Human-Elephant Conflict References (By date; most recent first)
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Von Hagen, L., C. A. LaDue and B. A. Schulte (2023). "Elephant Scar Prevalence in the Kasigau Wildlife Corridor, Kenya: Echoes of Human-Elephant Conflict." Animals (Basel) **13**(4).

Human-elephant conflict (HEC) compromises crop security and threatens elephant conservation. Most commonly, HEC manifests as crop-foraging as elephants modify natural foraging strategies to incorporate crops. Farmers may retaliate by frightening or harming elephants, leaving scars from inflicted wounds. We assessed the prevalence and distribution of scars on the bodies of African savanna elephants (Loxodonta africana) observed in the Kasigau Wildlife Corridor (KWC), part of the Greater Tsavo Ecosystem of Kenya, where conflict is prevalent. We surmised that scars on the body are largely a result of HEC as opposed to scars on the rump or head, which we attributed primarily to elephant-elephant conflict. We hypothesized that: (1) male elephants would have more scars than females; (2) older males would be more likely to have scars than younger males; and (3) most scars would be located on the bodies of elephants. We assessed scars from a photographic catalogue of elephants from the KWC. In line with our hypotheses, male elephants were more likely to have scars than females (32% of males compared to 6% of females); older males had significantly more scars than younger males (61% compared to 24%); and the majority of scars (89%) were located on the body. Scar presence may be useful as an animal-centered indicator to estimate the prevalence and demographic patterns of HEC.

Vasudev, D., R. J. Fletcher, Jr., N. Srinivas, A. J. Marx and V. R. Goswami (2023). "Mapping the connectivity-conflict interface to inform conservation." Proc Natl Acad Sci U S A **120**(1): e2211482119.

Balancing the competing, and often conflicting, needs of people and wildlife in shared landscapes is a major challenge for conservation science and policy worldwide. Connectivity is critical for wildlife persistence, but dispersing animals may come into conflict with people, leading to severe costs for humans and animals and impeding connectivity. Thus, conflict mitigation and connectivity present an apparent dilemma for conservation. We present a framework to address this dilemma and disentangle the effects of barriers to animal movement and conflict-induced mortality of dispersers on connectivity. We extend random-walk theory to map the connectivity-conflict interface, or areas where frequent animal movement may lead to conflict and conflict in turn impedes connectivity. We illustrate this framework with the endangered Asian elephant Elephas maximus, a species that frequently disperses out of protected areas and comes into conflict with humans. We mapped expected movement across a human-dominated landscape over the short- and long-term, accounting for conflict mortality. Natural and conflict-induced mortality together reduced expected movement and connectivity among populations. Based on model validation, our conflict predictions that explicitly captured animal movement better explained observed conflict than a model that considered distribution alone. Our work highlights the interaction between connectivity and conflict and enables identification of location-specific conflict mitigation strategies that minimize losses to people, while ensuring critical wildlife movement between habitats. By predicting

where animal movement and humans collide, we provide a basis to plan for broad-scale conservation and the mutual well-being of wildlife and people in shared landscapes.

Tsegaye, A., A. Bekele and A. Atikem (2023). "Local's attitude towards African elephant conservation in and around Chebra Churchura National Park, Ethiopia." PLoS ONE **18**(10): e0292641.

Economic growth and development in developing countries often involves land-use changes which fragment natural areas, bring humans and wildlife into closer proximity and escalating human- wildlife conflicts. Human-wildlife conflicts impose huge costs on local people and their livelihoods. Balancing developmental activities with the conservation of mega fauna such as the African and Asian elephants (Loxodonta Africana, Elephas maximus; respectively) remains problematic. Understanding the reasoning upon which perceived risks and level of human- elephant conflict laid is critical to address societal or cultural beliefs in order to develop effective mitigation strategies. The perceived risks and level of conflict have to be properly addressed for effective planning and implementation of appropriate mitigation strategies. We studied human- elephant interactions in Chebra Churchura National Park Ethiopia (CCNP) from September 8 to October 28, 2022 and collected baseline data on human perceptions of conflicts in an area where elephant populations are increasing. To complete our study, we surveyed 800 household from 20 villages adjacent to the CCNP. The purpose of this investigation was to identify the relevance of the existing human-elephant conflict (HEC) with the attitude of local communities towards elephant conservation, the park management and perceived effective mitigation techniques. The local communities trust in the implementation of different traditional mitigation techniques is generally weak. The households interviewed were less positive towards the effectiveness of most of the traditional techniques in chasing elephants away from their farm lands. They believed that elephants had already adapted and do not respond to most of these techniques. Against the above perception in exception of their usual absence and late arrival, perception of local communities about shooting warning gun by park scouts is among the most accepted effective methods in chasing elephants from their farm lands. The majority of respondents believe that separation of elephants and humans by constricting barriers is the best solution to the problem. The idea of constructing barriers such as electric fence; ditch or concrete wall and blocking corridors between the Park boundary and the villages have become the most popular idea of local communities followed by relocating people to other safer places, as the best protection method against the elephant attack irrespective of the associated initial and maintenance costs.

Robertson, M. R., L. J. Olivier, J. Roberts, L. Yonthantham, C. Banda, B. N'Gombwa I, R. Dale and L. N. Tiller (2023). "Testing the Effectiveness of the "Smelly" Elephant Repellent in Controlled Experiments in Semi-Captive Asian and African Savanna Elephants." Animals (Basel) **13**(21).

Crop-raiding by elephants is one of the most prevalent forms of human-elephant conflict and is increasing with the spread of agriculture into wildlife range areas. As the magnitude of conflicts between people and elephants increases across Africa and Asia, mitigating and reducing the impacts of elephant crop-raiding has become a major focus of conservation intervention. In this study, we tested the responses of semi-captive elephants to the "smelly" elephant repellent, a novel olfactory crop-raiding mitigation method. At two trial sites, in Zambia and Thailand, African elephants (Loxodonta africana) and Asian elephants (Elephas maximus) were exposed to the repellent, in order to test whether or not they

entered an area protected by the repellent and whether they ate the food provided. The repellent elicited clear reactions from both study groups of elephants compared to control conditions. Generalised linear models revealed that the elephants were more alert, sniffed more, and vocalised more when they encountered the repellent. Although the repellent triggered a response, it did not prevent elephants from entering plots protected by the repellent or from eating crops, unlike in trials conducted with wild elephants. Personality played a role in responses towards the repellent, as the elephants that entered the experimental plots were bolder and more curious individuals. We conclude that, although captive environments provide controlled settings for experimental testing, the ecological validity of testing human-elephant conflict mitigation methods with captive wildlife should be strongly considered. This study also shows that understanding animal behaviour is essential for improving human-elephant coexistence and for designing deterrence mechanisms. Appreciating personality traits in elephants, especially amongst "problem" elephants who have a greater propensity to crop raid, could lead to the design of new mitigation methods designed to target these individuals.

Pant, B., H. P. Sharma, B. R. Dahal, S. Regmi and J. L. Belant (2023). "Spatio-temporal patterns of human-wildlife conflicts and effectiveness of mitigation in Shuklaphanta National Park, Nepal." PLoS ONE **18**(4): e0282654.

