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Monitoring of illegal hunting in elephant range States

# LEVELS OF ILLEGAL KILLING OF ELEPHANTS IN THE LAIKIPIA-SAMBURU MIKE SITE

The attached information document has been submitted by the MIKE Central Coordination Unit of the Secretariat.

# Levels of illegal killing of elephants in the Laikipia-Samburu MIKE site

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## Introduction

A programme to monitor elephant mortality was agreed by the CITES parties in 1997. The MIKE (Monitoring of the Illegal Killing of Elephants) programme, was approved by CITES in 2000; and its current *modus operandi* follow Res. 10.10 (Rev. CoP14). It was set up to detect changes in levels of illegal killing of elephants.

Kenya has been monitoring elephant mortality through the Kenya Wildlife Service of all elephant populations in the country since 1990, including the current Laikipia-Samburu MIKE site. The information is stored in a national elephant mortality database. A report summarizing all information from 1990 to 2002 was undertaken prior to the inception of MIKE, intended by Kenya as their own base line against which future change could be measured (Thouless et al. 2008).

Kenya began implementing the MIKE programme in June 2002, and currently has four MIKE sites including the Laikipia-Samburu MIKE site, which includes the range of Kenya's second largest elephant population, currently numbering an estimated 7500 (Litoroh, pers comm.). These elephants live primarily outside protected areas and occupy a substantial part of the Laikipia and Samburu Districts and the western extension of the Isiolo District. A substantial segment of the population migrates northward from Laikipia into Samburu during the two rainy seasons in November and April, returning south as temporary waterholes dry up.

## Methods

### STUDY AREA

Laikipia-Samburu is the most complex MIKE site in Kenya in terms of land use. 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 entities (Fig. 1). Land uses by area in 2008 included national reserves (NR) (1.7% of area), community conservation areas (CCA) (9.4%), undeveloped government-owned trust land (T) (49%), forest reserves (FR) (10.1%), private ranches (PR) some of which comprise private wildlife sanctuaries (15.9%), agricultural settlement (S) (13.4%) and urban centers (US) (0.5%). Agricultural and urban settlements were combined into a single settlement category (S) for analyses, representing 13.9% of the study area. The semi-nomadic pastoralists, sedentary agriculturalists and large-scale private land-owners that inhabit this area have different attitudes towards elephants. Security and capacity for wildlife protection and monitoring across the MIKE site was highly variable, from non-existent in trust lands to a high degree of wildlife protection in ranches, private sanctuaries and national reserves. Moreover it varied over time and as new CCAs became established they became more secure. 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. Ecologically the region contains a diversity of habitats ranging from the lowland, xeric scrub bush lands comprising *Acacia* and *Commiphora* species to the highland, mesic cedar and camphor forests.

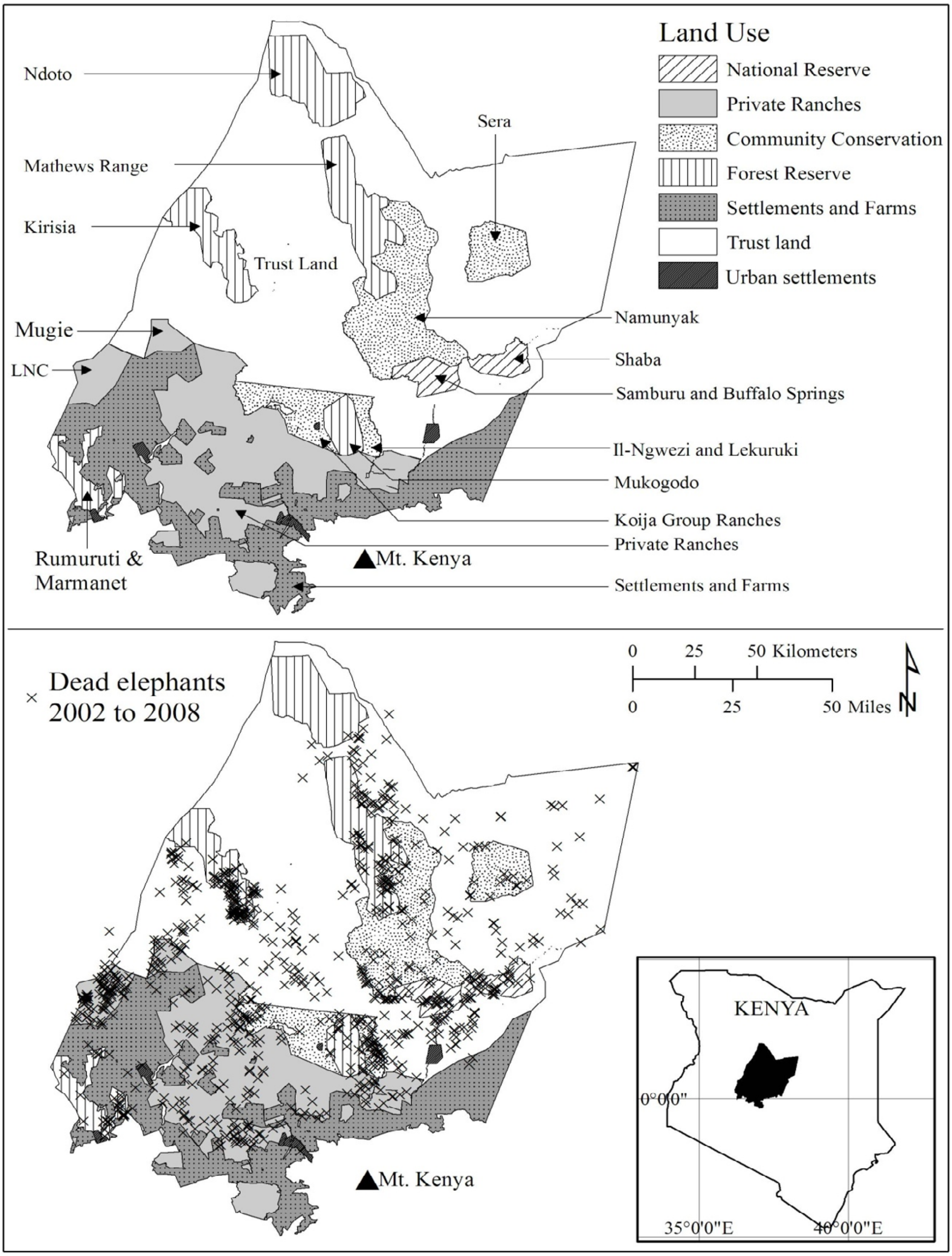


*Figure 1. Land uses in Laikipia Samburu Mike site (at the top) and the locations of the 1124 elephant carcasses recorded between 2002 and 2008 (bottom).*

