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Employing participatory surveys to monitor the illegal killing of elephants across diverse land uses in Laikipia–Samburu, Kenya

Onesmas Kahindi[1], George Wittemyer[2]*, Juliet King[3], Festus Ihwagi[1], Patrick Omondi[4] and Iain Douglas-Hamilton[5,1]

[1]*Save The Elephants, P.O. Box 54667, Nairobi 00200, Kenya,* [2]*Colorado State University, Fort Collins, CO, U.S.A.,* [3]*Northern Rangelands Trust, Isiolo, Kenya,* [4]*Kenya Wildlife Service, P.O. Box 40241, Nairobi 00200, Kenya and* [5]*Department of Zoology, University of Oxford, Oxford, U.K.*

Abstract

Levels and trends of illegal killing of elephants are measured by the Convention on International Trade in Endangered Species (CITES) Monitoring the Illegal Killing of Elephants (MIKE) programme in sites across Africa and Asia. In the mostly unprotected Laikipia–Samburu MIKE site in northern Kenya, elephant mortality data were collected using both standard law enforcement monitoring procedures, relying on patrolling, and participatory methods involving local communities. Qualitatively, traditional patrolling techniques were more successful in protected areas whereas participatory approaches provided more information outside protected areas, where elephant were most at risk from ivory poachers. A minimum of 35% of the 389 verified carcasses during 2001–2003 were illegally killed. In this baseline study, land uses ranked from highest to lowest by the proportion of illegally killed elephants (PIKE) were community conservation areas, government trust lands, forest reserves, private ranches, settlement areas and national reserves. PIKE trends derived from traditional and participatory data sources were similar across years and indicate elephants were at greater risk in regions outside government or privately patrolled areas. We suggest that PIKE is a useful index for comparing levels and trends in illegal killing of elephants, and that carcass ratios and presence/absence of tusks are useful proxy indicators of mortality and its causes.

Key words: African elephant, community conservation, ivory poaching

**Correspondence:* E-mail: G.Wittemyer@ColoState.edu

Résumé

Le niveau et les tendances des massacres illégaux d'éléphants sont mesurés par le programme MIKE (*Monitoring the Illegal Killing of Elephants* - Suivi à long terme de la chasse illicite à l'éléphant) utilisé par la CITES (Convention sur le commerce international des espèces de faune et de flore menacées d'extinction) dans différents sites d'Afrique et d'Asie. Dans le site MIKE en grande partie non protégé de Laikipia–Samburu, dans le nord du Kenya, on a récolté des données sur la mortalité des éléphants en utilisant les procédures standards de suivi de l'application des lois, en se basant sur les patrouilles, et des méthodes participatives impliquant les communautés locales. Du point de vue qualitatif, les techniques de patrouilles traditionnelles étaient plus efficaces dans les aires protégées tandis que les approches communautaires donnaient plus d'informations en dehors des aires protégées, là où les éléphants risquent plus de rencontrer des braconniers pour leur ivoire. Au moins 35% des 398 carcasses vérifiées de 2001 à 2003 avaient été tuées illégalement. Dans cette étude de référence, les utilisations des terres, classées de la plus forte à la plus légère selon la proportion d'éléphants tués illégalement (PIKE) étaient les suivantes : zones de conservation communautaire, les terres gouvernementales, les réserves forestières, les ranches privés, les zones d'installations et les réserves nationales. Les tendances PIKE dérivées des sources de données traditionnelles ou communautaires étaient semblables au cours des ans et indiquent que les éléphants couraient plus de risques dans les régions situées en dehors des zones surveillées par des patrouilles gouvernementales ou privées. Nous suggérons que PIKE est in indice utile pour comparer les niveaux et tendances des massacres illégaux d'éléphants, et que les rapports des carcasses par rapport à la présence/absence de défenses sont des indicateurs intermédiaires utiles de la mortalité et de ses causes.

Introduction

Gaps in law enforcement capacity and threats to wildlife populations can be accurately assessed through wildlife monitoring programs (Caughley & Sinclair, 1994). Applying monitoring frameworks in this capacity is critical for the conservation and management of African elephants, a species recognized as under pressure from illegal trade in their ivory and other anthropogenic impacts in certain countries and regions (Douglas-Hamilton, 1987; Blake *et al*., 2007). The variability in the status of elephants across the species range makes it crucial that decisions on elephant issues taken by the Convention on International Trade in Endangered Species (CITES) are based on reliable information, especially in relation to assessing the effects of CITES decisions on ivory poaching levels (Stiles, 2004). The Monitoring of the Illegal Killing of Elephants (MIKE) programme, approved in 1997 by CITES and ratified in the eleventh COP in 2000 (CITES, 2007), was set up to detect changes in elephant populations by monitoring mortality.