Human-wildlife interactions occur where human and wildlife coexist and share common resources including food or shelter. Increasing wildlife populations within protected areas also can increase interactions with humans living adjacent to these areas, resulting in conflicts including human casualty, livestock depredation, crop damage, and property loss. We analyzed six years human-wildlife conflict data from 2016-2021 in the buffer zone of Shuklaphanta National Park and conducted questionnaire survey to investigate factors influencing human-wildlife conflicts. Nineteen people were attacked by wildlife, primarily wild boar (Sus scrofa). Ninety-two livestock were killed by leopard (Panthera pardus), and among these most were sheep or goats killed near ShNP during summer. Crops were most frequently damaged by Asian elephants (Elephas maximus), followed by wild boar. Greatest economic losses were from damage to rice, followed by sugarcane and wheat. Asian elephant was the only reported species to cause structural damage to property (e.g., homes). Majority of respondents (83%) considered that the mitigation techniques that are currently in practice are effective to reduce the conflicts. However, the effectiveness of the mitigation techniques are the species specific, we recommend use of more efficacious deterrents (e.g., electric fencing) for large herbivores and mesh wire fencing with partially buried in the ground. Effective collaboration among different tiers of government, non-governmental organizations, civil societies and affected communities are important to share the best practices and continue to apply innovative methods for impactful mitigation of human-wildlife conflicts in the region.

Montero-De La Torre, S., S. L. Jacobson, M. Chodorow, M. Yindee and J. M. Plotnik (2023). "Day and night camera trap videos are effective for identifying individual wild Asian elephants." PeerJ **11**: e15130.

Regular monitoring of wild animal populations through the collection of behavioral and demographic data is critical for the conservation of endangered species. Identifying individual Asian elephants (Elephas maximus), for example, can contribute to our understanding of their social dynamics and foraging behavior, as well as to human-elephant conflict mitigation strategies that account for the behavior of specific individuals involved in the conflict. Wild elephants can be distinguished using a variety of different

morphological traits-e.g., variations in ear and tail morphology, body scars and tumors, and tusk presence, shape, and length-with previous studies identifying elephants via direct observation or photographs taken from vehicles. When elephants live in dense forests like in Thailand, remote sensing photography can be a productive approach to capturing anatomical and behavioral information about local elephant populations. While camera trapping has been used previously to identify elephants, here we present a detailed methodology for systematic, experimenter differentiation of individual elephants using data captured from remote sensing video camera traps. In this study, we used day and night video footage collected remotely in the Salakpra Wildlife Sanctuary in Thailand and identified 24 morphological characteristics that can be used to recognize individual elephants. A total of 34 camera traps were installed within the sanctuary as well as crop fields along its periphery, and 107 Asian elephants were identified: 72 adults, 11 sub-adults, 20 juveniles, and four infants. We predicted that camera traps would provide enough information such that classified morphological traits would aid in reliably identifying the adult individuals with a low probability of misidentification. The results indicated that there were low probabilities of misidentification between adult elephants in the population using camera traps, similar to probabilities obtained by other researchers using handheld cameras. This study suggests that the use of day and night video camera trapping can be an important tool for the long-term monitoring of wild Asian elephant behavior, especially in habitats where direct observations may be difficult.

Cabral de Mel, S. J., S. Seneweera, A. Dangolla, D. K. Weerakoon, T. Maraseni and B. L. Allen (2023). "Attitudes towards the Potential Use of Aversive Geofencing Devices to Manage Wild Elephant Movement." Animals (Basel) **13**(16).

Aversive geofencing devices (AGDs) or animal-borne satellite-linked shock collars might become a useful tool to mitigate human-elephant conflict (HEC). AGDs have the potential to condition problem elephants to avoid human-dominated landscapes by associating mild electric shocks with preceding audio warnings given as they approach virtual boundaries. We assessed the opinions of different stakeholders (experts, farmers, and others who have and have not experienced HEC; n = 611) on the potential use of AGDs on Asian elephants. Most respondents expressed positive opinions on the potential effectiveness of AGDs in managing elephant movement (62.2%). About 62.8% respondents also provided positive responses for the acceptability of AGDs if pilot studies with captive elephants have been successful in managing their movements. Some respondents perceived AGDs to be unacceptable because they are unethical or harmful and would be unsuccessful given wild elephants may respond differently to AGDs than captive elephants. Respondents identified acceptability, support and awareness of stakeholders, safety and wellbeing of elephants, logistical difficulties, durability and reliable functionality of AGDs, and uncertainties in elephants' responses to AGDs as potential challenges for implementing AGDs. These issues need attention when developing AGDs to increase support from stakeholders and to effectively reduce HEC incidents in the future.

Wiśniewska, M., I. Puga-Gonzalez, P. Lee, C. Moss, G. Russell, S. Garnier and C. Sueur (2022). "Simulated poaching affects global connectivity and efficiency in social networks of African savanna elephants-An exemplar of how human disturbance impacts group-living species." PLoS Comput Biol **18**(1): e1009792.

Selective harvest, such as poaching, impacts group-living animals directly through mortality of individuals with desirable traits, and indirectly by altering the structure of their social networks. Understanding the relationship between disturbance-induced,

structural network changes and group performance in wild animals remains an outstanding problem. To address this problem, we evaluated the immediate effect of disturbance on group sociality in African savanna elephants-an example, group-living species threatened by poaching. Drawing on static association data from ten free-ranging groups, we constructed one empirically based, population-wide network and 100 virtual networks; performed a series of experiments 'poaching' the oldest, socially central or random individuals; and quantified the immediate change in the theoretical indices of network connectivity and efficiency of social diffusion. Although the social networks never broke down, targeted elimination of the socially central conspecifics, regardless of age, decreased network connectivity and efficiency. These findings hint at the need to further study resilience by modeling network reorganization and interaction-mediated socioecological learning, empirical data permitting. The main contribution of our work is in quantifying connectivity together with global efficiency in multiple social networks that feature the sociodemographic diversity likely found in wild elephant populations. The basic design of our simulation makes it adaptable for hypothesis testing about the consequences of anthropogenic disturbance or lethal management on social interactions in a variety of group-living species with limited, real-world data.

Montero Botey, M., M. Soliño, R. Perea and M. Martínez-Jauregui (2022). "Let Us Give Voice to Local Farmers: Preferences for Farm-Based Strategies to Enhance Human-Elephant Coexistence in Africa." Animals (Basel) **12**(14).

Local communities surrounding wildlife corridors and natural reserves often face challenges related to human-wildlife coexistence. To mitigate the challenges and ensure the long-term conservation of wildlife, it is important to engage local communities in the design of conservation strategies. By conducting 480 face-to-face interviews in 30 villages along and adjacent to the Selous-Niassa Wildlife Corridor (Tanzania), we quantified farmers' preferences for farm-based measures to mitigate African elephant damage using choice experiments. Results show that farmers considered no action the least preferred option, revealing that they are open to trying different measures. The most preferred management strategy matched with the preferences of wildlife rangers in the area, suggesting low concern about the potential conflicts between stakeholders. However, a latent class model suggests that there are significant differences among responses triggered by farmers' previous experience with elephants, the intensity of the elephant damage, and the socioeconomic situation of the farmer. Results show a marked spatial distribution among respondents, highlighting the benefits of zone management as conflicts were found to be highly context dependent. Understanding the human dimension of conservation is essential for the successful planification and implementation of conservation strategies. Therefore, the development and broad utilization of methodologies to gather specific context information should be encouraged.

Mohd-Radzi, N. H. S., K. V. Karuppannan, N. A. F. Abdullah-Fauzi, A. R. Mohd-Ridwan, N. Othman, A. L. Muhammad Abu Bakar, M. Gani, M. F. A. Abdul-Razak and B. M. Md-Zain (2022). "Determining the diet of wild Asian elephants (Elephasmaximus) at human-elephant conflict areas in Peninsular Malaysia using DNA metabarcoding." Biodivers Data J **10**: e89752.