**DATA ACQUISITION METHODS**

Information on the location of elephant carcasses was derived from patrols and from local knowledge. Formal wildlife institutions contributing to the carcass database included the Kenya Wildlife Service (KWS), the research N.G.O. Save the Elephants (STE), the local county councils, and private or community area management. In addition, a participatory information network of local people, principally herders, was initiated through meetings in the villages, which led to a substantial flow of data. Standard effort metrics were not possible to collect since monitoring activity was not systematically conducted or recorded by any of the wildlife management entities. Information gained from the pastoralists depended more on trust for which we failed to find a quantifiable measure. Previous analysis demonstrated that differences in methods of data acquisition did not appear to affect the general trends in the proportion of illegally killed elephants (PIKE) (Kahindi et al. in review).

*Carcass specific information*

Most carcasses were visited by the principal investigator (Onesmas Kahindi) or by a KWS patrol. Standardized data was 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, geo-referenced 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, herders, researchers and tourists and other informants). Information provided by informants was used to determine the month and year of death, in combination with the application of standard carcass aging criteria following MIKE protocols based on Douglas-Hamilton and Hillman (1981). A carcass was classified as “fresh” if first discovered within three weeks of death; “recent” if first found between 3 weeks and 12 months after it died; “old” if discovered after 12 months but less than five 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.

Cause of death was determined from evidence acquired at the carcass, such as presence of injuries or eye witness accounts. Four categories were used to summarize causes of death: illegally killed, problem animal control (PAC), natural and unknown. Within carcasses classified as illegally killed, designation was further categorized as resulting from poaching or from human elephant conflict. 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 removed tusks were not automatically categorized as illegally killed unless circumstantial evidence (e.g. bullet holes) or observer reports of gunshots were coincident with the carcass. In cases where further clarification was needed to confirm presence or absence of tusks, the status of tusks was reported as unknown.

*Data verification*

Data from all sources were compiled and checked by the principal investigator, Onesmas Kahindi (Save the Elephants) working in collaboration with KWS scientists, wardens and elephant mortality database managers. Quality of data recorded varied. Where records were doubtful, either through internal inconsistencies, or through a lack of adequate location data, they were rejected.

*Aerial Surveys*

Two aerial surveys were conducted by KWS and collaborators during the study period, following standard methods of total counting (Douglas-Hamilton, 1996) which were in accordance with MIKE standards (Craig 2004). The first occurred in June during the dry season of 2002 and the second in November during the wet season of 2008 (Fig 2). Potentially as a function of this seasonal difference, certain land use categories demonstrated increases across the two counts while others showed declines.

In total, elephant numbers demonstrated an annualized growth rate of around 6% between the two counts. This rate of increase is unlikely to be a function of intrinsic growth alone, given the mortality detected in this study, and the lower rate of increase observed of the elephants living in the optimal habitat and high protection comprising the Samburu and Buffalo Springs national reserves (Wittemyer et al. 2005). It is thought that numbers were in part increased by movement of elephants into the site. Furthermore, radio tracking data in the ecosystem demonstrates that some elephants use quite different areas seasonally, with some relying on forests(excluded from the counts) during the dry season and low land savannahs included in the count during the wet season (Douglas-Hamilton et al. 2005; Thouless 1996). As a result of these considerations, analysis relying on live elephant density used the average of the two aerial surveys. Because forest areas and settlements were not adequately covered in the aerial counts, due to poor visibility in the first case and low expectations of seeing elephants on account of the nocturnal behaviour in the second, these land use categories were excluded in analyses relating live to dead elephants.