Kenya began implementing the MIKE programme in June 2002, and currently has four MIKE sites: Tsavo (Tsavo East, Tsavo West and adjacent group ranches), Mt Elgon National Park, Meru Conservation Area (Meru National Park and neighbouring national reserves), and Laikipia–Samburu elephant range (covering both protected and unprotected areas of Laikipia, Samburu, Isiolo, Meru Central and Nyambene districts). As the majority of Kenya's elephant populations continue to range across large areas, a policy decision was taken that the Kenyan MIKE sites would cover the entire range of the selected elephant populations rather than focusing solely on protected areas (CITES, 2001).

Reviews of Kenya's elephant mortality data collected during 1990–2002 (Thouless *et al*., 2008) show that only a small fraction of the elephants that die are ever found. Despite the emphasis on recording elephant deaths during this period, the number of carcasses located nationally represents only 15–20% of expected minimum mortality, based upon average natural mortality of 4% per annum (Laws, 1969). Under the best of circumstances, the MIKE monitoring system can only be expected to find a sample of the total mortality and monitoring limitations are likely to increase in landscapes containing numerous types of land holdings with a diversity of stakeholders.

In 2002, Save the Elephants (STE), an international research organization, began providing the Kenya Wildlife Service (KWS), the national custodian of wildlife conservation and management, technical support to implement the MIKE programme in the 26,135 km^2 Laikipia–Samburu MIKE Site, which comprises much of northern Kenya's elephant dispersal area (Omondi *et al*., 2002). This MIKE site contains the lowest proportion of national protected areas (<3% of the land-area) among Kenya's MIKE sites and, presents a relatively complicated mix of land use types. The objectives of this collaboration were to monitor a large proportion of elephant deaths by systematically recording any elephant carcasses located during 2002 and 2003. The project was designed to identify strengths and weaknesses of the MIKE monitoring in relation to the diversity of land uses in this complex site, and to establish a baseline against which future changes to elephant mortality in Laikipia–Samburu can be measured. This article presents the results and conclusions regarding these goals.

Elephant range outside protected areas in the Laikipia–Samburu MIKE site includes remote, often communally held regions with few roads. While this lack of infrastructure restricts the effectiveness of typical patrol methods which rely on roads for access, local pastoralists move across the region continuously and potentially offer a detailed source of information on the status of the region's wildlife. Participatory monitoring has been shown to be a suitable technique for gathering information on biodiversity in regions lacking research resources or formal protected status (Danielsen, Burgess & Balmford, 2005; Danielsen *et al*., 2007). We used participatory methods to gather information from local communities on elephant mortality. Mortality data collected using this approach are compared qualitatively with information collected using traditional patrolling methods across land use types within the Laikipia–Samburu elephant range. This provides insight to the effectiveness of the different methods, indices which can be used to compare trends in data collected using the different methods, and the relative risks elephants face across different land use categories.

Materials and methods

Study area

Laikipia–Samburu is the most complex MIKE site in Kenya. The elephants' range covers a wide variety of habitats, land use types and political boundaries that are managed by a variety of stakeholders and law enforcement authorities (Fig. 1). Land uses by area in 2003 included national reserves (2.3% of area), community wildlife conservancies (5.7%), pastoral group ranches and undeveloped government-owned trustland (60.7%), forest reserves (12.5%), private ranches and sanctuaries (16%) and agricultural settlement (2.8%). Security and capacity for wildlife protection and monitoring across the MIKE site were highly variable, from nonexistent to a high degree of wildlife protection. And, the semi-nomadic pastoralists, sedentary agriculturalists and large-scale private landowners who inhabit this area have different attitudes towards elephants. Furthermore, road density is highly variable across the region with much of the communal pastoralist lands being largely inaccessible by vehicle and, therefore, difficult to patrol. The region experiences biannual, seasonal rainfall, the majority of which falls in April and November.