Human-elephant conflict (HEC) contributes to the increasing death of Asian elephants due to road accidents, retaliatory killings and fatal infections from being trapped in snares. Understanding the diet of elephants throughout Peninsular Malaysia remains crucial to improve their habitat quality and reduce scenarios of HEC. DNA metabarcoding allows investigating the diet of animals without direct observation, especially in risky conflict

areas. The aim of this study was to determine: i) the diet of wild Asian elephants from HEC areas in Peninsular Malaysia using DNA metabarcoding and ii) the influence of distinct environmental parameters at HEC locations on their feeding patterns. DNA was extracted from 39 faecal samples and pooled into 12 groups representing the different sample locations: Kuala Koh, Kenyir, Ulu Muda, Sira Batu, Kupang-Grik, Bumbun Tahan, Belum-Temengor, Grik, Kampung Pagi, Kampung Kuala Balah, Aring 10 and the National Elephant Conservation Centre, which served as a positive control for this study. DNA amplification and sequencing targeted the ribulose-bisphosphate carboxylase gene using the next-generation sequencing Illumina iSeq100 platform. Overall, we identified 35 orders, 88 families, 196 genera and 237 species of plants in the diet of the Asian elephants at HEC hotspots. Ficus (Moraceae), Curcuma (Zingiberaceae), Phoenix (Arecaceae), Maackia (Fabaceae), Garcinia (Clusiaceae) and Dichapetalum (Dichapetalaceae) were the highly abundant dietary plants. The plants successfully identified in this study could be used by the Department of Wildlife and National Parks (PERHILITAN) to create buffer zones by planting the recommended dietary plants around HEC locations and trails of elephants within Central Forest Spine (CFS) landscape.

Makumbe, P., S. Mapurazi, S. Jaravani and I. Matsilele (2022). "Human-Wildlife Conflict in Save Valley Conservancy: Residents' Attitude Toward Wildlife Conservation." Scientifica (Cairo) **2022**: 2107711.

Human settlement in protected areas (PAs) is a major conservation concern in developing nations as it fuels human-wildlife conflicts (HWCs). The objectives of this study were to (i) determine the key wildlife species causing conflict, (ii) assess the perceptions of residents toward the major causes of conflict with wildlife, and (iii) evaluate the attitudes of residents toward problem animals. We conducted face-to-face semistructured interviews and two reconnaissance field surveys with 290 respondents residing in Save Valley Conservancy (SVC), in Southeast Lowveld Zimbabwe from January 2014 to June 2014. Results showed that lions (Panthera leo), spotted hyenas (Crocuta crocuta), elephants (Loxodonta africana), and Nile crocodiles (Crocodylus niloticus) were the major animals involved in the conflict. Our results also showed that the land-use change from wildlife ranching to farming and contested land ownership were perceived as the major causes of HWCs. Respondents who had lived in the area longer were more likely to agree that change in land use (Ordinal logistic regression: B = 1.32, Odds Ratio (OR) = 3.74) and contested land ownership (B = .67, OR = 1.95) were major sources of conflict. In addition, increased encounters between people and wildlife triggered mixed attitudes toward problem animals. For example, males were less likely to have a negative attitude toward problem animals compared to females (Multinomial logistic regression: B = -1.39; OR = .25). Residents who had stayed for less than five years were more likely to have a negative attitude toward problem animals than those who had stayed longer (B = 3.6; OR = 36.71). These results suggest that there is a need to relook at the resettlement pattern because coordinating HWCs and implementing sustainable conservation objectives are easy in a well-planned settlement. Stakeholders need to come together and create awareness of the use of HWCs mitigations measures.

Hahn, N. R., J. Wall, K. Denninger-Snyder, M. Goss, W. Sairowua, N. Mbise, A. B. Estes, S. Ndambuki, E. E. Mjingo, I. Douglas-Hamiliton and G. Wittemyer (2022). "Risk perception and tolerance shape variation in agricultural use for a transboundary elephant population." J Anim Ecol **91**(1): 112-123.

To conserve wide-ranging species in human-modified landscapes, it is essential to

understand how animals selectively use or avoid cultivated areas. Use of agriculture leads to human-wildlife conflict, but evidence suggests that individuals may differ in their tendency to be involved in conflict. This is particularly relevant to wild elephant populations. We analysed GPS data of 66 free-ranging elephants in the Serengeti-Mara ecosystem to quantify their use of agriculture. We then examined factors influencing the level of agricultural use, individual change in use across years and differences in activity budgets associated with use. Using clustering methods, our data grouped into four agricultural use tactics: rare (<0.6% time in agriculture; 26% of population), sporadic (0.6%-3.8%; 34%), seasonal (3.9%-12.8%; 31%) and habitual (>12.8%; 9%). Sporadic and seasonal individuals represented two-thirds (67%) of recorded GPS fixes in agriculture, compared to 32% from habitual individuals. Increased agricultural use was associated with higher daily distance travelled and larger home range size, but not with age or sex. Individual tactic change was prevalent and the habitual tactic was maintained in consecutive years by only five elephants. Across tactics, individuals switched from diurnal to nocturnal activity during agricultural use, interpreted as representing similar risk perception of cultivated areas. Conversely, tactic choice appeared to be associated with differences in risk tolerance between individuals. Together, our results suggest that elephants are balancing the costs and benefits of crop usage at both fine (e.g. crop raid events) and long (e.g. yearly tactic change) temporal scales. The high proportion of sporadic and seasonal tactics also highlights the importance of mitigation strategies that address conflict arising from many animals, rather than targeted management of habitual crop raiders. Our approach can be applied to other species and systems to characterize individual variation in human resource use and inform mitigations for human-wildlife coexistence.

Dai, Y. (2022). "The overlap of suitable tea plant habitat with Asian elephant (Elephus maximus) distribution in southwestern China and its potential impact on species conservation and local economy." Environ Sci Pollut Res Int **29**(4): 5960-5970.

The expansion of land being used for cash crop cultivation has threatened wildlife in recent decades. Tea has become the dominant cash crop in southwestern China. Unfortunately, tea plantations may threaten Asian elephant (Elephus maximus) populations via habitat loss and fragmentation. Identifying areas of suitable habitat for tea plant cultivation, and where this habitat overlaps with Asian elephant distribution, is vital for planning land use, managing nature reserves, shaping policy, and maintaining local economies. Here, we assess the potential impact of tea plantations on Asian elephants in southwestern Yunnan province, China. We used MaxEnt modeling with bioclimatic and environmental variables to identify suitable habitat for tea plant cultivation under the current climate scenario, and then overlapped this habitat with 9 known Asian elephant distribution areas (G1-G9) to determine "threatened areas." Our results showed that (1) annual precipitation (48.1% contribution), temperature constancy (29 % contribution), and slope (8.7 % contribution) were key in determining suitable habitat for tea plants; (2) the cumulative area of suitable habitat for tea plants was 13,784.88 km(2), mainly distributed in Menghai (3934.53 km(2)), Lancang (3198.67 km(2)), and Jinghong (2657.74 km(2)); (3) the distribution area of elephants was 943.75 km(2), and these areas overlapped with suitable tea plant habitat primarily located in G4 (379.40 km(2)), G3 (251.18), and G7 (168.03 km(2)); and (4) threatened areas in G1 and G7 were predominately located along the periphery of current nature reserves. Win-win solutions that work for elephant conservation and economic development include rescoping nature reserve boundaries, strengthening management on the periphery of nature reserves,

establishing ecological corridors and new nature reserves within regions where elephants are currently distributed, planting alternative cash crops, and financial subsidies to farmers. This study improves understanding of human-elephant coexistence, and will assist in guiding land use policy for the future conservation outcomes seeking to promote responsible and profitable cash crop farming and elephant conservation.

Syahmi, W. M., M. M. Mafauzy, K. A. Baharuddin, S. M. Ikhwan, K. A. Sayuti and S. Mohd Shukruddeen (2021). "Elephant attack - A rare case of survival." Med J Malaysia **76**(5): 741-743.