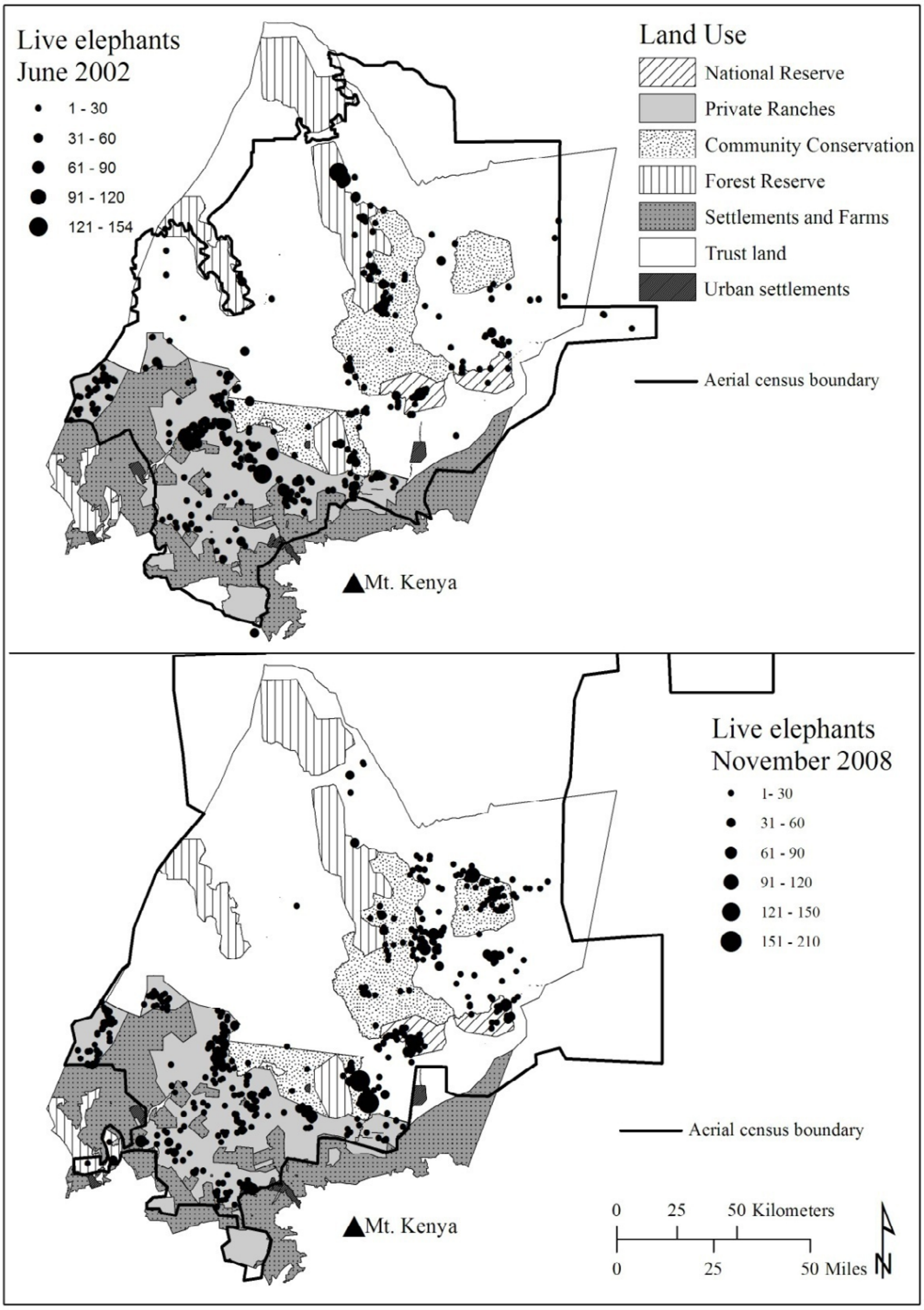


*Figure 2. Live elephant numbers and aerial survey boundaries of 2002 (top) and 2008 (bottom) census*

For purposes of analysis, carcass ratios, CR=Dead / (Dead + Live), were calculated for the entire MIKE site and for the four land use categories within the site, using the carcasses recorded by the ground study and live elephants recorded by the average of two aerial counts. Relating the Laikipia-Samburu MIKE site average annual carcass ratio of 0.0187 to the observed density of elephants in the four land use categories analyzed (C.R. including all 6 land use categories was 0.0215), the expected numbers of carcasses detected per year were calculated. 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. Analyses of the correlation of proportional data were conducted using non-parametric Spearman's rank correlations.

*Sampling Intensity Simulation*

Previous work demonstrated the potential utility of using the proportion of illegally killed elephants (PIKE) compared across years and land use categories as an index of the conservation status of an elephant population (Kahindi et al. in review). As shown in the study, trends in PIKE in the MIKE site were relatively robust to methodological differences used to locate carcasses. The number of detected carcasses relative to the population size is a potential factor impacting the accuracy of this index, a relationship that will influence confidence limits around PIKE. Assuming a mortality rate of around 5% in the MIKE site and an average elephant population size of approximately 6000 elephants, 300 elephants are expected to die per year, though this is known to vary in relation to ecological fluctuations and potentially other factors (Wittemyer et al. 2007). To assess the relative confidence interval around PIKE figures presented in this study, the impact of carcass sample size on PIKE error rates was assessed through a simple simulation assessment. Specifically, 300 carcasses were randomly assigned illegally killed status (yes or no) at five different probabilities (0.1, 0.25, 0.5, 0.75, and 0.9). This carcass population was randomly sampled 100 times at different proportional regimes (ranging from 1% or *n* = 3 to 50% or *n* = 150), and PIKE calculated for each sample. The standard deviations of the 100 samples at each sampling frequency were then calculated to provide estimates of the PIKE confidence levels at different sampling intensities.

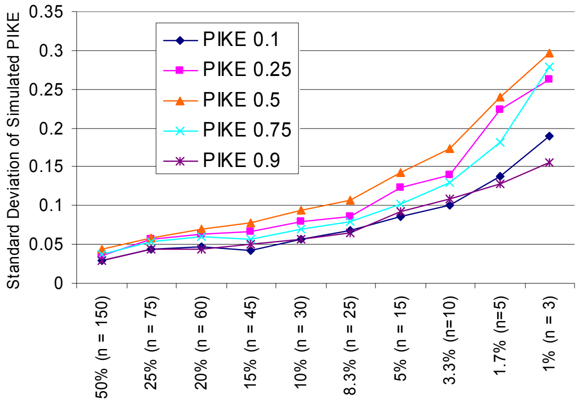


*Figure. 3. Simulations tests assessed error around PIKE values at different PIKE levels (0.1-0.9) and at different sampling intensities (50% to 1% of all carcasses) for a sample population of 300 carcasses (the approximate number of carcasses expected in the study area given mortality of 5% annually). Illegally killed or natural death categories were randomly assigned to carcasses, in respect to the assumption that carcasses were randomly detected in relation to their cause of mortality. Error increased with a decrease in the proportion of the carcasses detected. As a function of the high carcass detection rate (~50%) in the Laikipia-Samburu MIKE site, the expected error in presented PIKE values is low (S.D. < 5%).*

## Results

*Sampling intensity simulation*

Assuming carcass detection of illegally killed and natural mortality is random, simulation results demonstrated that sampling intensity influenced the accuracy of PIKE estimates. Sampling intensity representing 10% or more of the estimated annual dead demonstrated standard deviations around the PIKE mean of less than 10%, with standard deviation of estimates for extreme PIKE values (0.1 or 0.9) approaching 5%. Sampling intensity of approximately half of the estimated number of dead per year in the Laikipia-Samburu MIKE site was found to have low error with standard deviations being less than 5% regardless of PIKE levels. As sampling intensity dipped to less than 10%, error increased. But even sampling intensities of 3-8% appear to offer PIKE values with standard deviations less than 20%. Only at very low levels of carcass detection were errors inflated beyond a useful level. Error in PIKE was lower around extreme PIKE values (0.1 or 0.9) than intermediate values.

