Research Note

Hunting, Law Enforcement, and African Primate Conservation

PAUL K. N'GORAN,*†‡§ CHRISTOPHE BOESCH,*†‡ ROGER MUNDRY,* ELIEZER K. N'GORAN,** ILKA HERBINGER,‡ FABRICE A. YAPI,†† AND HJALMAR S. KÜHL*‡‡

*Department of Primatology, Max Planck Institute for Evolutionary Anthropology, Deutscher Platz 6, 04103 Leipzig, Germany
†Centre Suisse de Recherches Scientifiques en Côte-d'Ivoire, 01 BP 1303 Abidjan 01, Côte d'Ivoire
‡Wild Chimpanzee Foundation s/c CSRS 01 BP 1303 Abidjan 01, Côte d'Ivoire
§UFR Sciences de la Nature, Université d'Abobo-Adjamé, 02 BP 801 Abidjan 02, Côte d'Ivoire
**UFR Biosciences, Université de Cocody, 01 BP V34 Abidjan 01, Côte d'Ivoire
††Office Ivoirien des Parcs et Réserves, Direction de Zone Sud-Ouest, BP 1342 Soubré, Côte d'Ivoire

Abstract: *Primates are regularly hunted for bushmeat in tropical forests, and systematic ecological monitoring can help determine the effect hunting has on these and other hunted species. Monitoring can also be used to inform law enforcement and managers of where hunting is concentrated. We evaluated the effects of law enforcement informed by monitoring data on density and spatial distribution of 8 monkey species in Taï National Park, Côte d'Ivoire. We conducted intensive surveys of monkeys and looked for signs of human activity throughout the park. We also gathered information on the activities of law-enforcement personnel related to hunting and evaluated the relative effects of hunting, forest cover and proximity to rivers, and conservation effort on primate distribution and density. The effects of hunting on monkeys varied among species. Red colobus monkeys (*Procolobus badius*) were most affected and Campbell's monkeys (*Cercopithecus campbelli*) were least affected by hunting. Density of monkeys irrespective of species was up to 100 times higher near a research station and tourism site in the southwestern section of the park, where there is little hunting, than in the southeastern part of the park. The results of our monitoring guided law-enforcement patrols toward zones with the most hunting activity. Such systematic coordination of ecological monitoring and law enforcement may be applicable at other sites.*

Keywords: density gradient, long-term presence, monitoring, population size, ranger patrols, spatial modeling, spatial eigenvector, Taï National Park

Resumen: *Los primates son cazados regularmente en bosques tropicales, y el monitoreo ecológico sistemático puede ayudar a determinar el efecto de la caza sobre estas y otras especies. El monitoreo también puede ser utilizado en la aplicación de la ley y por gestores de sitios donde se concentra la cacería. Evaluamos los efectos de la aplicación de la ley con base en datos de monitoreo de la densidad y distribución espacial de 8 especies de mono en el Parque Nacional Taï, Costa de Marfil. Realizamos muestreos intensivos de monos y buscamos señales de actividad humana en el parque. También reunimos información sobre las actividades de agentes del orden público relacionada con la caza y evaluamos los efectos relativos de la caza, cobertura forestal y cercanía a ríos, y los de los esfuerzos de conservación sobre la distribución y densidad de primates. Los efectos de la caza sobre monos varió entre especies. El mono Colobus rojo (*Procolobus badius*) fue la especie más afectada y el mono Campbell (*Cercopithecus campbelli*) fue la especie menos afectada por la caza. La densidad de las especies, independientemente de la especie, fue 100 veces mayor cerca de una estación de investigación y un sitio turístico en la sección suroccidental del parque, donde hay poca caza, que en la parte suroriental del parque. Los resultados de nuestro monitoreo condujeron al patrullaje de guardias hacia las*

‡‡*Address correspondence to H. S. Kühl, email kuehl@eva.mpg.de*
Paper submitted January 3, 2011; revised manuscript accepted October 19, 2011.

Conservation Biology, Volume 26, No. 3, 565–571

DOI: 10.1111/j.1523-1739.2012.01821.x

zonas con la mayor actividad cinegética. Tal coordinación sistemática del monitoreo ecológico y la aplicación de la ley puede ser utilizada en otros sitios.