Conflict of human-wild elephant is not uncommon in Malaysia. Most of the human victims usually succumb to death due to internal organ injuries. Here we report a case of a woman who was the victim of an elephant attack and successfully survived to share our experience in managing this type of polytrauma.

Singh, P. K., S. M. Ali, M. Sethi and D. B. Manohar (2021). "Injuries in survivors of elephant attack - Report of three cases." Chin J Traumatol.

Human-elephant conflict (HEC) in India is becoming a growing health problem causing many fatalities every year. Elephants produce injuries by trampling, stomping, squeezing, tossing in the air, or crushing/targeting the head and chest commonly. The adult elephants are most aggressive in their mating season, leading to maximum incidences of HECs in this period. These attacks are mostly unprovoked, though most HECs are provoked. In this case series, the authors described the injuries sustained by three survivors in a short span of one month due to the sudden and unprovoked elephant attack. All the injuries were mild to moderate in severity and involved the chest in common. Timely rescue and prompt initiation of treatment were pivotal in their survival. The authors also want to create awareness about the mating season of elephants to minimize these unfortunate events in the future.

Vogel, S. M., B. Lambert, A. C. Songhurst, G. P. McCulloch, A. L. Stronza and T. Coulson (2020). "Exploring movement decisions: Can Bayesian movement-state models explain crop consumption behaviour in elephants (Loxodonta africana)?" J Anim Ecol **89**(4): 1055-1068.

Animal movements towards goals or targets are based upon either maximization of resource acquisition or risk avoidance, and the way animals move can reveal information about their motivation. We use hidden Markov models (HMMs) fitted in a Bayesian framework and hourly Global Positioning System fixes to distinguish animal movements into distinct states and analyse the influence of environmental variables on being in, and switching to, a particular state. Specifically, we apply our models to understand elephant movement decisions around agricultural fields, and crop consumption. As it is unclear what the role of habitat features are on this complex process, we analyse whether elephants target agricultural crops for consumption, or simply pass through them in search of water. Our HMMs separate elephant movements into two states: exploratory movements that are fast and directional, and encamped movements that are slow and meandering. For each elephant, we ran 16 models with each possible combination of selected habitat features (river, elephant corridor, agricultural field, trees), and repeated these analyses including interaction effects with both season and time of day. We used cross-validation to select the best model. In corridors, exploratory movements are dominant. Elephants mainly showed encamped movements at the river during the dry season, when temporary water sources have dried out and elephants relied on this permanent water source. In fields, males most often exhibited exploratory movements to

and from the river, while females showed an increase in the frequency of encamped behaviour during the dry season and at night-the times when most crop consumption and movements through fields occur. Adaptation to risk could explain this behaviour, since foraging in fields is likely less risky under the cover of darkness and during the dry season when farmers are absent. This sex segregation in elephant movement decisions highlights the importance of predation risk in shaping movement patterns, which can result in sex segregation in responses to mitigation methods. The increase in encamped movements in the dry season suggests the importance of agricultural timing, and shows the potential for early ploughing and early-harvest crop types in order to reduce elephant crop consumption. Taking this into account could increase efficiency of elephant crop consumption mitigation.

Nyumba, T. O., O. E. Emenye and N. Leader-Williams (2020). "Assessing impacts of human-elephant conflict on human wellbeing: An empirical analysis of communities living with elephants around Maasai Mara National Reserve in Kenya." PLoS ONE **15**(9): e0239545.

Human-elephant conflict is an often intractable problem that threatens the contribution of conservation interventions to human wellbeing and securing livelihoods in Africa and Asia. Local human populations living in key elephant ranges are among the world's most poor and vulnerable people. In efforts to address this problem, previous studies have mainly focused on the direct impacts of conflict and applied standard regression models based on the assumption of individual-level homogeneity. More recently, human-elephant conflict has been seen to extend well beyond the physical, to the psychological and social sides of wellbeing. However, the impacts on human wellbeing have not been robustly explored, especially for local communities co-existing with elephants. We evaluated the impacts of conflicts on the wellbeing of local communities around the world-famous Masai Mara National Reserve in Kenya. We conducted 18 focus group discussions with 120 community members in different locations and administered a questionnaire survey to 367 sampled households from 26 sub-locations in Trans Mara. We used descriptive statistics with appropriate statistical tests, including propensity score matching, to evaluate the impacts of conflict on human wellbeing. Before matching, the results of the descriptive statistics showed differences between households experiencing conflicts and those without in terms of gender, age, education level, household size, benefiting from elephant conservation, main occupation and number of income sources. Our matching results indicate the existence of a significant negative and positive impacts on four and one of our eight wellbeing indicators for households that experienced conflicts, respectively. Better conflict mitigation approaches and conservation policies need to be adopted to realize the harmonious and concurrent development of ecological and wellbeing objectives.

Naha, D., S. K. Dash, A. Chettri, A. Roy and S. Sathyakumar (2020). "Elephants in the neighborhood: patterns of crop-raiding by Asian elephants within a fragmented landscape of Eastern India." PeerJ **8**: e9399.

Loss of forest cover, rise in human populations and fragmentation of habitats leads to decline in biodiversity and extinction of large mammals globally. Elephants, being the largest of terrestrial mammals, symbolize global conservation programs and co-occur with humans within multiple-use landscapes of Asia and Africa. Within such shared landscapes, poaching, habitat loss and extent of human-elephant conflicts (HEC) affect survival and conservation of elephants. HEC are severe in South Asia with increasing attacks on humans, crop depredation and property damage. Such incidents reduce societal tolerance towards elephants and increase the risk of retaliation by local communities. We analyzed a

2-year dataset on crop depredation by Asian elephants (N = 380) events in North Bengal (eastern India). We also explored the effect of landscape, anthropogenic factors (area of forest, agriculture, distance to protected area, area of human settlements, riverine patches and human density) on the spatial occurrence of such incidents.Crop depredation showed a distinct nocturnal pattern (22.00-06:00) and majority of the incidents were recorded in the monsoon and post-monsoon seasons. Results of our spatial analysis suggest that crop depredation increased with an increase in the area of forest patches, agriculture, presence of riverine patches and human density. Probability of crop depredation further increased with decreasing distance from protected areas. Villages within 1.5 km of a forest patch were most affected. Crop raiding incidents suggest a deviation from the "high-risk high-gain male biased" foraging behavior and involved proportionately more mixed groups (57%) than lone bulls (43%). Demographic data suggest that mixed groups comprised an average of 23 individuals with adult and sub adult females, bulls and calves. Crop depredation and fatal elephant attacks on humans were spatially clustered with eastern, central and western parts of North Bengal identified as hotspots of HEC. Our results will help to prioritize mitigation measures such as prohibition of alcohol production within villages, improving condition of riverine patches, changing crop composition, fencing agriculture fields, implement early warning systems around protected areas and training local people on how to prevent conflicts.

Musiwa, A. R. and W. Mhlanga (2020). "Human-wildlife conflict in Mhokwe Ward, Mbire District, North-East Zimbabwe." African Journal of Ecology.