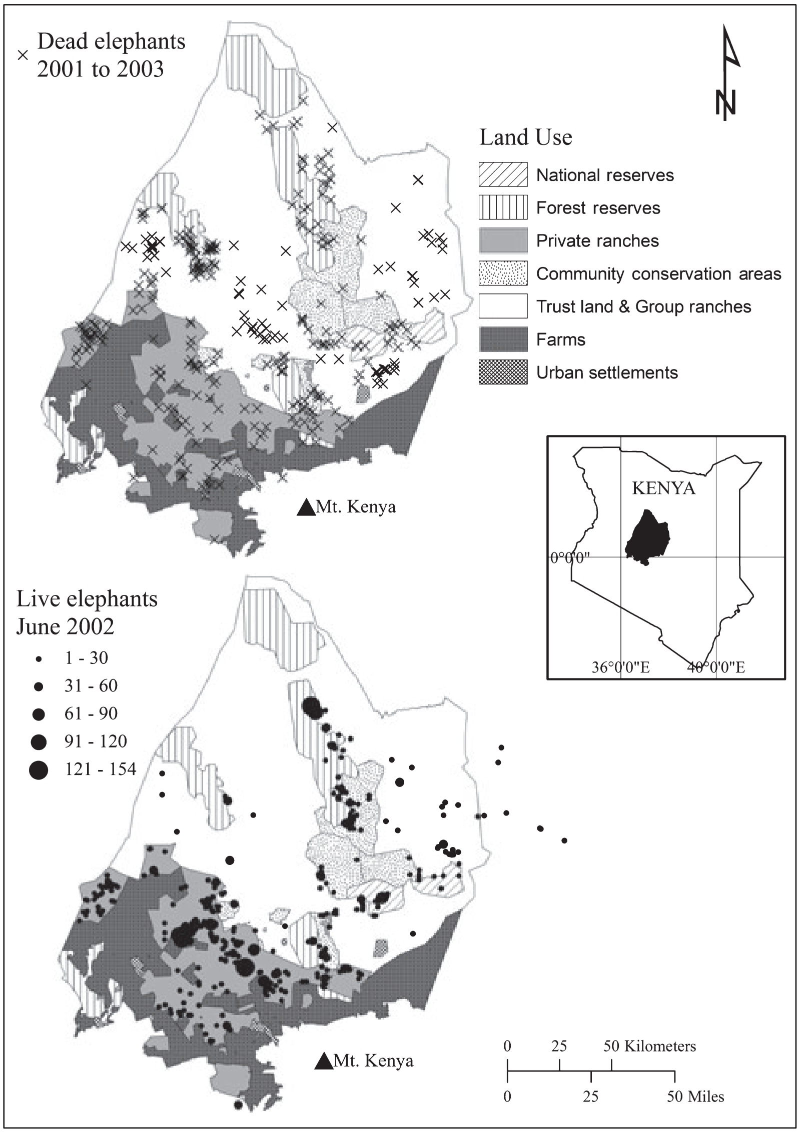

Fig 1 Map of the Laikipia–Samburu MIKE site showing different land use categories and the locations of carcasses from 2001 to 2003 (top) and live elephants from the 2002 aerial survey (bottom)

Ecologically, the region contains a diversity of habitats ranging from the lowland, xeric scrub bushlands comprising *Acacia* and *Commiphora* species to the highland, mesic cedar and camphor forests.

Data acquisition methods

The locations of elephant carcasses were collected and collated from two main sources, the first relying on information derived from patrolling by the KWS, county council protected area rangers or private management and the second derived from consultation with local communities through participatory meetings. Both data sources placed emphasis on acquiring information about all dead elephants, rather than specifically those illegally killed. For each carcass reported, that died during 2001–2003, the method by which the carcass was first found was recorded. A full-time researcher (O. Kahindi) and field assistant verified in the field approximately 90% of all carcasses reported.

Mortality data from the KWS national elephant mortality database were primarily acquired through patrols initiated in response to information on dead elephants provided by KWS informants and field officers, private ranches, and research projects. All data from these standard monitoring sources are considered to be derived from traditional patrolling methods, although these data were not collected using a single systematic patrol method and no information or metrics regarding effort was collected. Data from participatory approaches were derived from oral testimony used to acquire information (Abbot & Guijt, 1998). In this study, the principle researcher held interviews and village consultations in order to build a local information network on elephant mortality. Local people with social and geographical knowledge of their respective areas were selected for assistance. Cash incentives were not given to local people for the information. Previously unrecorded elephant carcasses were identified through these interviews and, in many cases, information regarding the circumstances surrounding their deaths was provided, which was used in the study when the field researcher was able to verify the testimony through carcass observations.

A total of 149 meetings (averaging approximately 20 participants per meeting) with villagers, rangers, community conservancy leaders, KWS staff, ranch managers, landowners, politicians, chiefs and elders were held to explain the survey objectives. Carcasses were visited with the approval of the local community or landowners. Repeat visits to many communities were conducted. This usually resulted in more cooperation and produced additional carcasses for investigation. In this article, we refer to the nomadic and semi-nomadic informants who use trust land, group ranches, forest reserves and community conservation areas for grazing their livestock as 'herdsman'.

Measurement of effort

The MIKE Technical Advisory Group has recognized the importance of local information networks but methodology for measuring effort has always been problematic. Efforts by herdsmen or ranch patrols are not conducive to classic metrics of patrolling intensity as their activities are typically motivated by herding their livestock rather than strictly monitoring wildlife populations. While standard effort metrics were not possible to collect as monitoring activity was a function of pastoralist land use behaviours, information on the effort of the field researcher was collected including number of participatory meetings and participants and the distance the field researcher travelled to verify carcass information. Researcher travel distance was not biased to areas adjacent to a central location (i.e. base camp), as study area coverage was conducted such that several consecutive days were spent in areas being investigated rather than repeated trips to and from a central location. These three metrics of researcher effort (number of meetings, average number of meeting participants and distance driven) were compared with carcass numbers to ensure no methodological bias in data acquisition. Researcher effort is also compared to the proportions of illegally killed elephants (PIKE) by land use category to ensure PIKE was not a function of researcher activity. Comparison between researcher field days and carcasses detected is also conducted to assess the relationship between effort and catch.