Palabras Clave: eigenvector espacial, gradiente de densidad, modelo espacial, monitoreo, Parque Nacional Taï, patrullaje de guardias, presencia a largo-plazo, tamaño poblacional

Introduction

Most primate populations in tropical forests are affected to some degree by human activities, particularly hunting and habitat modification (Cowlishaw & Dunbar 2000; Fa et al. 2005). The probability of persistence of a monkey population depends on a variety of factors, including whether a population lives inside or outside a protected area and the amount of a species' range that is within a network of protected areas (IUCN 2004).

Probability of persistence within a protected area depends in part on the magnitude of human activities. Monkey populations that are intensely hunted are likely to be extirpated (Oates 2000). In addition, fewer monkeys are taken by hunters in inaccessible areas such as swamps and steep slopes. Furthermore, traditional taboos against hunting certain species may increase probabilities of population persistence (Cowlishaw & Dunbar 2000).

The demographic, physiological, and behavioral traits of a species also affect population persistence. Species that are relatively large bodied, vocalize loudly, or travel and forage on the ground are more likely to be killed by hunters (Bodmer et al. 1997; Fa et al. 2005). Similarly, species that are widely distributed, have short gestation times and reproductive intervals, and do not have specialized dietary requirements are more likely than specialists to survive in human-modified landscapes (Cardillo et al. 2005). Dispersal behavior determines a species' ability to recolonize previously occupied areas or colonize new areas and to survive in human-modified landscapes (Lawes 2002).

In Taï National Park (TNP) (southwestern Côte d'Ivoire), large mammals have been monitored since 2005 by Wild Chimpanzee Foundation and the Office Ivoirien des Parcs et Réserves. Monitoring was designed to inform park managers about the status of mammals.

We examined whether the density and spatial distribution of 8 species of monkeys that occur in TNP, all of which are regularly hunted for bushmeat (Refisch & Koné 2005), reflected differences in the intensity of hunting and whether law enforcement targeted areas with higher hunting activity when provided with data from the monitoring program. We also evaluated whether the effects of hunting were lower near a research station, as suggested by the results of previous studies (Köndgen et al. 2008; Campbell et al. 2011; Hoppe-Dominik et al. 2011). The ecology, behavior, and responses of these species to hunting are well known (McGraw 2007).

Methods Study Area and Primate Diversity

The TNP (Supporting Information) covers 5363 km^2 and is managed by the Office Ivoirien des Parcs et Réserves. It is mainly mature tropical lowland forest; <1% of the area is plantations. A research station in western TNP was created in 1977 (Guillaumet et al. 1984) and has a continuous human presence. A site where tourists can visit a habituated group of chimpanzees was established in 1992 near the village of Djouroutou in southwestern TNP (Koné & Cipolletta 2008). Ongoing deforestation of the remaining forest fragments outside TNP has left the park an isolated forest block surrounded by a rapidly increasing human population.

The park is occupied by 8 monkey species: western red colobus monkey (*Procolobus badius*), western black and white colobus monkey (*Colobus polykomos*), olive colobus monkey (*Procolobus verus*), Diana monkey (*Cercopithecus diana*), sooty mangabey (*Cercocebus atys*), Campbell's monkey (*Cercopithecus campbelli*), lesser spot-nosed monkey (*Cercopithecus petaurista*), and Stampfli's putty-nosed monkey (*Cercopithecus nictitans*) (McGraw 2007).

Sampling

We collected field data with a systematic, clustered survey (Supporting Information) and standard line-transect distance sampling (Buckland et al. 2001). Each sampling unit was 2 km of transects broken into 4, 0.5-km segments on the edges of a 1-km square. We divided transects into segments to avoid double-counting animals at the vertices of the squares. Forty-six sampling units were distributed systematically across the park by spacing their centroids 11 km apart. The clustering of transects reduced overall travel time by 60% compared with travel time if the same number of transects were equally spaced and not clustered.

We recorded distances from the observer to all detected monkey groups; number of individuals in each group (group size); signs of human activity (hereafter human sign), such as machete cuts to vegetation and trails; and signs of poaching (e.g., cartridges, snares, gunshots, and hunting camps). Whenever monkeys moved away upon detecting human observers, such that group size could not reliably be determined, we estimated group size independent of the transect sampling by following groups of monkeys quietly and at a distance until we could record the number of individuals. We used only data collected between 2006 and 2008 because during this period all field surveys were supervised by P.N.