*Elephant mortality in the Laikipia-Samburu MIKE site*

During the seven year study of elephant mortality in the Laikipia-Samburu MIKE site, 1124 carcasses were detected, averaging 160.6 (minimum = 93, maximum = 234) carcasses per year. Considering that mortality in the individually monitored elephants using the Samburu and Buffalo Springs National Reserves within the MIKE site averaged 2.6% between 1998-2003, the annual number of carcasses may potentially represent over 90% of the mortality in the population (assuming a population size of approximately 6,350, i.e. the average of the 2002 and 2008 aerial census). Assuming a more realistic putative mortality of 5% per year (see Kahindi et al. in review), the number of carcasses detected would represent approximately half of the expected number of deaths in the system, a level that simulations indicate would provide accurate estimates of the cause of death assuming carcass detection in relation to cause of death is random. The most common cause was illegal killing (42%), followed by natural (28%) and unknown causes (23%), with problem animal control (PAC) accounting for 7% of deaths.

Carcass numbers varied by land use as did the number of live elephants in the MIKE site (Fig 1 and 2). However, the number of carcasses found was not significantly correlated with the number of live elephants (using the average of the two aerial surveys) in the four land use categories analyzed ($r_s = 0.8$, $p = 0.164$; all 6 land use categories: $r_s = 0.772$, $p = 0.084$).

Observed numbers of carcasses differed significantly from expected numbers, calculated using carcass ratios as described in the methods section, across the four land uses analysed ($\chi^2 = 23.1$, *d.f.* = 3, $p < 0.001$; all 6 land use categories: $\chi^2 = 65.5$, *d.f.* = 5, $p < 0.001$). Observed numbers of carcasses were greater than expected in trust land (75%), and lower than expected in national reserves (-46%) and private ranches (-27%). Carcass ratios in community conservation areas were close to MIKE site averages (Table 1). This appears to reflect the differential mortality between these land use types.

| Land Use | Area ($km^2$) | Live elephants 2002 | Live elephants 2008 | Avg. live elephants | Carcasses 2002 -08 | Carcass Ratio | PIKE | Tusks missing |
|---|---|---|---|---|---|---|---|---|
| **Forest Reserves** | 3239 | 778 | 68 | 423 | 195 | n/a | 0.53 | 45% |
| **Trust land** | 15733 | 832 | 1782 | 1307 | 344 | 21% | 0.48 | 35% |
| **CCA** | 3027 | 551 | 1709 | 1130 | 178 | 14% | 0.45 | 24% |
| **National Reserves** | 533 | 208 | 1093 | 651 | 53 | 8% | 0.32 | 30% |
| **Ranches** | 4447 | 2778 | 2755 | 2767 | 304 | 10% | 0.31 | 10% |
| **Settlement** | 5109 | 135 | 8 | 71.5 | 50 | n/a | 0.24 | 4% |

*Table 1. Land use category specific information regarding elephant distribution and mortality*

*Causes of death*

Causes of death also varied by land use, and in this case the full sample of 6 land use types could be used for this analysis, irrespective of whether they were covered by the aerial surveys or not. Illegal killing was the predominant cause of death in forest reserves (53%), trust land (48%) and community conservancies (45%). Natural causes were most common in national reserves (53%) and private ranches (35%), while problem animal control was the major cause of death in settlement/cultivation areas (46%) (Fig. 4). The proportion of carcasses with missing tusks was strongly correlated with PIKE ($r_s = 0.943$, $n = 6$, $p = 0.035$; Table 1).

The distribution of annual natural deaths did not differ significantly from that expected from the distribution of live elephants estimated from the two aerial censuses ($\chi^2 = 1.28$, *d.f.* = 3, $p = 0.734$), however the distribution of annual illegally killed carcasses was significantly different from expected ($\chi^2 = 19.96$, *d.f.* = 3, $p = 0.0003$). Therefore, landscape characteristics correlated with illegal killing were apparently unrelated to factors causing natural death. Land use categories with higher numbers of illegally killed carcasses matched those where more carcasses were detected, with trust land/group ranches and forest reserves showing the greatest disparity between observed and expected in both categories. Interestingly, the differences between the total observed and expected numbers of carcasses was strongly correlated with the difference in illegally killed carcasses ($r_s = 1.0$, $n = 4$, $p = 0.08$), suggesting the disparity in numbers of live and dead elephants was related to patterns of illegal killing.

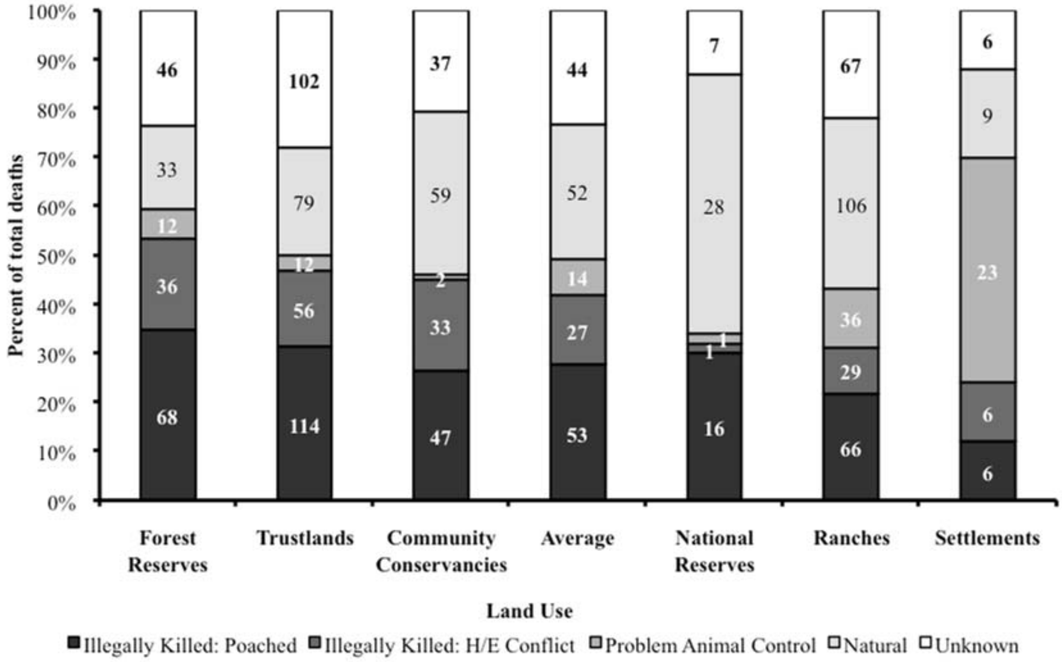


*Figure 4. Number of carcasses in each land use type categorized by cause of deaths*