Because of the lack of appropriate effort measurements, comparison between carcasses per standardized unit of effort was not possible. While results may reflect herdsman activity rather than efficiency of the method employed, qualitative differences offer insights to the status of the MIKE site with implications for monitoring activities.

Carcass specific information

Standardized data were collected at each carcass visited using the MIKE carcass form and the protocols designed by the MIKE Technical Advisory Group. These included the date visited, georeferenced location using a global positioning system (GPS) unit, year and cause of death (if verifiable), age of elephant and how the carcass was first discovered (i.e. aerial reconnaissance, ground patrols, informants, researchers and tourists). Information provided by informants was used to determine the month and year of death. This was further verified by categorizing the age of each carcass following MIKE criteria based on Douglas-Hamilton & Hillman (1981). A carcass was classified as 'fresh' if first discovered within 3 weeks of death; 'recent' if first found between 3 weeks and 12 months after it died; 'old' if discovered after 12 months but <5 years after death, and 'very old' if later than this. These criteria were used by the researcher to assign the year of death in each case.

Age at death of each animal was determined from the molar progression on either the upper or lower mandible of a skeleton where possible (Laws, 1966; Jachmann, 1985). Sex of the animal was determined through examination of morphological differences in skulls (Merwe, Bezuidenhout & Seegers, 1995), mandibles and tusks (Ngure, 1996), if present.

Cause of death was determined from evidence acquired at the carcass, such as presence of injuries or eyewitness accounts. Four categories were used to summarize causes of death: illegally killed, problem animal control (PAC), natural and unknown. The presence or absence of tusks was recorded for each carcass, noting whether tusks were naturally absent or whether they were removed after the elephant had died. Carcasses with tusks removed were not automatically categorized as illegally killed unless circumstantial evidence, e.g. bullet holes, or observer reports of gunshots, or an attempt to conceal the carcass with branches, was also seen. In cases where further clarification was needed to confirm presence or absence of tusks, the status of tusks was reported as unknown.

Statistical analysis

Although some elephants in the study area are known to cover large ranges (Thouless, 1996; Douglas-Hamilton, Krink & Vollrath, 2005), live elephants counted in the 2002 aerial survey results offer the best available estimate of elephant density and distribution at a landscape scale. Using the 2002 aerial survey data and those carcasses found to have died in 2002, carcass ratios, # carcasses / # carcasses + #live, were calculated for the entire MIKE site and for the six land use categories within the site (Fig. 1). An expected number of carcasses per land use category was calculated by relating the overall MIKE site carcass ratio to the number of live elephants counted in each land use area. Expected and observed values were compared using Chi-square goodness of fit tests (Zar, 1999) to identify areas with more or less carcasses relative to the number of live elephants found in the sub-region. Similar analyses were carried out to compare differences in cause of death by land use category, where the proportion of elephants in each land use category was used to calculate the expected number of carcasses categorized by cause of death. Carcass counts were compared directly in analysis of carcasses detected using participatory and traditional approaches. Analyses of the correlation of proportional data were conducted using non-parametric Spearman's rank correlations.

Results

Qualitative comparison of carcass data from patrol-based and participatory approaches

During the 3-year study period, a total of 389 elephant carcasses were verified. Approximately 40 more carcasses that had been reported were never found and were not used in the analysis. Reasons for carcases being unverifiable may be misinformation, the carcass being too remote to visit, flood removal as occurs in seasonal riverbeds, incineration for anthrax control, human consumption and the selling of bones or scavenger removal and bone dispersal. Generally, greater numbers of carcasses were recorded annually by the researcher conducting participatory meetings (average = 84) than from the traditional patrol sources (average = 66.5; $\chi^2 = 23.5$, d.f. = 2, $P < 0.001$). Herdsmen typically interviewed through participatory meetings were the source of 63% of all carcasses recorded and verified. Traditional patrols were the second most important information source, detecting 26% of carcasses, whereas other methods accounted for a small percentage (~12% combined) of carcasses found (Fig. 2).

While greater effort (in the form of herder coverage of the study area) may have resulted in greater numbers of carcasses being detected through participatory methods, the efficacy of the two approaches qualitatively differed in relation to land use (Fig. 3). Across the 3 years for which carcass data were collected, traditional patrolling in

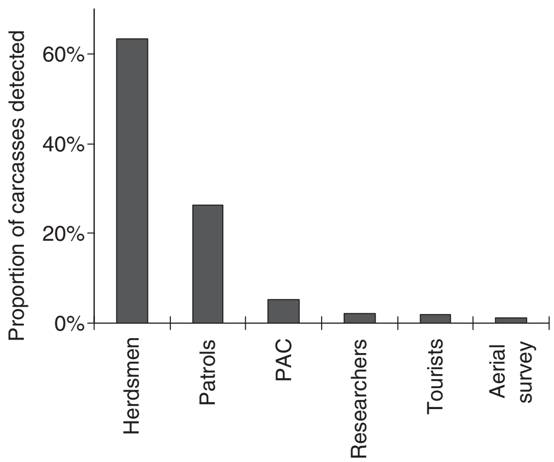

Fig 2 Comparison of the proportion of carcasses detected by different data collection methods demonstrated herdsmen were the most critical information source. Information on carcasses from herdsmen was typically accessed through participatory approaches