This research investigates the economic and social aspects of human-wildlife conflict (HWC) in Mhokwe, Mbire district, Zimbabwe. Data were collected through key informant interviews and a questionnaire survey. Most households in Mhokwe rely on crop and livestock production, and hence, HWC is an important factor affecting livelihoods. More than 60% of respondents experienced problems with lions (Panthera leoLinnaeus), spotted hyaenas (Crocuta crocutaErxleben), armoured bush crickets (Acanthoplus speiseriBrancsik) and quelea birds (Quelea queleaReichenbach). Other problem animals included elephant (Loxodonta africanaBlumenbach), vervet monkey (Chlorocebus pygerythrusCuvier), kudu (Tragelaphus strepsicerosPallas), chacma baboon (Papio ursinusKerr), bushpig (Potamochoerus porcusLinnaeus) and common duiker (Sylvicapra grimmiaLinnaeus). Few incidences of conflicts were reported for hippopotamus (Hippopotamus amphibiusLinnaeus), side-striped jackal (Canis adustusSundevall), porcupine (Hystrix africaeaustralisPeters), nile crocodile (Crocodylus niloticusLaurenti), African wild cat (Felis lybicaForster), African python (Python sebaeGmelin) and guinea fowl (Numida meleagrisLinnaeus). Livestock and crop losses were US$45,285 and US$57,541 in 2013 and 2014, respectively. Despite the losses, most respondents had positive attitudes towards wildlife. Construction of strong kraals and implementation of integrated pest management (IPM) can contribute to conflict reduction.

Killion, A. K., J. M. Ramirez and N. H. Carter (2020). "Human adaptation strategies are key to cobenefits in human-wildlife systems." Conservation Letters.

Sustainable development goals such as global food security and biodiversity conservation can conflict because these efforts create situations where humans and wildlife share landscapes, often leading to interactions that detrimentally affect both groups. Therefore, coexistence between humans and wildlife is more likely when adaptation strategies produce and sustain cobenefits, rather than benefitting one group only. However, we lack a good understanding of how different social and ecological factors contribute to cobenefit

outcomes, which limits our opportunities to address local issues and scale up successful conservation actions. Here, we performed the first global review of the human-wildlife interaction literature to assess which human adaptation strategies generated cobenefits and how stakeholder involvement and other context-specific conditions mediated those outcomes. We found that active guarding, fencing, repellents, and socioeconomic mechanisms consistently led to cobenefits across species and contexts. Thus, these interventions might be the best candidates for scaling up coexistence from local to regional or national scales. Surprisingly, stakeholder involvement was less consequential than other variables, yet, overall, it played an important role in sustaining cobenefits regardless of adaptation strategy or social-ecological context. We highlight future research directions to help manage tradeoffs and achieve sustainable coexistence outcomes in shared landscapes.

Horgan, F. G. and E. P. Kudavidanage (2020). "Farming on the edge: Farmer training to mitigate human-wildlife conflict at an agricultural frontier in south Sri Lanka." Crop Protection **127**.

Efforts to increase food production across Asia have relied on the intensification of established farms, as well as the expansion of farming activities into previously wild areas. Farms at agricultural frontiers face distinct challenges from those in historically farmed regions and require distinct support structures. We interviewed 324 rice farmers at seven sites in southern Sri Lanka to determine challenges to rice production in the region and the propensity for human wildlife conflict. Farmers (80%) reported wildlife including peafowl (Pavo cristatus) and other birds, as well as free-ranging (semi-)domestic animals such as buffalo (Bubalus bubalis), as their principal biotic constraints across sites, with relatively few farmers regarding weeds, insect pests, or diseases as a constraint (mentioned by 25% of farmers in total). Farmers near wilderness areas reported elephants (Elephas maximus) and wild boar (Sus scrofa) as major constraints to rice production. 64% of farmers had received training from government and other support agencies during the five years prior to our survey. Training mainly addressed insect pests and diseases and focused on lethal product-based solutions (88% of training). Farmers did not receive support or advice to mitigate crop foraging and human-wildlife conflict; instead, farmers relied heavily on repellence (human activated) responses, such as early warning systems and active scaring. We suggest that Agriculture, Development and Wildlife authorities might increase intergovernmental cooperation and coordination of farmer training to better manage crop foraging in our study region. We present a review of possible non-lethal, farm-based methods that could be promoted during training programs for farmers facing challenges from wildlife in such a biologically diverse region. Currently, a wide range of low-cost avoidance, barrier and deterrence systems (that are not monitored or activated by humans) are available. These can be used to avoid harmful repellence practices. © 2019 Elsevier Ltd

He, C., J. Du, D. Zhu and L. Zhang (2020). "Population viability analysis of small population: a case study for Asian elephant in China." Integr Zool.

Small populations are at risk of extinction from deterministic and stochastic factors. Less than 250 Asian elephants (Elephas maximus) remain in China, and are distributed in a few isolated areas; yet, population viability analyses of this endangered population have not been conducted. Here, the current genetic status of the Pu'Er-Mengyang Asian elephant populations in China was analyzed, and the risk of extinction was predicted over the next 500 years. Factors affecting the viability of this population were determined through simulations. The genetic diversity of the population was very low (mean allele number:

3.1; expected heterozygosity: 0.463), even though a recent population bottleneck was not detected. The effective population size was approximately 24.1 adult elephants. Enough adult breeding individuals exist to maintain population viability. VORTEX simulation model showed that this population would not go extinct in the next 500 years. However, illegal poaching and harvesting could negatively affect population size. A sensitivity analysis showed that the mean stochastic growth rate of the study population is sensitive to sex ratio, number of breeding females, mortality of females of different age classes, carrying capacity, and lethal equivalents. Based on our results, we suggest that action should be taken to alleviate inbreeding and any further loss of genetic diversity, by connecting fragmented elephant habitat or by translocating individual elephants. In addition, human-elephant conflict should be mitigated using various modern approaches, including crop guarding techniques, and by encouraging farmers to switch to crops and income sources not vulnerable to elephant raids.

Hariohay, K. M., W. A. Munuo and E. Roskaft (2020). "Human-elephant interactions in areas surrounding the Rungwa, Kizigo, and Muhesi Game Reserves, central Tanzania." Oryx **54**(5): 612-620.

This study assesses the patterns of crop damage by elephantsLoxodonta africanain areas adjacent to the Rungwa, Kizigo and Muhesi Game Reserves in Tanzania. We used a questionnaire survey to collect data from a total of 210 household heads from seven villages, with 30 household heads in each village, during June-August 2015. Proximity was a significant factor influencing losses, with crop farms within < 1 km from the reserves having higher losses, followed by those 1-5 km and > 5 km distant. Most households (81.0%) < 1 km from a reserve reported crop damage whereas those within 1-5 km (65.9%) and > 5 km (20.0%) reported less damage. Most of the losses (79.8%) occurred in the first half of the year (the wet season). Immigrants reported higher average losses to crops than Indigenous respondents. Noise making, flashlights, setting fire around fields and disturbance by shooting were the methods used to deter elephants from entering crop fields. We recommend that communities around these game reserves avoid areas that are < 1 km from the reserve boundary, plant crops such as chilli, use honeybeeApis melliferafences to deter elephants from their crops, and receive education on available mitigation methods, to help minimize crop losses to elephants.

Dror, S., F. Harich, O. Duangphakdee, T. Savini, A. Pogany, J. Roberts, J. Geheran and A. C. Treydte (2020). "Are Asian elephants afraid of honeybees? Experimental studies in northern Thailand." Mammalian Biology **100**(4): 356-363.

In many parts of South and Southeast Asia, rural farmers living at the borders of protected areas frequently encounter Asian elephants (Elephas maximus) raiding their crops and threatening farmers lives and livelihoods. Traditional deterrent methods often have limited success as elephants become habituated or alternate their movement and behavior. While African bees (Apis mellifera scutellate) have been shown to effectively and sustainably deter African elephants (Loxodonta africana) little is known about their Asian counterparts. We conducted two experiments to estimate the effectiveness of bees as an Asian elephant deterrent method. We analyzed the behavioral reaction of seven captive Asian elephants when confronted with a fence ofA. melliferahives blocking their way to a desired source of food. In addition, we explored the defensive reaction of fiveA. ceranahives and sixA. melliferahives to an artificial disturbance during both day and night time. The elephants crossed the beehive fence in 51% of the cases, the probability of crossing increased over time and the number of exposures had a significant effect on an

elephant's crossing probability, indicating that elephants became habituated to the presence of the beehive fence. In the bee experiment, only one out of fiveA. ceranahives and one out of sixA. melliferahives reacted to the disturbance during the daytime, while during nighttime, none of them reacted defensively after being disturbed. We, therefore, conclude that neitherA. melliferanorA. ceranabees are likely to be effective in deterring wild Asian elephants from entering crop fields.