*Subdivisions of land use by block*

When subdivisions of each land use type shown in Fig. 1 are analysed, large differences appear in the PIKE values. Placed in rank order, from high to low as in Fig 5, it is apparent that Community Conservation areas (CCAs) separate into Sera and Koija with high PIKE, Namunyak, and Ilngwezi / Lekuruki with low PIKE. Likewise, Forest Reserves (F) have high PIKE for Sera and Koija, and low PIKE for Rumuruti/ Marmanet. The ranches (R) show a division between high PIKE for Mugie and LNC and low PIKE for all the others. The national reserves are divided between high PIKE for Shaba and low PIKE for Samburu and Buffalo Springs. Trust lands all have above average PIKE values and settlement has low PIKE, probably related to the high level of Problem Animal Control. The rank ordering of PIKE is a convenient way of sorting areas from a relatively high level of risk to elephants to a relatively low risk from illegal killing, depending on whether they fall above or below the average PIKE value.

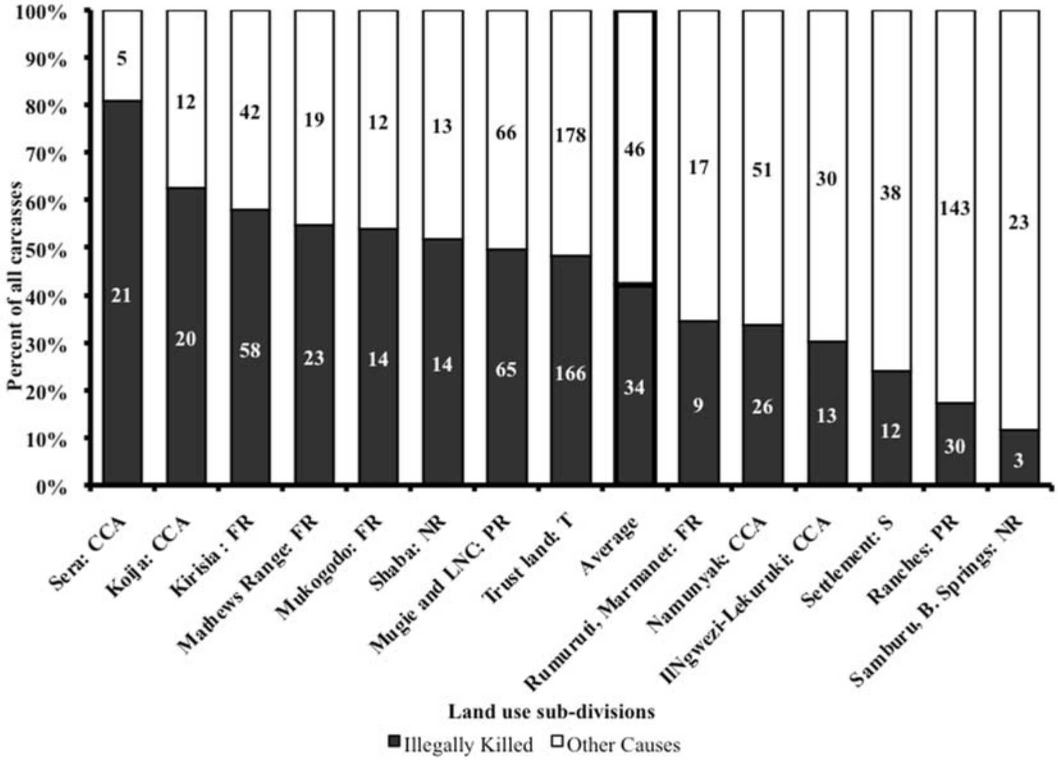


*Figure 5. The proportion of illegally killed elephants (PIKE; dark portion of columns) contrasted with other causes of elephant mortality (white portion of columns) in different land parcels in the Laikipia-Samburu MIKE site.*

*Annual Variation*

From 2002 to 2008 the number of carcasses detected per year in the MIKE site was the lowest in 2007 at 93 and the greatest in 2008 at 234. Autocorrelation in carcass numbers was not found at any lag, therefore we treated annual counts as independent. PIKE also varied across years hitting the high in 2008 at 54% and the low in 2003 at 28%, and averaging 41% (Fig 6).Comparison with the confidence interval around the 2002-2008 mean demonstrated that 2008 was significantly greater than average, with 2007 being the second greatest PIKE value during the seven year study but slightly below a significant level. Autocorrelation in PIKE was not found at any lag, therefore we treated annual counts as independent. MIKE site annual totals of PIKE and numbers of carcasses detected were not significantly correlated ($r_s = 0.107$, $n = 6$, $p = 0.787$). Nor were PIKE and carcass numbers in any of the land use categories with the exception of forest reserves. The foregoing statistics show that PIKE was not correlated with carcass numbers (i.e. detection effort and rate). This is an indication that PIKE is relatively independent of effort, as PIKE values calculated in this study were not simply reflective of effort where the expectation would be that the more carcasses detected the higher the PIKE.

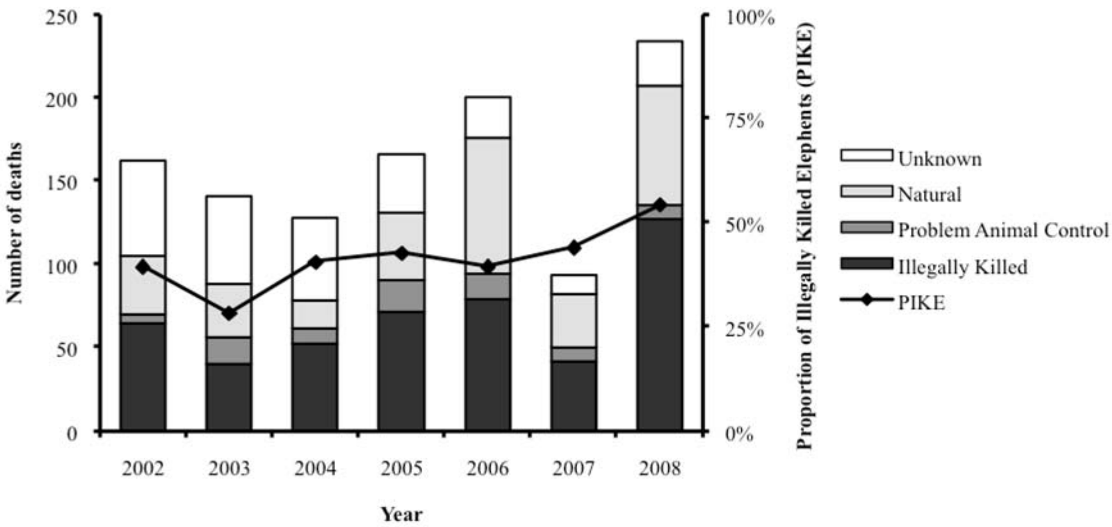


*Figure 6. The primary axis displays the number of carcasses recorded from 2002 to 2008 (shade coded for cause of death). The secondary axis displays PIKE values for each year of the study.*