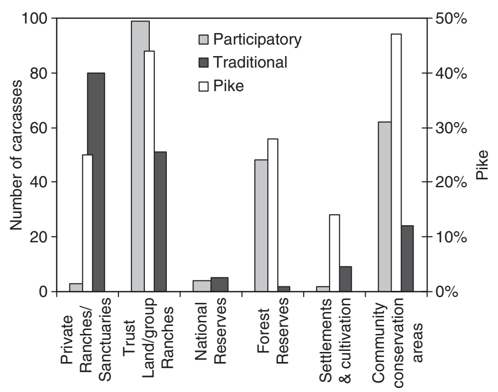

Fig 3 Carcasses in communal lands, trust lands/group ranches and forest reserves were primarily detected using participatory approaches, while carcasses on private ranches were detected primarily through traditional methods. The proportion of illegally killed elephants (PIKE) differed across land use categories and was highest in areas where the majority of information was derived through participatory approaches

private ranches detected significantly greater numbers of carcasses (over 80% of the total) than participatory approaches ($\chi^2 = 14.4$, d.f. = 2, $P < 0.001$). In contrast, significantly greater numbers of carcasses were detected through participatory methods in trust lands/group ranches ($\chi^2 = 19.2$, d.f. = 2, $P < 0.001$), community conservation areas ($\chi^2 = 10.1$, d.f. = 2, $P = 0.006$) and forest reserves ($\chi^2 = 21.9$, d.f. = 2, $P < 0.001$), where 73% of carcasses in these land use categories were detected by herders. Significant differences between methods were not found in national reserves or settlement/cultivated areas. Researcher effort was not correlated with carcasses per land use (see below).

Finally, the causes of death differed substantially between carcasses identified by the two approaches (Fig. 4). Across the 3 years, significantly greater numbers of illegally killed elephants were detected by participatory methods ($\chi^2 = 76.5$, d.f. = 2, $P < 0.001$). Carcasses originating from unknown causes also tended to be detected more frequently through participatory methods ($\chi^2 = 25.7$, d.f. = 2, $P < 0.001$). But the numbers of carcasses originating from natural causes did not vary between the methods ($\chi^2 = 3.11$, d.f. = 2, $P = 0.211$). As the wildlife authority carried out all problem animal control in the study area, traditional methods detected all carcasses originating from this source.

Effort

While direct measures of effort were not available, we explored our proxy indices to assess if carcass detection was biased towards any single land use. Indices of participatory based detection effort were not correlated with the number of carcasses recorded by land use category, where three

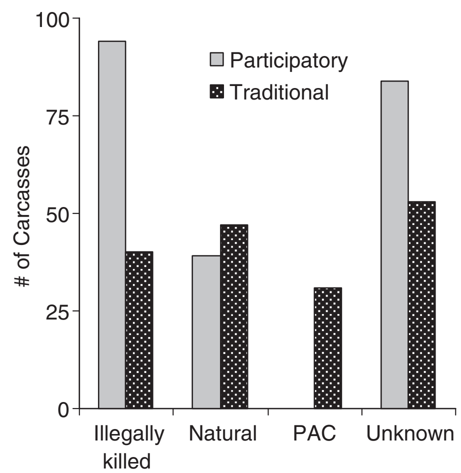

Fig 4 The majority of illegally killed carcasses were detected through participatory methods, whereas traditional methods accounted for all elephants killed through problem animal control. Both methods found similar numbers of naturally dead or carcasses originating from unknown causes

indices of researcher effort were used in analyses – density of participatory meeting (meetings per km^2 of land use category; $r_s = 0.143$, $P = 0.749$), participants per meeting (average participant/meeting by land use category; $r_s = 0.371$, $P = 0.401$) and kilometres driven (road km per km^2 of land use category; $r_s = 0.486$, $P = 0.276$). Both density of meetings and roads actually demonstrated a non-significant negative relationship indicating land use categories which were the focus of the greatest effort contained the fewest detected carcasses. These results indicate that it is unlikely participatory approach effort resulted in systematic biased carcass detection in respect to land use and differences in carcass density, causes of mortality, and ivory status were not a function of researcher effort.

Elephant mortality in the Laikipia–Samburu MIKE site

Carcass densities across different land use categories in the Laikipia–Samburu MIKE site were significantly correlated with the densities of live elephants ($r_s = 0.942$, $P = 0.035$), although this relationship was skewed by the large area of trust land/group ranches resulting in low carcass density despite containing the greatest number of carcasses (38% of the total carcasses with 15% of live elephants). The actual numbers of live and dead were not significantly correlated across land use categories ($r_s = 0.314$, $P = 0.478$). Trust land/group ranches and community conservation areas, the land use categories containing the most carcasses, contained over 63% of carcasses whereas harbouring 26% of the live elephants (Table 1).

