-017-0105-9
- Gandiwa, E., Heitkönig, I. M. A., Lokhorst, A. M., Prins, H. H. T., & Leewis, C. (2013). Illegal hunting and law enforcement during a period of economic decline in Zimbabwe: A case study of northern Gonarezhou National Park and adjacent areas. *Journal for Nature Conservation*, 21, 133–142.
- Global Forest Watch. (2019). *Tree cover loss data*. Retrieved from <https://www.globalforestwatch.org/dashboards/country/CIV>
- Gonedélé Bi, S., Koné, I., Bitty, E. A., Bené, J. C. K., Akpatou, B., & Zinner, D. (2012). Distribution and conservation status of catarrhine primates in Côte d'Ivoire (West Africa). *Folia Primatol*, 83, 11–23.
- Gonedélé Bi, S., Koné, I., Bené, J. C. K., Bitty, E. A., Kouassi, B. A., & Gaubert, P. (2016). Bushmeat hunting around a remnant coastal rainforest in Côte d'Ivoire. *Oryx*, 51, 418–427. doi:10.1017/S0030605315001453
- Gray, M., & Kalpers, J. (2005). Ranger based monitoring in the Virunga–Bwindi region of East-Central Africa: A simple data collection tool for park management. *Biodiversity and Conservation*, 14, 2723–2741.
- Hanson, T., Brooks, T. M., Da Fonseca, G. A. B., Hoffman, M., Lamoreux, J. F., Machlis, G., ... Pilgrim, J. D. (2009). Warfare in biodiversity hotspots. *Conservation Biology*, 23, 578–587.
- Higonnet, E., Bellantonio, M., & Hurowitz, G. (2018). *Chocolate's dark secret: How the cocoa industry destroys national parks* (Report from MightyEarth.Org, Washington, Mighty Earth, 24 p.).
- Hilborn, R., Arcese, P., Borner, M., Hando, J., Hopcraft, G., Loibooki, M., ... Sinclair, A. R. E. (2006). Effective enforcement in a conservation area. *Science*, 314, 1266.
- Hoppe-Dominik, B., Kuhl, H. S., Radl, G., & Fischer, F. (2011). Long-term monitoring of large rainforest mammals in the Biosphere Reserve of Tai National Park, Cote d'Ivoire. *African Journal of Ecology*, 49, 450–458.
- Hötte, M. H. H., Kolodin, I. A., Berezuk, S. L., Slaght, J. C., Kerley, L. L., Soutyrina, S. V., ... Miquelle, D. G. (2016). Indicators of success for smart law enforcement in protected areas: A case study for Russian Amur Tiger (*Panthera tigris altaica*) Reserves. *Integrative Zoology*, 11(1), 2–15.
- Jachmann, H. (2008). Monitoring law-enforcement performance in nine protected areas in Ghana. *Biological Conservation*, 141, 89–99.
- Jachmann, H., & Billiow, M. (1997). Elephant poaching and law enforcement in the central Luangwa Valley, Zambia. *Journal Applied Ecology*, 34, 233–244.
- James, A. N., Green, M. J. B., & Paine, J. R. (1999). *Global review of protected area budgets and staff*. Cambridge, England: World Conservation Monitoring Centre.
- Jenks, K. E., Howard, J., & Leimgruber, P. (2012). Do ranger stations deter poaching activity in national parks in Thailand? *Biotropica*, 44(6), 826–833.
- Kablan, Y., Diarrassouba, A., Mundry, R., Campbell, G., Normand, E., Kül, Koné, I., ... Oesch, C. (2017). Effects of anti-poaching patrols on the distribution of large mammals in Tai National Park, Côte d'Ivoire. *Oryx*, 53, 469–478. doi:10.1017/S0030605317001272
- Keane, A., Jones, J. P. G., & Milner-Gulland, E. J. (2011). Encounter data in resource management and ecology: Pitfalls and possibilities. *Journal Applied Ecology*, 48, 1164–1173.
- Kouamé, N. F., & Zoro, B. I. A. (2010). [New division of the dense humid forest zone of Côte d'Ivoire]. *Sciences & Nature*, 7(2), 177–194.
- Laurence, W. F., Useche, D. C., Rendeiro, J., Kalka, M., Bradshaw, C. J., Sloan, S. P., ... Zamzani, F. (2012). Averting biodiversity collapse in tropical forest protected areas. *Nature*, 489, 291–294.
- Leader-Williams, N., & Milner-Gulland, E. J. (1993). Policies for the enforcement of wildlife laws: The balance between detection and penalties in Luangwa Valley, Zambia. *Conservation Biology*, 7, 611–617.
- Linkie, M., Martyr, D. J., Harihar, A., Risdianto, D., Nugraha, R. T., Maryati Leader Williams, N., & Wong, W. M. (2015). Safeguarding Sumatran tigers: Evaluating

- effectiveness of law enforcement patrols and local informant networks. *Journal Applied Ecology*, 52, 851–860.
- Lotter, W., & Clark, K. (2014). Community involvement and joint operations aid effective anti-poaching in Tanzania. *Parks*, 10(1), 19–28.
- Moreto, W. D., & Matusiak, M. C. (2017). “We fight against wrong doers”: Law enforcement rangers’ roles, responsibilities, and patrol operations in Uganda. *Deviant Behavior*, 38(4), 426–447.
- N’Goran, P. K., Boesch, C., Mundry, R., N’Goran, E. K., Herbinger, I., Yapi, F. A., & Kuhl, H. (2012). Hunting, law enforcement, and African primate conservation. *Conservation Biology*, 26, 565–571.
- Norris, K., Asase, A., Collen, B., Gockowski, J., Mason, J., Phalan, B., & Wade, A. (2010). Biodiversity in a forest-agriculture mosaic—The changing face of West African rainforests. *Biological Conservation*, 143, 2341–2350.
- Nutakor, E., Marfo, E., & Tutu, P. O. (2011). Socio-political constraints to the enforcement of forest laws: A case study of chainsaw operations in Ghana. *Ghana Journal of Forestry*, 27, 24–36.
- Nyirenda, V. R., & Chomba, C. (2012). Field foot patrols effectiveness in Kafue National Park, Zambia. *Journal of Ecology and the Natural Environment*, 4(6), 163–172.
- Ratcliffe, J. (2004). The hotspot matrix: A framework for the spatio-temporal targeting of crime reduction. *Police Practice and Research*, 5, 5–23.
- Tranquilli, S., Abedi-Lartey, M., Katharine Abernethy, K., & Amsini, K. (2014). Protected areas in tropical Africa: Assessing threats and conservation activities. *PLoS One*, 9, e114154. doi:10.1371/journal.pone.0114154
- Wittemyer, G., Elsen, P., Bean, W. T., Burton, A. C. O., & Brashares, J. S. (2008). Accelerated human population growth at protected area edges. *Science*, 321, 123–126.
- Woods, D. (2003). The tragedy of the cocoa pod: Rent-seeking, land and ethnic conflict in Ivory Coast. *Journal of Modern African Studies*, 41, 641–655.
- Yao, K. A., Bitty, E. A., Kassé, K. B., Soulemane, O., Akpatou, Y. C., Kouakou, Y. C., ... McGraw, W. S. (2018). Distribution and abundance of forest duikers in Dassioko Sud Forest Reserve, Cote d’Ivoire. *Wildlife Research*, 44(8), 660–668.