Compaore, A., D. Sirima, E. M. Hema, B. Doamba, S. N. Ajong, M. Di Vittorio and L. Luiselli (2020). "Correlation between increased human-elephant conflict and poaching of elephants in Burkina Faso (West Africa)." European Journal of Wildlife Research **66**(1).

Human-elephant conflict (HEC) represents a serious threat to both survival of wild elephants and human economic activities at the local level in many African regions, but has been relatively little investigated in West Africa. Here, the ecological correlates of HEC and correlation between HEC and elephant poaching, are investigated in the PONASI complex of protected areas in Burkina Faso (West Africa). Out of 144 villages surveyed, HEC was observed in 78 villages. Within this sample, we interviewed 188 local farmers who were victims of elephant damages during the period 2011–2015. Elephant raids were positively correlated with some crop types in farms (sorghum, maize, millet, and rice) and negatively with beans, and increased most significantly with increases in seeds, seedlings, plant growing and, especially, crops at maturation in the farms. Five cases of human deaths as consequence of elephant raids were also recorded. We observed a significant increase of the number of raids during the period 2011–2015, as well as of the number of elephants killed by year by poachers. Poaching was concentrated especially in the dry season (December to February), just after the end of the harvest period. There was also a clear correspondence between provinces that were more affected by elephant raids and where elephant poaching was most intense. Thus, although local poachers also likely contributed to the illegal ivory market, it was apparent that avoiding elephant raids was among the main reasons for pushing them to hunt illegally for elephants. Insufficient participation of communities hampers the PONASI protected area complex sutainable management. In order to gain the people's support for the ideals of wildlife conservation, it is essential that they would feel that their concerns are taken into account, thus by adopting policies that minimize HEC effects on local economies.

Azeem, S., R. Bengis, R. Van Aarde and A. D. S. Bastos (2020). "Mass Die-Off of African Elephants in Botswana: Pathogen, Poison or a Perfect Storm?" African Journal of Wildlife Research **50**(1): 149-156.

Reports of a mass die-off of ~350 elephants (Loxodonta africana) in northern Botswana over a period of two months (May-June 2020), has fuelled speculation and concern regarding the cause. Although the area in which these mortalities occurred is not protected and is considered a hotspot for human-elephant conflict and poaching, both malicious poisoning and poaching are unlikely to have played a role as other species were not affected, and elephant carcasses were found with tusks intact. In the absence of a confirmed cause we sought to identify the lines of enquiry that are most likely to lead to a definitive answer. In particular, we consider viral and bacterial agents that could precipitate species-specific mortalities on this scale, potential environmental sources of poisoning and the samples and tests that would assist in excluding/confirming these candidate causes. Whilst it may be argued that these mortalities are unlikely to negatively impact the broader elephant population of ~130 000 individuals in Botswana, the same

cannot be said of the many vulnerable population pockets in other parts of Africa. For this reason, it is essential that the cause of the current die-off is identified as it is the only way to prevent similar losses of susceptible elephants elsewhere.

Alemayehu, N. and W. Tekalign (2020). "Prevalence of crop damage and crop-raiding animals in southern Ethiopia: the resolution of the conflict with the farmers." Geojournal.

The conflict between humans and wildlife often arises from crop raiding and has a significant impact on both subsistence humans' livelihoods and long-term wildlife survival in developing countries. The study aimed to identify crop-raiding wild animals, the prevalence of crop damage, and the conflict resolution mechanism. Data were collected by questionnaire, interview, and direct field observation to estimate the extent of the crop loss and species of an animal involved in crop-raiding. The findings identified Anubis Baboon (Papio anubis), Vervet Monkey (Chlorocebus pygerythrus), and Grivet Monkey (Chlorocebus aethiops) as the major crop pests, followed by Porcupines (Hystrix cristata), Birds and Mongoose (Helogale hirtula). Foraging typically Maize (Zea may) followed by Teff (Eragrostis tef), Enset (Ensete ventricosum), and Barley (Hordeum vulgare). Deforestation, illegal agricultural activities, and farmland distance to the forest were identified as causes of the conflict. In addition, scarecrow, chasing, and permanent guardians have been identified as traditional crop damage prevention techniques of the local people of the area. Therefore, to alleviate the existing impact of crop damage or loss by crop-pest or crop-raiding animals in the area adopting various most suitable approaches along with the awareness and involvement of local farmers would be a critical step.

Ngama, S., J. Bindelle, J. R. Poulsen, J. L. Hornick, A. Linden, L. Korte, J. L. Doucet and C. Vermeulen (2019). "Do topography and fruit presence influence occurrence and intensity of crop-raiding by forest elephants (Loxodonta africana cyclotis)?" PLoS ONE **14**(3): e0213971.

Crop damage by forest elephants (Loxodonta africana cyclotis) and the resulting human-elephant conflict are issues of great concern for both the conservation of the species and the protection of rural livelihoods in Central Africa. Addressing these problems requires identifying the factors that facilitate or impede crop-raiding by forest elephants. Yet to date, the environmental or anthropogenic factors that influence the occurrence and intensity of crop-raiding by forest elephants are largely unknown. We used a multivariate approach to investigate conditions under which forest elephants raid some fields and not others in the buffer zone of Monts de Cristal National Park (MCNP), Gabon. We first interviewed 121 farmers from 11 villages situated within 10 km of MCNP regarding the occurrence of elephant crop-raiding of their fields. We then collected data on 39 explanatory variables to characterize the agricultural fields. Of these, the most important predictors of elephant raid occurrence of crop damage were presence of fruit trees, elephant deterrents (scarecrows, fire, wire string fences and empty barrels), and field topography. We secondly assessed the effect of stage of crop growth, presence of fruit trees, field topography and presence of elephant deterrents on crop-raiding occurrence and intensity by counting raids and measuring areas of crop damage every week in 17 plantations over 19 weeks in the most elephant-impacted zone of the study area. We found that fruit presence and stage of crop growth led to more intense damage to crops, whereas local deterrents did not inhibit raiding events and crop damage by elephants. We report a tradeoff between non-timber forest products (NTFP) services and crop-raiding by elephants. We show for the first time that steep topography impedes elephant damage to

crops with no raids recorded in fields with surrounding slopes greater than 25%. We discuss whether farming on steep fields could be used as a strategy for mitigating crop-raiding to favor human-elephant coexistence and enhance elephant conservation.

Ihwagi, F. W., A. K. Skidmore, T. Wang, G. Bastille-Rousseau, A. G. Toxopeus and I. Douglas-Hamilton (2019). "Poaching lowers elephant path tortuosity: implications for conservation." Journal of Wildlife Management **83**(5): 1022-1031.