Each transect was visited twice between 2006 and 2008. The interval between visits was about 1 year. Thirteen transects could be sampled only once (2006/2007) because they were temporarily inundated in 2008. Another 17 transects were sampled a second time, but then excluded from the analyses because the quality of the data was ambiguous. We combined the data from the 2 visits. We summed the distance sampled during both visits to each transect (i.e., 4 km), and we summed the number of groups of monkeys and number of individual monkeys.

There are 2 types of armed law-enforcement patrols in TNP. Park-sector guards patrol for 10 days/month in their respective sector and mobile patrol units patrol for 15 days/month throughout the park. The duration of an individual patrolling period depends on its objectives, which may include capturing poachers, seizing bushmeat, and destroying hunting camps. Most of the patrol itineraries were planned after receiving information from the monitoring teams immediately upon their return from surveys. We obtained duration of patrolling periods and the location of patrol routes from mission reports and from coordinates recorded by guards with a global positioning system during patrols.

Analyses

We included 5 spatial covariates in our analyses. Human pressure, a proxy for hunting intensity, was a composite measure derived from principal component analyses (PCA) of the shortest distance from the center of each sampling unit to villages and roads, human population size, and number of villages in a 25-km radius from the center of the sampling unit (Supporting Information). We also included percentage of primary forest in a 2 × 2 km neighborhood surrounding the center of each sampling unit (Supporting Information) and shortest distance from the center of the sampling unit to rivers (Supporting Information). Number of patrol days and distance from the center of the sampling unit to the research station and tourism site were proxies for conservation effort (Supporting Information).

We examined the relation between our response variable (number of monkey groups per transect) and the 5 covariates with generalized linear models (GLMs) (McCullagh & Nelder 1989). We used an eigenvector-based spatial filter (Borcard & Legendre 2002; Griffith 2004) to account for spatially autocorrelated residuals. We ran 5 separate sets of GLMs. We modeled the density of sooty mangabeys and red colobus, Diana, and Campbell's monkeys and the density of all species combined (Supporting Information). We did not model the other 4 species separately because we encountered fewer than 35 groups of each species. We used GLMs to examine the relation between number of patrol days and number of human signs and number of poaching signs (Supporting Information).

We used model selection and multimodel inference (Buckland et al. 1997; Burnham & Anderson 2002; Johnson & Omland 2004) to identify the covariates that best explained the data (Supporting Information). We calculated the Akaike weight for each covariate by summing the Akaike weight of all models in which the covariate was included. For each species or pool of species, we used a likelihood ratio test (Dobson 2002) to compare the full model with a null model that did not include number of patrol days, hunting pressure, or distance to the research station and tourism site (Mundry 2011). We also tested whether individual covariates in the full model explained significant variance in the observed data (Forstmeier & Schielzeth 2011).

We projected the spatial distribution and density of sooty mangabeys and red colobus, Diana, and Campbell's monkeys 8 monkey species combined throughout the park with the parameter estimates of all fitted models and values of the 5 covariates for the entire park at a resolution of 1 km^2. We projected group density for each cell by calculating a weighted (Akaike weight) average of the projections of all models (Supporting Information). We used R version 2.11.1 (R Development Core Team 2010) for all analyses.

Results

We encountered 139 monkey groups along 184 sampled transects (362 km) during the first monitoring period and 63 monkey groups along 144 sampled transects (272.5 km) during the second monitoring period. We encountered human signs throughout the park (average 2.92 signs/km). The number of these signs per km decreased from 2.99 in 2006–2007 to 2.68 in 2007–2008 (GLM estimate −0.33, $p < 0.001$). The surveillance teams carried out 285 patrols and spent 1390 8-hour days in the park. They arrested 178 hunters and confiscated the remains of 613 animals, 103 hunting guns, and 674 cartridges.

The spatial distributions of monkey species differed considerably (Fig. 1; Supporting Information). For example, red colobus largely occupied the northwest of the park. The most widely distributed species was the Diana monkey.

Estimated abundances of monkeys in the park ranged from 29,682 Campbell's monkeys to 97,486 red colobus (Supporting Information). We estimated total abundance of the 8 species of monkeys as 361,768 individuals

Table 1. Results of models of density of 8 species of monkeys[a] in Taï National Park, Côte d'Ivoire.