As was found for the total MIKE site, PIKE was not significantly auto correlated at any lag in any land use category. Comparison across land use categories of PIKE demonstrated that illegal killing varied by year as well as location. Only private ranches and trust lands ($r_s$ = 0.905, n = 8, p = 0.016) and forest reserves and national reserves ($r_s$ = 0.774, n = 8, p = 0.040) demonstrated significant correlations in PIKE across years. The average correlation coefficient across all land use comparisons was -0.042, demonstrating a lack of synchronicity in PIKE values across the study area. This shows that PIKE was pretty specific to certain areas. Poaching surges in one land use did not necessarily mean poaching surges in other areas.

In contrast, the number of carcasses showed much greater system wide correlation, averaging 0.546 across all pair-wise comparisons demonstrating much greater synchronicity in general mortality. This implies that ecological drivers are more consistent across the site, for example droughts kill elephants everywhere.

The earlier 1990 to 2002 dataset is considered a base line of for measuring change in levels of illegal killing (Thouless et al. 2008). During the 19 years of monitoring in the Samburu/Laikipia ecosystem, six years demonstrated PIKE values significantly greater than the nineteen year average. Of those six, four of the past five years saw significant levels of illegal killing (2004, 2005, 2007, and 2008), with a nineteen year high PIKE value observed in 2008. These results indicate that illegal killing of elephants in the Laikipia-Samburu MIKE site has increased. Early returns from 2009 indicate this trend is continuing and a peak has not yet occurred.

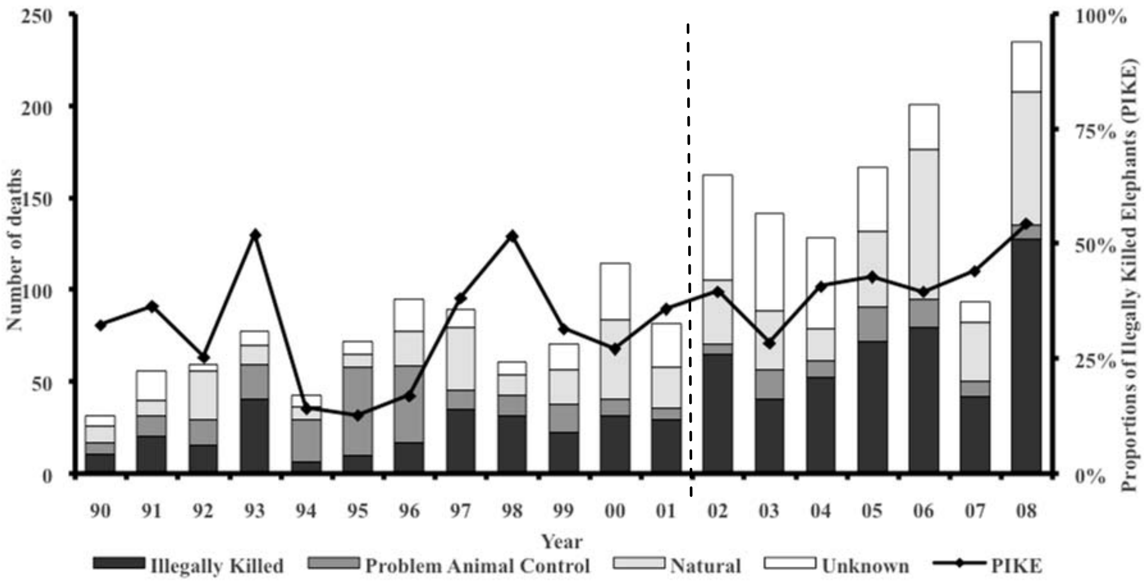

*Figure 7. Carcass data recorded in the Laikipia-Samburu MIKE site from 1990 to 2002 (Thouless et al, 2008), and this study right of broken line, 2002 to 2008. The PIKE values are shown on the secondary y axis.*

*Correlates of PIKE*

Land use category PIKE values during the seven year study were not significantly correlated with elephant population sizes (Using 4 land use categories: average 2002 and 2008 aerial surveys: $r_s$ = -0.200, *p* = 0.726 with the same results if using strictly the 2002 and 2008 surveys). The lack of correlation between population size and PIKE was similar if all 6 land use categories were analyzed (average aerial surveys: $r_s$ = 0.086, *p* = 0.841; 2002 aerial survey: $r_s$ = 0.371, *p* = 0.401; 2008 aerial survey: $r_s$ = 0. 086, *p* = 0. 841). PIKE was also not significantly correlated with land use category area ($r_s$ = 0.40, *p* = 0.484; with all 6 land use categories: $r_s$ = -0.857, *p*> 0. 841).

*Comparisons within land use category*

While results are presented in relation to coarse land use categories, areas within these categories demonstrated important differences that provide insight to the conditions driving higher PIKE. Among private ranches, Mugie and the Laikipia Nature Conservancy (LNC), two spatially isolated private ranches in politically volatile areas, experienced significantly greater levels of illegal killing per year than other private ranches and sanctuaries (Wilcoxon rank sum Z= 2.747, p = 0.0061). This was because the isolated Mugie and LNC ranches have to cope with a particularly lawless ethnic group, the Pokot, who are well armed with automatic weapons and poaching for ivory. This sort of threat does not exist against the other ranches. Comparison of new and older community conservation areas demonstrated that newer areas had significantly greater annual PIKE than those that had been established for several years (Wilcoxon rank sum Z= 2.236, p = 0.0253). This is thought to be because it takes a few years before conservation practices become established in this new form of land use. Finally the average PIKE was greater in Shaba National Reserve (0.56) than in the high tourist density Samburu/Buffalo Springs National Reserves (0.12). Shaba has a lower tourist density, and is less protected and less well managed. Annual values however were not significantly different (Wilcoxon rank sum Z= 1.342, p = 0.1797) due to multiple years when 0 illegally killed carcasses were found in either park.