Poaching is the most immediate threat to African elephants (Loxodonta africana). Several continental-wide surges in poaching have occurred since the latter half of the twentieth century, and the latest surge occurred from 2007 to 2012. The behavioral responses of elephants to poaching risk has not been studied widely because of a lack of high-resolution movement data collected simultaneously with verified causes of mortality. We managed to collate 2 such datasets from 2004 to 2013. We studied the spatial-temporal changes in movement behavior of 11 elephants in their core areas. Past studies have focused on elephant movement along corridors. We tested for the effect of poaching risk on their path straightness (i.e., tortuosity) while controlling for other environmental and human activities in the landscape using a set of generalized linear mixed models. To test for temporal variation of tortuosity, we used a time-series linear model. Elephants turned less frequently while they were in poaching locations and at times with a high level of poaching activity, even though their speed did not change. The variation of tortuosity is a good indicator of differences in poaching risk as perceived by the elephants, which could complement patrol-based anti-poaching efforts by wildlife managers, especially in remote, inaccessible landscapes. (c) 2019 The Authors. The Journal of Wildlife Management published by Wiley Periodicals, Inc. on behalf of The Wildlife Society

van de Water, A. and K. Matteson (2018). "Human-elephant conflict in western Thailand: Socio-economic drivers and potential mitigation strategies." PLoS ONE **13**(6): e0194736.

Understanding human-wildlife conflict is an important first step in the conservation of highly endangered species that can have adverse effects on human communities, such as elephants. To gain insights into variables that shape attitudes toward elephant conservation in Asia, we surveyed 410 households and 46 plantation owners in seven villages around the Salakpra Wildlife Sanctuary in western Thailand, an area of high human-elephant conflict. We sought to evaluate how past experiences with elephants (positive or negative), as well as socio-economic variables (age, income level, gender, and employment type) affect attitudes toward elephant conservation and coexistence in this area. In addition, we quantified deterrence methods currently used and identify potential mitigation strategies supported by community members. In general, less supportive attitudes toward elephant conservation and coexistence were held by individuals older than 35 years of age, those who had previously had experienced negative interactions with elephants, those with lower incomes, and those working in the agricultural sector. Conversely, those who had received benefits from living near elephants (e.g., supplemental income or feelings of pride from hosting volunteers or participating in conservation work) had more supportive views of elephant coexistence. Plantation owners reported using a variety of deterrence methods with varying success, with firecrackers being the most commonly utilized method. Community members identified several potentially beneficial mitigation strategies including forest restorations and patrol teams, adding water sources to wild elephant habitat, and education of local school and community groups. Overall, our results highlight the value of community members receiving benefits from living near elephants and suggest that special incentives may be

needed for demographic groups disproportionately affected by elephants (e.g. those at lower income levels, those working in agriculture). A combination of these and other approaches will be required if human-elephant coexistence in western Thailand is to be realized.

Osipova, L., M. M. Okello, S. J. Njumbi, S. Ngene, D. Western, M. W. Hayward and N. Balkenhol (2018). "Fencing solves human-wildlife conflict locally but shifts problems elsewhere: A case study using functional connectivity modelling of the African elephant." Journal of Applied Ecology **55**(6): 2673-2684.

Fencing is one of the most common methods of mitigating human-wildlife conflicts. At the same time, fencing is considered one of the most pressing threats emerging in conservation globally. Although fences act as barriers and can cause population isolation and fragmentation over time, it is difficult to quantitatively predict the consequences fences have for wildlife. Here, we model how fencing designed to mitigate human-elephant conflict (HEC) on the Borderlands between Kenya and Tanzania will affect functional connectivity and movement corridors for African elephants. Specifically, we (a) model functional landscape connectivity integrating natural and anthropogenic factors; (b) predict seasonal movement corridors used by elephants in non-protected areas; and (c) evaluate whether fencing in one area can potentially intensify human-wildlife conflicts elsewhere. We used GPS movement and remote sensing data to develop monthly step-selection functions to model functional connectivity. For future scenarios, we used an ongoing fencing project designed for HEC mitigation within the study area. We modelled movement corridors using least-cost path and circuit theory methods, evaluated their predictive power and quantified connectivity changes resulting from the planned fencing. Our results suggest that fencing will not cause landscape fragmentation and will not change functional landscape connectivity dramatically. However, fencing will lead to a loss of connectivity locally and will increase the potential for HEC in new areas. We estimate that wetlands, important for movement corridors, will be more intensively used by the elephants, which may also cause problems of overgrazing. Seasonal analysis highlights an increasing usage of non-protected lands in the dry season and equal importance of the pinch point wetlands for preserving overall function connectivity. Synthesis and applications. Fencing is a solution to small-scale human-elephant conflict problems but will not solve the issue at a broader scale. Moreover, our results highlight that it may intensify the conflicts and overuse of habitat patches in other areas, thereby negating conservation benefits. If fencing is employed on a broader scale, then it is imperative that corridors are integrated within protected area networks to ensure local connectivity of affected species.

Mumby, H. S. and J. M. Plotnik (2018). "Taking the elephants' perspective: Remembering elephant behavior, cognition and ecology in human-elephant conflict mitigation." Frontiers in Ecology and Evolution **6**(AUG).

Conflict between humans and wildlife is an increasing problem worldwide due to human population growth and habitat fragmentation, with growing interest amongst scientists and conservationists in developing novel solutions toward sustainable coexistence. Current efforts to mitigate human-wildlife conflict, however, are often unbalanced; they consider immediate human-centric concerns and offer deterrents against wildlife, rather than offering solutions to the underlying problems. Recently, there has been an increase in the number of calls to action for the integration of animal behavior, cognition and knowledge of individual variation into conservation practice. However, as elephant researchers, we

have seen that most human-elephant conflict mitigation strategies employed in Asia and Africa are based on conditioning fear in elephants, or general monitoring of individual or group activities aimed at altering elephant movements, rather than understanding and providing for elephant and human needs. We see an opportunity to do more by investigating elephant behavior, cognition and ecology at the level of the individual to prevent conflict from occurring in the first place. Here, we review studies on elephants to illustrate this concept and to outline avenues for the application of research on elephant ecology, life history, behavior and personality to the development of new, comprehensive conservation strategies that take both human and elephant behavior into account. © 2018 Mumby and Plotnik.

King, L. E., F. Lala, H. Nzumu, E. Mwambingu and I. Douglas-Hamilton (2017). "Beehive fences as a multidimensional conflict-mitigation tool for farmers coexisting with elephants." Conserv Biol.

Increasing habitat fragmentation and human population growth in Africa has resulted in an escalation in human-elephant conflict between small-scale farmers and free-ranging African elephants (Loxodonta Africana). In 2012 Kenya Wildlife Service (KWS) implemented the national 10-year Conservation and Management Strategy for the Elephant in Kenya, which includes an action aimed at testing whether beehive fences can be used to mitigate human-elephant conflict. From 2012 to 2015, we field-tested the efficacy of beehive fences to protect 10 0.4-ha farms next to Tsavo East National Park from elephants. We hung a series of beehives every 10 m around the boundary of each farm plot. The hives were linked with strong wire. After an initial pilot test with 2 farms, the remaining 8 of 10 beehive fences also contained 2-dimensional dummy hives between real beehives to help reduce the cost of the fence. Each trial plot had a neighboring control plot of the same size within the same farm. Of the 131 beehives deployed 88% were occupied at least once during the 3.5-year trial. Two hundred and fifty-three elephants, predominantly 20-45 years old entered the community farming area, typically during the crop- ripening season. Eighty percent of the elephants that approached the trial farms were kept out of the areas protected by the beehive fences, and elephants that broke a fence were in smaller than average groups. Beehive fences not only kept large groups of elephants from invading the farmland plots but the farmers also benefited socially and financially from the sale of 228 kg of elephant-friendly honey. As news of the success of the trial spread, a further 12 farmers requested to join the project, bringing the number of beehive fence protected farms to 22 and beehives to 297. This demonstrates positive adoption of beehive fences as a community mitigation tool. Understanding the response of elephants to the beehive fences, the seasonality of crop raiding and fence breaking, and the willingness of the community to engage with the mitigation method will help contribute to future management strategies for this high human-elephant conflict hotspot and other similar areas in Kenya.