Carcass ratios are the standard approach for presenting aerial census data on mortality relative to density (Douglas-Hamilton & Hillman, 1981; Douglas-Hamilton & Burril, 1991). Because the only reliable estimate of elephant numbers was collected from the 2002 aerial survey, carcass ratios (relating live elephants counted from the air to dead elephants counted on the ground) were only calculated and analysed for this year. Relating the overall Laikipia–Samburu MIKE site carcass ratio of 0.03 to the observed density of elephants in each land use category, expected numbers of carcasses were calculated. Carcass counts differed significantly from expected across the six land uses analysed ($\chi^2 = 121$, d.f. = 5, $P < 0.001$), with lower than expected numbers of carcasses in private ranches and national reserves and greater than expected in trust land/group ranches and community conservation areas. Carcass ratios in forest reserves and settlements/cultivation areas were relatively similar to MIKE site averages (Table 1).

Causes of death also varied by land use. More than half of the carcasses located were the result of natural or unknown mortality causes in all land use categories with the exception of cultivated/settlement areas where 70% of mortality resulted from PAC. In 2002, PAC deaths were not distributed in proportion to elephant numbers estimated from an aerial count ($\chi^2 = 17.4$, d.f. = 5, $P = 0.004$), with greater than expected deaths on cultivated/settlement areas. In 2002, illegal killing was also not distributed in proportion to elephant aerial count numbers ($\chi^2 = 66.8$, d.f. = 5, $P < 0.001$), with greater than expected illegal kills in trust land/group ranches (40% of the total number of illegally killed elephants in 2002) and community conservation areas (32%) and fewer in private ranches (17%) and national reserves (0%). The proportion of illegally killed elephants (PIKE) also was greatest in trust land/group ranches and community conservation areas, matching patterns shown by the

Table 1 Area, number of live elephants, number of carcasses, carcass ratios, and the proportion of illegally killed elephants (PIKE) by land-use type in the Laikipia–Samburu MIKE site

	Land area (km^2)	Aerial count of live elephants 2002	Total carcasses 2002	Carcass ratio 2002 (%)	Total carcasses 2001–2003	Proportion of illegal killing of elephants 2001–2003 (%)
Laikipia–Samburu MIKE site	26135	5339	160	2.9	389	35
Community conservation areas	1296	556	40	6.7	86	47
Trust land/group ranch	13877	826	61	6.9	125	44
Forest reserves	2864	778	21	2.6	54	28
Private ranches/sanctuaries	3649	2827	34	1.2	98	25
Settlements and cultivation	3915	136	3	2.2	14	14
National reserves	534	216	1	0.5	12	0

overall carcass distribution and indicating these were hotspots of poaching during the 3 years of data collection (Table 1; Fig. 3). In contrast, natural deaths across land use categories were not significantly different from expected numbers based on the aerial count data ($\chi^2 = 7.02$, d.f. = 5, $P = 0.219$). Area specific causes of death were similar in 2001 and 2003.

Age–structure of carcasses

Age–structure of carcasses indicated that the majority of carcasses were adults (48.5%), with 27.1% of carcasses being sub-adults, and juveniles accounting for only 13.4%. The number of juvenile carcasses recorded was relatively low probably due to a faster decay and scavenging rate as a function of their small size. Detailed demographic research on a sub-sample of individually identified elephants in the MIKE site demonstrated the numbers of juvenile deaths are greater than those of adults or sub-adults, but few carcasses of juveniles are located (deaths were determined in relation to strict criteria; Wittemyer *et al.*, 2005). Assuming this trend in age-specific mortality holds across the ecosystem, the results presented here are biased towards older age groups. Thus, it can be concluded that the 2002 carcass ratio of 2.9% is probably a substantial underestimate (potentially by >2% if age specific proportions of deaths match those of Wittemyer *et al.*, 2005). Approximately 11% of the carcasses was not aged, either because carcass condition rendered estimation not possible or because the report did not state the age of carcass.

Tusk recovery

The majority of carcasses (63%) had tusks intact at the time of reporting or carcass verification. Only among the illegally killed carcasses were the majority (53%; n = 69) missing tusks (Fig. 5) – designation of illegally killed status was based on corroborative evidence and not only on missing tusks. The proportion of carcasses with missing tusks varied across the different land-use types, and was significantly related to PIKE ($r_s = 0.886$, $P = 0.047$). While the greatest proportion of carcasses missing tusks were found in forest reserves (56%), PIKE in this land use category was low relative to the proportion of carcasses with missing tusks because the cause of death for the majority of carcasses was unknown (see Section 'Discussion'). Private ranches had one of the lowest proportions of