Model covariates[b]	Parameter[b]				Coefficient[b]					
	k[c]	*AIC*	*AIC*$_w$	*rank*	*intercept*	*RIV*	*VEG*	*SUR*	*HUM*	*REC*
RIV + VEG	3 + 4	476.74	0.00	7	1.216	−0.075	0.378			
RIV + VEG + SUR	4 + 4	478.73	0.00	8	1.217	−0.075	0.372	−0.013		
RIV + VEG + HUM	4 + 4	467.70	0.00	5	1.176	−0.046	0.045		−0.518	
RIV + VEG + REC[c]	4 + 4	452.09	0.23	2	0.829	0.033	0.401			−0.740
RIV + VEG + SUR + HUM	5 + 4	468.13	0.00	6	1.162	−0.042	0.085	0.177	−0.592	
RIV + VEG + SUR + REC[c]	5 + 4	453.50	0.11	4	0.819	0.035	0.355	−0.100		−0.754
RIV + VEG + HUM + REC[c]	5 + 4	450.64	0.48	1	0.852	0.033	0.216		−0.286	−0.644
RIV + VEG + SUR + HUM + REC[c]	6 + 4	452.63	0.18	3	0.854	0.033	0.218	0.014	−0.294	−0.640
p Value						0.780	0.213	0.921	0.094	< 0.001

[a]Cercocebus atys, Cercopithecus campbelli, Cercopithecus nictitans, Cercopithecus petaurista, Cercopithecus diana, Colobus polykomos, Procolobus badius, Procolobus verus.
[b]*All predictor variables (covariates) were z transformed before model fitting.*
[c]*Models in the 95% confidence.*
Abbreviations: RIV, shortest distance from center of sampling units to rivers; VEG, percent cover of primary forest in a 2 × 2 km neighborhood surrounding the center of sampling units; SUR, number of law-enforcement patrol days in a 10-km radius from the center of sampling units; HUM, hunting pressure as a composite measure of a principal component analysis of shortest distance from the center of sampling units to villages and roads, population size, and number of villages in a 25-km radius from the center of sampling units; REC, distance to research station and tourism site; k, *number of covariates (including the intercept) + number of spatial eigenvectors; AIC, Akaike's information criterion; AIC*$_w$*, Akaike weight; rank, model rank from smallest to largest AIC.*

(95% CI 354,390–368,887). Mean group density was 5.7 groups/km^2, and mean individual density was 61.3 individuals/km^2 (Supporting Information).

Comparison between full and respective null models indicated number of patrol days was associated with human signs and that human pressure and distance to the research station and tourism site were strongly associated with density of all monkey groups and with density of sooty mangabeys, red colobus, and Diana monkeys (Supporting Information). The relation between group density and human pressure was also indicated by summed Akaike weights >0.6 (Tables 1 & 2 & Supporting Information). The association between human pressure and group density was unequal among species. The estimates of human pressure on sooty mangabeys and red colobus were nearly the same (average across all models −1.07 [Supporting Information]). Estimates were considerably smaller for Diana and Campbell's monkeys (average across all models: −0.46 [Supporting Information]).

Table 2. Relative strength of association[a] of 3 covariates[b] in models predicting the respective density of monkey species.

Species	*SUR*	*HUM*	*REC*
Sooty mangabey, *Cercocebus atys*	0.380	0.995	0.304
Western red colobus, *Procolobus badius*	0.965	0.992	0.779
Diana monkey, *Cercopithecus diana*	0.302	0.844	0.940
Campbell's monkey, *Cercopithecus campbelli*	0.280	0.661	0.354
All monkey species	0.291	0.654	1.000

[a]*Measured as Akaike weights summed across all models for the different species of monkeys.*
[b]*Abbreviations: SUR, number of law-enforcement patrol days in a 10-km radius of the center of sampling units; HUM, hunting pressure as a composite measure of a principal component analysis of shortest distance from the center of sampling units to villages and roads, population size, and number of villages in a 25-km radius from the center of sampling units; REC, distance to research station and tourism site.*

Number of patrol days was positively associated with number of human signs and poaching signs (human signs: coefficient [SE] = 2.93 [0.75], $t_{181} = 3.89$, $p < 0.001$; poaching signs: coefficient [SE] = 3.34 [1.16], $t_{181} = 2.89$, $p < 0.01$) (Fig. 2). In contrast, neither the density of groups of sooty mangabeys and Diana and Campbell's monkeys nor the density of all species combined was significantly associated with number of patrol days (Table 2 & Supporting Information).