**Discussion and Conclusion**

We see that the numbers of dead elephants recorded year by year fluctuate. In some cases this is due to changes in effort. For example 2007 was a year when the principal investigator could not travel to all parts of the study area due to insecurity. Thus, inadequate sampling occurred during this year, and the total number of carcasses verified was at an all time low for the study period. Even so, over 90 carcasses were detected representing an estimated 30% of the putative annual mortality in the study area. Such coverage appears to offer a robust assessment of PIKE according to our simulation study on sampling levels and, therefore, we included this year in all analyses. In general, the level of carcass detection in this study appears much higher than levels where issues of limited sample size are likely to impact results (Fig. 3). Although a metric for “effort” would be desirable this was not possible, given the wide sources of information (see discussion of this in Kahindi et al. in review).

When MIKE was first instituted in the Laikipia-Samburu MIKE site in 2002 the carcass count was high. The presence of the investigator on the ground contacting communities to provide information is thought to have depressed some of the illegal killing that was going on and 2003 and 2004 were both lower in total numbers than 2002. However, given the subjective nature of this interpretation, PIKE appears to be a more useful measure of the level of illegal killing than the total number actually recorded.

Within the MIKE site PIKE varied from high in the poorly protected areas, such as Forest Reserves and Trust land, to low in the well protected areas such as national reserves, and ranches (some of which incorporated private wildlife sanctuaries). Community conservation areas, which were in the process of getting started during the study period showed mixed results, with the longer established CCAs (Namunyak and surrounding areas of West Gate and Kalama, Ilngwezi and Lekuruki) showing relatively low PIKE, and more recently established CCAs such as Sera and Koija showing significantly higher annual PIKE values. In the well established CCAs, an apparent trend towards lower PIKE was interspersed with flare-ups in illegal killing related to dissatisfaction of some of the parties involved.

Interestingly, annual PIKE values were not well correlated across different land use categories, indicating that illegal killing was not synchronized. Not all illegal killings were motivated by ivory. Elephants were also killed in other situations broadly classified as Illegal Conflict (Fig 4). The motivations were various, at times in defense of livestock, to prove manhood, or to express dissatisfaction or defiance with landowners or wildlife authorities.

Curiously few elephants were killed illegally in defense of crops as in the crop growing region in the south of the MIKE site the KWS employed an active Problem Animal Control unit, legally empowered to shoot crop raiders or fence breakers or elephants judged dangerous. This PAC amounted to a high proportion of the elephant mortality in that region.

Clearly, illegal killing is higher where law enforcement is stretched, particularly in the less patrolled trust lands and forest reserves where PIKE is highest. The difference in PIKE found in Samburu/Buffalo Springs National Reserves and Shaba National Reserve also exemplifies this relationship, where Shaba is poorly managed and experienced greater PIKE. However, some areas like LNC, with relatively high protective investment were isolated and bordered by insecure regions, and experienced higher PIKE than the other private ranches that were all in one block. Unfortunately we do not have information on the relationship between illegal killing and market access, and can say nothing about it. In contrast to the lack of correlation in PIKE across the MIKE site, carcass ratios were relatively well correlated across land use categories. The relatively strong correlation in ecosystem wide mortality was probably a function of the strong influence of drought and rain cycles on elephant natural mortality in the ecosystem.

*Comparison of PIKE within Kenya for the 1990 to 2002 KWS dataset*

The average PIKE value was 35.3% in the independent KWS data set from 1990 to 2002 (Thouless et al, 2008), with districts arranged in rank order of PIKE in Fig 8. Once again the rank ordering of PIKE is a convenient way of sorting areas with a high level of risk to elephants from illegal killing from those with a low risk, depending on whether they fall above or below the average PIKE value. This separates the populations of Tsavo, Samburu-Laikipia, Amboseli, Mara the Aberdares, Mt Kenya and Shimba Hills all of which are known to be relatively well protected from those of Marsabit, Turkana, Mt Elgon, Meru and the Eastern Province, all of which were known in that period to be poorly protected.