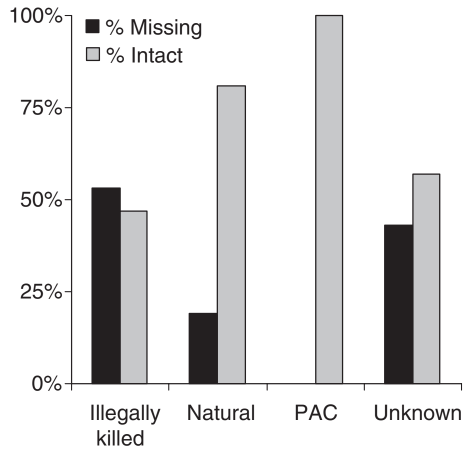

Fig 5 Ivory was missing from the majority of illegally killed carcasses, but tusks were recovered from most carcasses originating from other causes. The number of carcasses originating from unknown causes tended to have high levels of missing tusks, indicating that many of these carcasses were probably illegally killed

carcasses with missing tusks (12%), even among those illegally killed. This may indicate that the motive for illegal killing on private ranches is not for ivory as discussed below.

Qualitative comparison of mortality trends across method

During the 3-year study, proportional trends in causes of death registered using participatory or traditional approaches were qualitatively similar; both assigned the greatest PIKE during 2002, although participatory methods consistently registered higher proportions of illegally killed (Fig. 6). Temporal trends of PAC, natural and

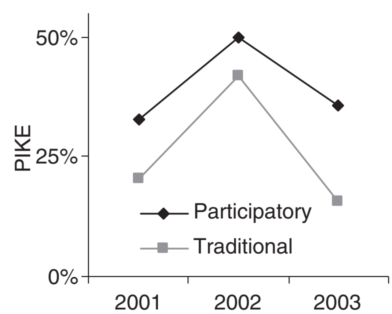

Fig 6 Carcasses detected using participatory and traditional approaches showed consistent annual trends in the proportion of illegally killed elephants (PIKE)

unknown mortalities were also similar between the methods, even though methodological differences affected the number, locations and causes of death of the registered carcasses. These similarities suggest PIKE offered a robust index of threat, although systematic differences between methods must be considered (see Section 'Discussion').

Discussion

The participatory method

The resources available for elephant monitoring and protection vary across the Laikipia–Samburu MIKE site and the best sources for information on elephant mortality are a function of land use and ownership. These conditions are not uncommon across elephant range states (Jachmann & Billiouw, 1997). Participatory methods of communal meetings and interviews accessed data in remote regions of the MIKE site that were previously inaccessible. The results show that in communally managed regions (the predominant land use in this MIKE site), greater numbers of fresh and recent carcasses were detected through participatory than standard patrolling approaches (Fig. 3). Herdsmen found 63% of all carcasses registered during the study and greater than 50% of carcasses in all land-use categories, except for private ranches and national reserves, where their access was limited (Fig. 2). While we were unable to relate effort to this qualitative difference in participatory versus traditional detection of carcasses, our results demonstrate the importance of communal-based information networks in areas with little or no investment in wildlife security. In contrast, patrols found over 80% of all carcasses on ranches, and tourists and researchers detected the majority of carcasses in national reserves. Interestingly, these numbers are likely underestimates of the total contribution of herdsmen as carcasses detected through other means (KWS, community conservancy or private ranch patrols) were often found only after following up on unofficial herder reports. As links are developed with communities in remote regions, additional information on elephant mortality will likely become more accessible.

While communities offer a powerful source of information, the information they give is also dependent on the strength of relationships. As incentives change, so to might the flow of information. This is illustrated by the fact that successive visits to villages often resulted in greater procurement of information, which most likely was a function of strengthening trust. Such trust-based information networks could also work the other way. Should trust deteriorate the flow of information would be expected to deteriorate. As such, checks on data quality need to be instituted, and potential limitations of the data considered in analysis. In this study, carcasses were individually investigated by the primary researcher before being entered in the database (i.e. community information was verified as much as possible), areas where communities were hostile to the researcher were not sampled (i.e. areas where information would obviously be politicized), and limitations regarding the interpretability of the results are discussed.

Elephant mortality and illegal killing

The average number of carcasses found annually in the period 2001–2003 in the Laikipia–Samburu MIKE site was 2.9% of the 2002 elephant population, as defined in the aerial census (Table 1). This cannot be considered as a mortality rate, as 10% of carcasses reported were never verified and many more were simply never found (especially the known under-sampling of juvenile deaths). Comparison of the results presented here with individual based data from the protected Samburu and Buffalo Springs National Reserves (Wittemyer *et al.*, 2005) indicates that elephants outside protected areas are at greater risk (e.g. higher rates of illegal killings) and are experiencing mortality probably double to that of elephants regularly using the protected areas.