Distance to the research station and tourism site was included in all models of total monkey density in the 95% confidence set (Table 1). Density of groups of red colobus and Diana monkeys was highest in zones close to the research station and tourism site. The association between density and distance to the research station and tourism site was not significant for sooty mangabeys and Campbell's monkeys (Supporting Information).

Discussion

We found monkey density was associated with hunting pressure as measured by a composite of proximity to villages and roads and density of humans and villages. On the basis of the association between number of patrol days and number of signs of human activity and poaching, we infer that our monitoring data helped guide law-enforcement patrols to areas where hunting was concentrated.

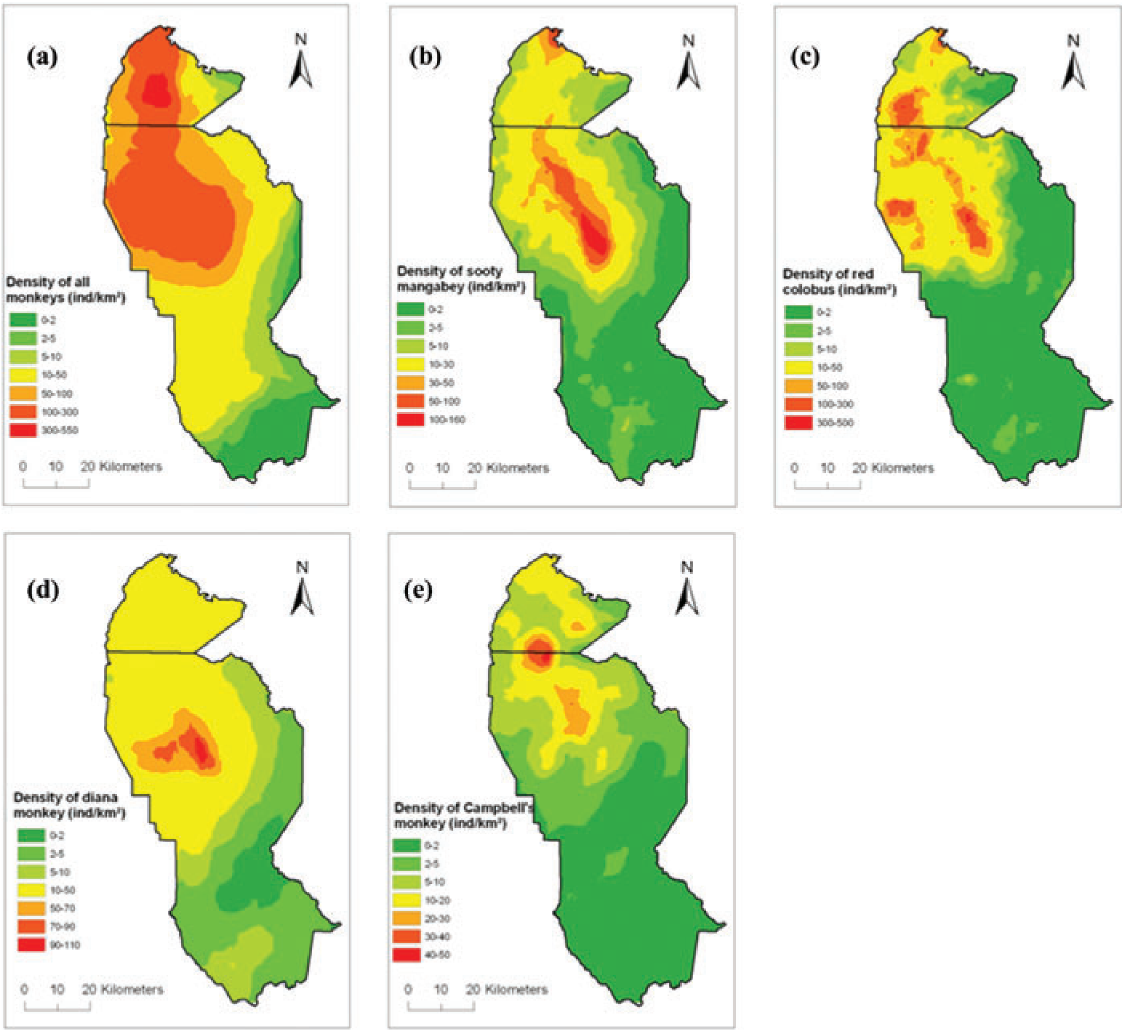

Figure 1. Distribution maps from model projections for (a) all 8 diurnal monkey species occurring in Taï National Park, (b) sooty mangabey (Cercocebus atys), *(c) red colobus* (Procolobus badius), *(d) Diana monkey* (Cercopithecus diana), *and (e) Campbell's monkey* (Cercopithecus campbelli).