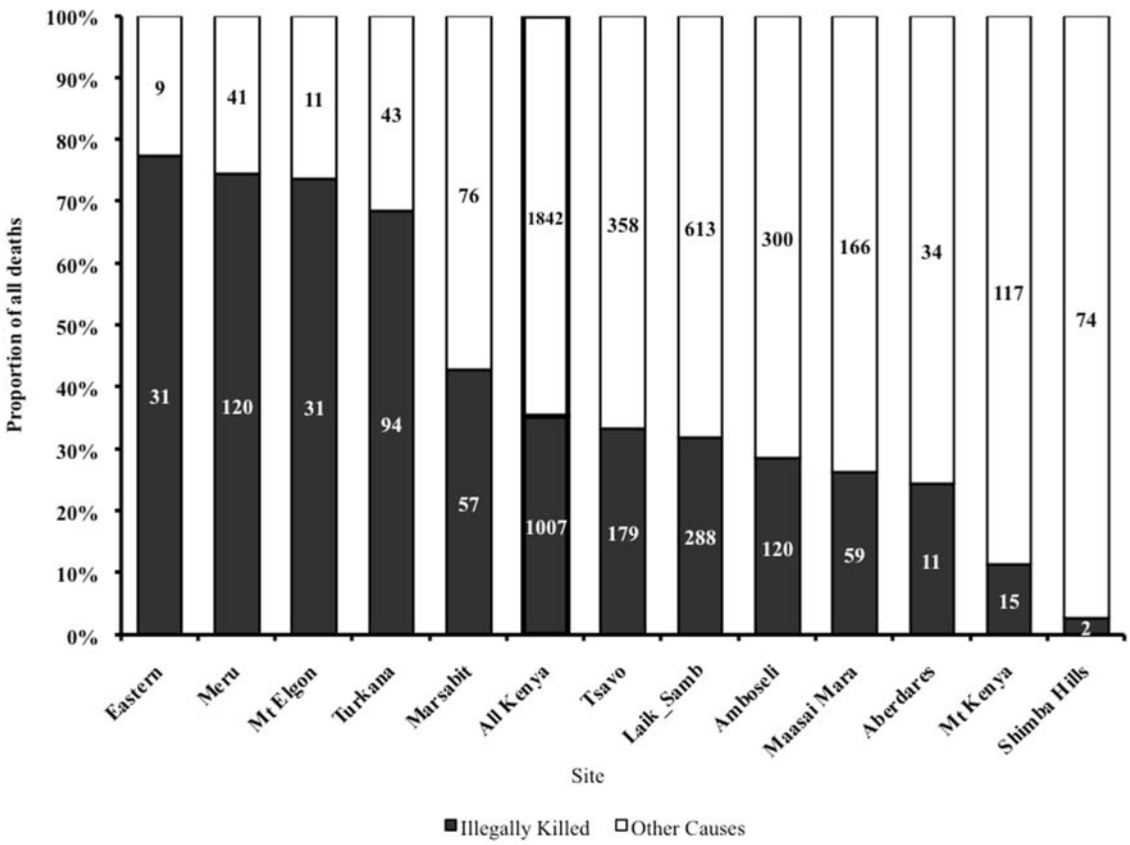


*Figure 8. Proportional cause of death of 2849 elephant carcasses found in Kenya 1990 to 2002 (Thouless et. al. 2008). The N is given for each column according to cause of death, illegal killing, or other.*

*Comparison of PIKE across the Africa and Asia*

Finally, we looked at the variation of PIKE values across MIKE sites in the data available up to 2009. We selected only sites that had a total of more than 30 carcasses in order to remove small samples. The average PIKE value was 40%. It emerged that PIKE averages from three sets of data - the current study in Samburu-Laikipia, the 1990 to 2002 Kenya dataset and the MIKE baseline data for 2007 - all tended to lie between 30-40%, and that sites with higher levels of PIKE tended to be those perceived to be suffering from high poaching activity, whereas sites with lower than average levels of PIKE seem to be those in which poaching is better under control

When the exercise was repeated in 2009 for a fuller set of data up to the end of 2008, the average PIKE had climbed both in the Laikipia-Samburu MIKE site and in the world MIKE dataset suggesting that a trend had occurred. Further analysis on recent changes in PIKE at a continental level is beyond the scope of this paper, but see Burne and Blanc et al (ref to COP paper in current preparation).

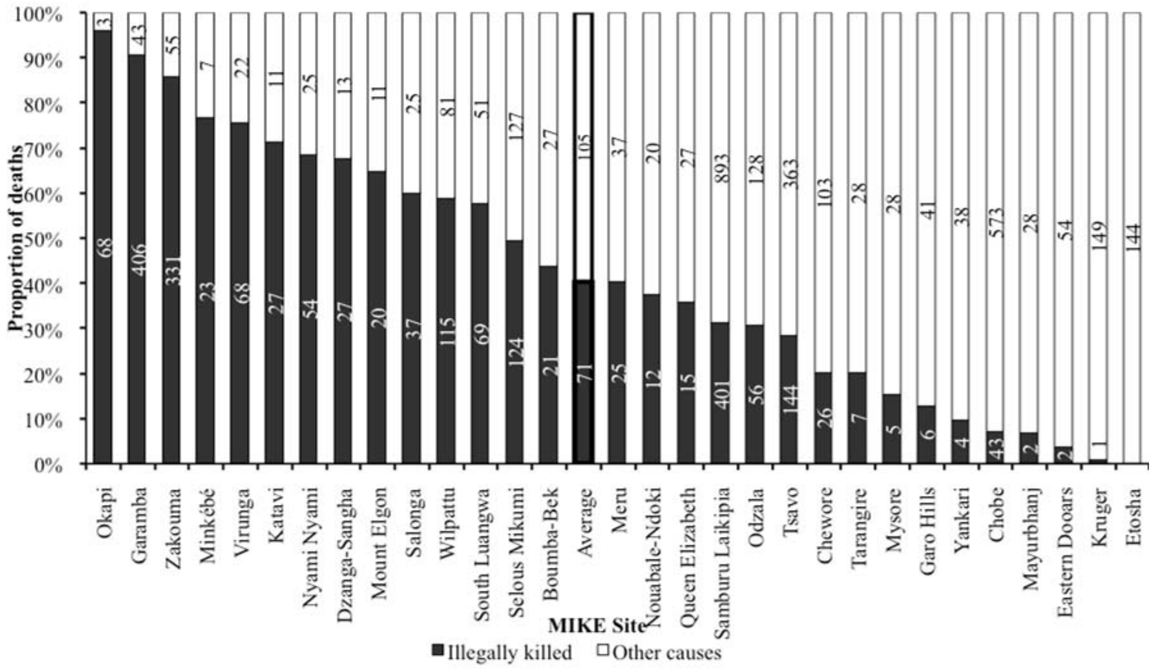


*Figure 9. PIKE values across MIKE sites in Africa and Asia with more than 30 carcass sample size. (n values indicated on each portion of bar)*

*Medium term trend in levels of illegal killing*

Results from this study clearly indicate that areas with higher degrees of insecurity or political strife experienced higher levels of illegal killing. Similarly, relatively well protected areas surrounded by insecure regions (Shaba National Reserve, LNC) demonstrated much higher PIKE values than similar areas bordering on more secure regions. Neither population size nor area was significantly correlated with PIKE, indicating the landscape context is the critical aspect related to illegal killing.

In summary, comparison with the average PIKE from the 1990-2008 at 35% (Thouless et al. 2008) demonstrated significantly elevated PIKE levels in 1993, 1998, 2004, 2005, 2007, 2008. It was notable that four of the last five years (2004, 2005, 2007, and 2008) contained significantly elevated PIKE, with 2008 showing the highest PIKE ever found in the MIKE site. We conclude that our analyses indicate that PIKE is a useful measurement of the level of illegal killing of elephants and that poaching in the Laikipia-Samburu MIKE site has significantly increased.

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