The proportion of illegal killing of elephants (PIKE) during 2001–2003 was estimated at a minimum of 35% (Table 1). Trust land/group ranches and community conservation areas, which had the highest carcass ratio, also had the greatest proportion of illegally killed carcasses (Fig. 3). Forest reserves also were hotspots of illegal killing. Nearly half (46%) of carcasses in trust land/group ranches, community conservation areas and forest reserves had tusks missing. While these results clearly demonstrate that poaching for ivory is a concern in the Laikipia–Samburu MIKE site, not all areas are of equal concern. Illegal killing was substantially lower in regions with well-structured enforcement such as national reserves and ranches, some of which are run as private sanctuaries (Fig. 3).

Most of the areas with the highest numbers of poached carcasses in the MIKE site are relatively remote regions with substantial populations of wildlife, but with infrequent patrolling because lack of resources. Because of the remoteness of these areas, carcasses were typically located weeks or months after death which often made it difficult to assign the cause of death. For example, although almost 50% of tusks were missing from carcasses in the Karisia Forest Reserve, it was difficult to determine if tusks were removed opportunistically from elephants dying naturally or as a result of targeted poaching. Consequently, the cause of death was often recorded as 'unknown'. Interestingly, the proportion of tusks missing from unknown carcasses in the MIKE site (~43%) was second only to those known to be illegally killed (~53%) and substantially higher than those from natural mortality (19%), suggesting at least some of the carcasses recorded as unknown were illegally killed (Fig. 5). In addition, some regions are historically insecure and have been subject to cattle raiding, ivory poaching and banditry limiting monitoring ability even using participatory approaches. As such, the true levels of illegal killing and PIKE in this MIKE site are higher than those reported here.

While illegal killing in the more frequently patrolled ranches accounted for 25% of mortality, over 85% of tusks was recovered. Some elephant killing has a traditional, ceremonial basis for certain ethnic groups living around the private ranches. As such, illegal killing on private ranches may not always be for ivory (see Jones, Andriamarovololona & Hockley, 2008 for discussion on cultural mechanisms impacting conservation efforts). Illegal killing was also infrequent in settlement and cultivation areas, although human causes were still the dominant source of mortality but in the form of PAC. Levels of elephant deaths from PAC were second highest in private ranches, whereas <1% of carcasses were the result of PAC in communal lands and national reserves.

Information on illegally killed elephants is sensitive, and local communities may be reticent to share such information during participatory interviews for fear of inviting trouble from the authorities. However, the results presented here indicate that areas with the highest levels of illegal killing (both in total numbers and in PIKE) were where carcass information was derived through participatory approaches. Our experience was that once trust was gained information was forthcoming. It is clear that valuable information can be gleaned through participatory approaches. This enhances understanding of elephant dynamics across diverse land uses. However, the potential for misinformation must be considered, particularly should a community became less approachable in successive years. Subjective understanding of participant attitudes coupled with verification exercises is important for data quality assessment.

Implications for MIKE

Increasingly, community based monitoring is applied successfully in biodiversity assessments (Danielsen, Burgess & Balmford, 2005, 2007; Van Rijsoort & Zhang, 2005; Holmern, Muya & Roskaft, 2007; Jachmann, 2008). Here we demonstrate that community-based monitoring of elephant mortality is valuable in non-protected elephant range, especially areas that are inaccessible or not regularly patrolled. Use of conventional ground and aerial patrolling alone has limitations in a complex ecosystem like the Laikipia–Samburu MIKE site, with a small proportion of officially protected areas. Information from participatory meetings provided the majority of information on mortality in areas where elephants were at most risk from illegal killing. Ultimately, comprehensive understanding of a dynamic ecosystem like Samburu–Laikipia can be best accomplished through comparison of data derived from traditional and participatory approaches. Such comparison will also enable the identification of problems, strengths and weaknesses of the different monitoring approaches. In sites with a complexity of land use types, use of local information coupled with a rigorous system for verification and collation of data will further MIKE goals.

Quantifying the effort entailed in collecting information through participatory approaches remains a challenge. Measuring effort by community members is difficult, and is qualitatively different from trained wildlife personnel for whom patrolling is part of their occupational duties. The flow of information also depends on unquantifiable factors such as the extent to which the data collector and informant is trusted – a factor that is difficult to assess but can be advanced through rigorous field verification exercises. Nevertheless, data collected from different sources can be analysed and compared independently to provide a holistic understanding of mortality pressures across a dynamic landscape. The variation in the cause of death was collated from participatory and traditional data sources and shown to be similar. In terms of long-term monitoring, results presented here indicate that PIKE offers a useful metric for comparing levels of illegal killing temporally and spatially; during the study period trends in PIKE were relatively robust to systematic differences in methodology and spatial differences in data focus (traditional records are predominantly from private lands while participatory records are predominantly from unprotected areas; Fig. 3). Nevertheless, PIKE as calculated from data collected through participatory approaches was systematically elevated demonstrating that comparison will be most powerful when looking at temporal trends in areas where monitoring methods and spatial factors are consistent. In addition, the influence of sample size and its relation to random error in PIKE values should be considered in any future application of this metric. Further evaluation of this promising method is needed in other contexts.

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