Decreasing monkey densities toward the southeast of the park were associated with higher human pressure in the southeast. The densities of other species of mammals also are lower in the southeastern park (Hoppe-Dominik et al. 2011). Relative to other areas around the park, in the southeast infrastructure is better, human population density is higher, and major cities are nearer (Köndgen et al. 2008; Hoppe-Dominik et al. 2011). The positive association between species densities and distance to the research station and tourism site, which we assume is because of relatively low hunting activity in these areas, is similar for other mammals across the park and to a lesser extent around the research station (Köndgen et al. 2008; Campbell et al. 2011; Hoppe-Dominik et al. 2011).

The observed differences in the 4 species' densities relative to human pressure reflected the species' estimated probabilities of extirpation in TNP (McGraw 2007). On the basis of their densities in the absence of hunting, habitat availability, body size, substrate association, and behavioral response to humans, we believe red colobus are the most and Campbell's monkeys the least likely to be extirpated (also see McGraw 2007). Similarly, in Cameroon, the densities of Preuss's red colobus (*Procolobus pennantii*) and red-capped mangabeys (*Cercocebus torquatus*) are more likely to decrease in response to hunting than the density of Mona monkeys (*Cercopithecus mona*) (Linder & Oates 2011). Other species-specific ecological characteristics not accounted for in our spatial model, such as density-dependent effects, may have confounded the projected distribution of density. However, results similar to ours were obtained in a similar study of a smaller area around the research station (Campbell et al. 2011).

Currently, we do not have enough data to test whether increased law-enforcement deters poachers. However,

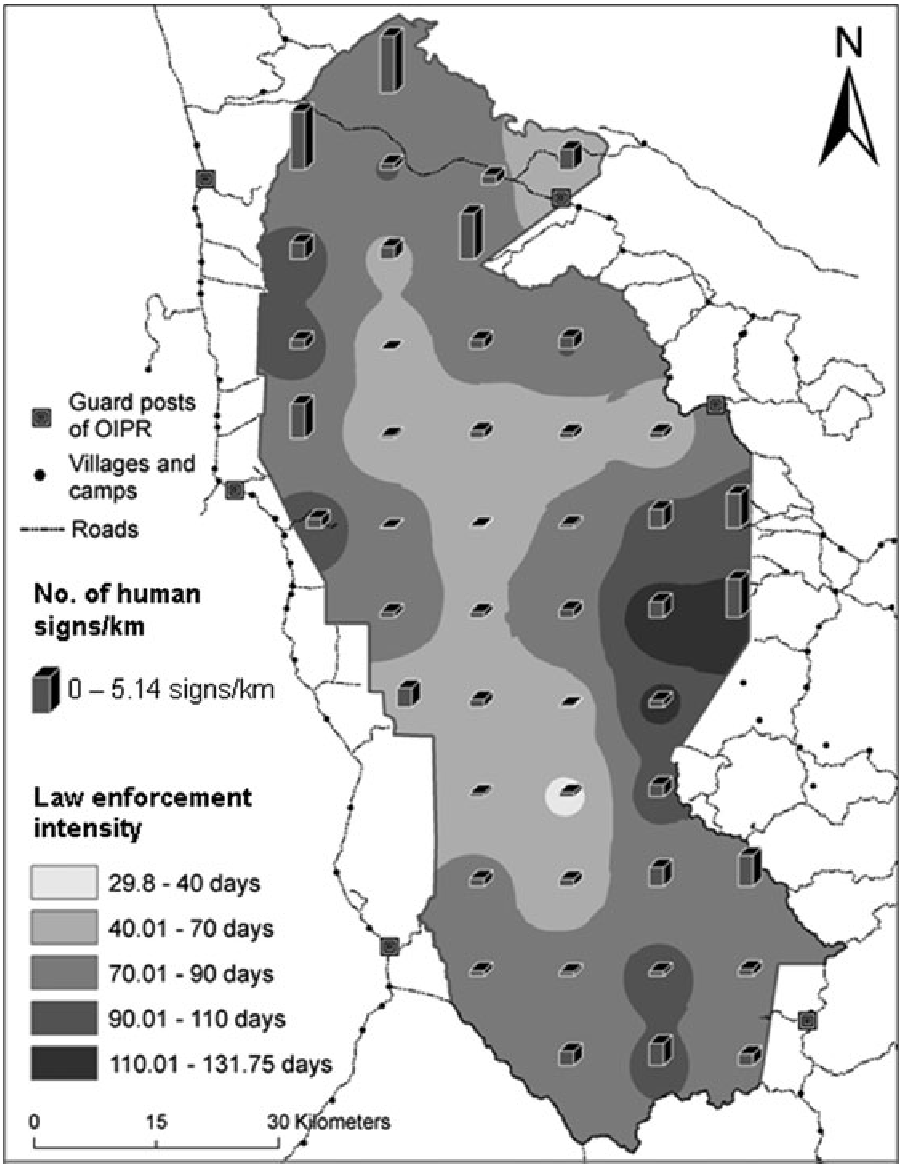

Figure 2. Distribution of number of law-enforcement patrol days in Taï National Park and density of signs of human activity in each sampling unit (bars) (OIPR, Office Ivoirien des Parcs et Réserves).

we think the targeting of hunting areas is a first step and, if poachers are effectively discouraged by law enforcement, may eventually lead to recovery of monkey populations.

Three criteria must be met to implement a study such as ours elsewhere. First, data on density must be collected. Use of primate-group encounter rate instead of density may seem easier; however, use of encounter rate may lead to bias because of observer differences or variation in detection probability (Keane et al. 2011). Second, spatial extent and temporal resolution of sampling design should be established to detect trends in density as quickly as possible. At sites with relatively low densities of primates, repeated sampling of each transect may increase the accuracy of density estimates. Third, coordination among survey teams and law-enforcement guards must be effective and communication rapid. We suggest ongoing training and motivation of field staff and that data quality be checked regularly.

The analyses we used are not limited to assessment of associations between response variables and spatial covariates. It can be extended to other covariates that may affect species persistence, such as demography, physiology, and behavior. Continued sampling will eventually allow us to identify factors that are associated with primate persistence.

Acknowledgments

We thank the Ivorian authorities, particularly the Ministère de l'Environnement, des Eaux et Forêts, the Ministère de l'Enseignement Supérieur et de la Recherche Scientifique, and the Université d'Abobo-Adjamé. We are grateful to the Office Ivoirien des Parcs et Réserves for their collaboration. We acknowledge the Max Planck Society, the Wild Chimpanzee Foundation, the Centre Suisse de Recherches Scientifiques, the World Wide Fund for Nature, the European Union, the Great Apes Survival Project, the United Nations Environment Programme, the German Technical Cooperation, the KFW Bank Group, and Conservation International for financial and technical support. We thank H. Boesch, S. Konaté, A. Tondossama, N.R. Maho, Z.B. GonéBi, A. Nandjui, D. Dervla, Y.C. Kouakou, G. Campbell, and the field teams for project management, fund raising, and data collection, Y. Moebius for great help in revising the manuscript, and three anonymous referees for helpful comments on an earlier version of the manuscript.

Supporting Information

A full explanation of our analytical methods (Appendix S1) and species-specific results (Appendix S2) are available online. The authors are responsible for the content and functionality of these materials. Queries should be directed to the corresponding author.

Literature Cited

Bodmer, R. E., J. F. Eisenberg, and K. H. Redford. 1997. Hunting and the likelihood of extinction of amazonian mammals. Conservation Biology **11:**460–466.

Borcard, D., and P. Legendre. 2002. All-scale spatial analysis of ecological data by means of principal coordinates of neighbour matrices. Ecological Modelling **153:**51–68.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford University Press, Oxford, United Kingdom.

Buckland, S. T., K. P. Burnham, and N. H. Augustin. 1997. Modelselection: an integral part of inference. Biometrics **53:**603–618.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach, 2nd Ed. Springer, New York.

Campbell, G., H. Kuehl, A. Diarrassouba, P. K. N'Goran, and C. Boesch. 2011. Long-term research sites as refugia for threatened and overharvested species. Biology Letters DOI: 10.1098/rsbl.2011.0155.

Cardillo, M., G. M. Mace, K. E. Jones, J. Bielby, O. R. P. Bininda-Emonds, W. Sechrest, C. D. L. Orme, and A. Purvis. 2005. Multiple causes of high extinction risk in large mammal species. Science **309:**1239–1241.

Cowlishaw, G., and R. Dunbar. 2000. Primate conservation biology. The University of Chicago Press, Chicago.

Dobson, A. J. 2002. An introduction to generalized linear models. Chapman & Hall/CRC, Boca Raton.

Fa, J. E., S. F. Ryan, and D. J. Bell. 2005. Hunting vulnerability, ecological characteristics and harvest rates of bushmeat species in afrotropical forests. Biological Conservation **121:**167–176.

Forstmeier, W., and H. Schielzeth. 2011. Cryptic multiple hypotheses-testing in linear models: overestimated effect sizes and the winner's curse. Behavioral Ecology and Sociobiology **65:**47–55. DOI: 10.1007/s00265-00010-01038-00265.

Griffith, D. A. 2004. A spatial filtering specification for the autologistic model. Environment and Planning A **36:**1791–1811.

Guillaumet, J. L., G. Couturier, and H. Dosso. 1984. Recherche etaménagement en milieu forestier tropical humide: le Projet Taï de Côte d'Ivoire. UNESCO, Paris.

Hoppe-Dominik, B., H. S. Kühl, G. Radl, and F. Fischer. 2011. Long-term monitoring of large rainforest mammals in the biosphere reserve of Taï National Park, Côte d'Ivoire. African Journal of Ecology DOI: 10.1111/j.1365-2028.2011.01277.x.

IUCN (International Union for Conservation of Nature). 2004. 2004 IUCN red list of threatened species. A global species assessment. IUCN, Gland, Switzerland.

Johnson, J. B., and K. S. Omland. 2004. Model selection in ecology andevolution. Trends in Ecology and Evolution **19:**101–108.

Keane, A., J. P. G. Jones, and E. J. Milner-Gulland. 2011. Encounter data in resource management and ecology: pitfalls and possibilities. Journal of Applied Ecology DOI: 10.1111/j.1365-2664.2011.02034.x.

Köndgen, S. et al. 2008. Pandemic human viruses cause decline of endangered great apes. Current Biology **18:**260–264.

Koné, I., and C. Cipolletta. 2008. Taï National Park, a world heritagein Côte d'Ivoire. Unpublished report. Office Ivoirien des Parcs etRéserves, Abidjan.

Lawes, M. J. 2002. Conservation of fragmented populations of *Cercopithecus mitis* in South Africa: the role of reintroduction, corridors, and metapopulation ecology. Pages 375–392 in M. Glenn and M. Cords, editors. The guenons: diversity and adaptation of African monkeys. Kluwer Academic/Plenum, New York.

Linder, J. M., and J. F. Oates. 2011. Differential impact of bushmeat hunting on monkey species and implications for primate conservation in Korup National Park, Cameroon. Conservation Biology **144:**738–745.

McCullagh, P., and J. A. Nelder. 1989. Generalized linear models. Chapman and Hall/CRC, London.

McGraw, W. S. 2007. Vulnerability and conservation of the Taï monkey fauna. Pages 290–316 in W. S. McGraw, K. Zuberbühler, and R. Noë, editors. Monkeys of the Taï Forest. Cambridge University Press, Cambridge, United Kingdom.

Mundry, R. 2011. Issues in information theory based statistical inference – a commentary from a frequentist's perspective. Behavioral Ecology and Sociobiology **65:**57–68. DOI: 10.1007/s00265-00010-01040-y.

Oates, J. F., M. Abedi-Lartey, W. S. McGraw, T. T. Struhsaker, and G. H. Whitesides. 2000. Extinction of a west African red colobus. Conservation Biology **14:**1526–1532.

R Development Core Team. 2010. A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna. Available from http://www.R-project.org. Accessed May 2010.

Refisch, J., and I. Koné. 2005. Impact of commercial hunting on monkey populations in the Taï region, Côte d'Ivoire. Biotropica **37:**136–144.