Gross, E. M., N. Drouet-Hoguet, N. Subedi and J. Gross (2017). "The potential of medicinal and aromatic plants (MAPs) to reduce crop damages by Asian Elephants (Elephas maximus)." Crop Protection **100**: 29-37.

In all 13 Asian range countries of the wild Asian elephant (Elephas maximus L.), farmers suffer from crop damages caused by this endangered and highly protected species. As elephants are lured by highly nutritional crop types into agricultural lands, measures to deter or repel them from the high attraction will always be costly and labour intensive. The cultivation of crops, which are less attractive to elephants, yet economically viable for

local farmers could lead to a new direction of land-use and income generation in human-elephant conflict areas. In this study, seven medicinal and aromatic plants (MAPs) containing higher amounts of specific plant secondary compounds were explored for their attractiveness to wild Asian elephants against a control of rice (Oryza sativa L.) and maize (Zea mays L.). The results show that chamomile (Matricaria chamomilla L.), coriander (Coriandrum sativum L.), mint (Mentha arvensis L.), basil (Ocimum basilicum L.), turmeric (Curcuma longa L.), lemon grass (Cymbopogon flexuosus (Nees ex Steud.) W. Watson) and citronella (Cymbopogon winterianus Jowitt.) were less attractive and were not consumed by elephants compared to rice. Damages to the MAPs occurred only through trampling, with mint being most prone to being trampled. Other wildlife species, however, were observed to feed on lemon-grass. Long-term learning effects and the eventual palatability of crops with less efficient antifeedants need to be further explored. This study, however, gives first evidence that MAPs bear a high potential for a secure income generation in and close to Asian elephant habitats. Furthermore, the strategic plantation of crops unattractive and attractive to elephants could lead to new land-use strategies and improve functionality of elephant corridors. © 2017 Elsevier Ltd

Breuer, T., F. Maisels and V. Fishlock (2016). "The consequences of poaching and anthropogenic change for forest elephants." Conserv Biol **30**(5): 1019-1026.

Poaching has devastated forest elephant populations (Loxodonta cyclotis), and their habitat is dramatically changing. The long-term effects of poaching and other anthropogenic threats have been well studied in savannah elephants (Loxodonta africana), but the impacts of these changes for Central Africa's forest elephants have not been discussed. We examined potential repercussions of these threats and the related consequences for forest elephants in Central Africa by summarizing the lessons learned from savannah elephants and small forest elephant populations in West Africa. Forest elephant social organization is less known than the social organization of savannah elephants, but the close evolutionary history of these species suggests that they will respond to anthropogenic threats in broadly similar ways. The loss of older, experienced individuals in an elephant population disrupts ecological, social, and population parameters. Severe reduction of elephant abundance within Central Africa's forests can alter plant communities and ecosystem functions. Poaching, habitat alterations, and human population increase are probably compressing forest elephants into protected areas and increasing human-elephant conflict, which negatively affects their conservation. We encourage conservationists to look beyond documenting forest elephant population decline and address the causes of these declines when developing conversation strategies. We suggest assessing the effectiveness of the existing protected-area networks for landscape connectivity in light of current industrial and infrastructure development. Longitudinal assessments of the effects of landscape changes on forest elephant sociality and behavior are also needed. Finally, lessons learned from West African elephant population loss and habitat fragmentation should be used to inform strategies for land-use planning and managing human-elephant interactions.

Zeppelzauer, M. and A. S. Stoeger (2015). "Establishing the fundamentals for an elephant early warning and monitoring system." BMC research notes **8**(1).

Background: The decline of habitat for elephants due to expanding human activity is a serious conservation problem. This has continuously escalated the human-elephant conflict in Africa and Asia. Elephants make extensive use of powerful infrasonic calls (rumbles) that travel distances of up to several kilometers. This makes elephants well-

suited for acoustic monitoring because it enables detecting elephants even if they are out of sight. In sight, their distinct visual appearance makes them a good candidate for visual monitoring. We provide an integrated overview of our interdisciplinary project that established the scientific fundamentals for a future early warning and monitoring system for humans who regularly experience serious conflict with elephants. We first draw the big picture of an early warning and monitoring system, then review the developed solutions for automatic acoustic and visual detection, discuss specific challenges and present open future work necessary to build a robust and reliable early warning and monitoring system that is able to operate in situ. Findings: We present a method for the automated detection of elephant rumbles that is robust to the diverse noise sources present in situ. We evaluated the method on an extensive set of audio data recorded under natural field conditions. Results show that the proposed method outperforms existing approaches and accurately detects elephant rumbles. Our visual detection method shows that tracking elephants in wildlife videos (of different sizes and postures) is feasible and particularly robust at near distances. Discussion: From our project results we draw a number of conclusions that are discussed and summarized. We clearly identified the most critical challenges and necessary improvements of the proposed detection methods and conclude that our findings have the potential to form the basis for a future automated early warning system for elephants. We discuss challenges that need to be solved and summarize open topics in the context of a future early warning and monitoring system. We conclude that a long-term evaluation of the presented methods in situ using real-time prototypes is the most important next step to transfer the developed methods into practical implementation. © 2015 Zeppelzauer and Stoeger.

Zeppelzauer, M., S. Hensman and A. S. Stoeger (2015). "Towards an automated acoustic detection system for free-ranging elephants." Bioacoustics-the International Journal of Animal Sound and Its Recording **24**(1): 13-29.

The human-elephant conflict is one of the most serious conservation problems in Asia and Africa today. The involuntary confrontation of humans and elephants claims the lives of many animals and humans every year. A promising approach to alleviate this conflict is the development of an acoustic early warning system. Such a system requires the robust automated detection of elephant vocalizations under unconstrained field conditions. Today, no system exists that fulfils these requirements. In this paper, we present a method for the automated detection of elephant vocalizations that is robust to the diverse noise sources present in the field. We evaluate the method on a data-set recorded under natural field conditions to simulate a real-world scenario. The proposed method outperformed existing approaches and robustly and accurately detected elephants. It thus can form the basis for a future automated early warning system for elephants. Furthermore, the method may be a useful tool for scientists in bioacoustics for the study of wildlife recordings.

Madhusudan, M. D., N. Sharma, R. Raghunath, N. Baskaran, C. M. Bipin, S. Gubbi, A. J. T. Johnsingh, J. Kulkarni, H. N. Kumara, P. Mehta, R. Pillay and R. Sukumar (2015). "Distribution, relative abundance, and conservation status of Asian elephants in Karnataka, southern India." Biological Conservation **187**: 34-40.

Karnataka state in southern India supports a globally significant-and the country's largest-population of the Asian elephant Elephas maximus. A reliable map of Asian elephant distribution and measures of spatial variation in their abundance, both vital needs for conservation and management action, are unavailable not only in Karnataka, but across

its global range. Here, we use various data gathered between 2000 and 2015 to map the distribution of elephants in Karnataka at the scale of the smallest forest management unit, the 'beat', while also presenting data on elephant dung density for a subset of 'elephant beats.' Elephants occurred in 972 out of 2855 forest beats of Karnataka. Sixty percent of these 972 beats-and 55% of the forest habitat-lay outside notified protected areas (PAs), and included lands designated for agricultural production and human dwelling. While median elephant dung density inside protected areas was nearly thrice as much as outside, elephants routinely occurred in or used habitats outside PAs where human density, land fraction under cultivation, and the interface between human-dominated areas and forests were greater. Based on our data, it is clear that India's framework for elephant conservation-which legally protects the species wherever it occurs, but protects only some of its habitats-while being appropriate in furthering their conservation within PAs, seriously falters in situations where elephants reside in and/or seasonally use areas outside PAs. Attempts to further elephant conservation in production and dwelling areas have extracted high costs in human, elephant, material and monetary terms in Karnataka. In such settings, conservation planning exercises are necessary to determine where the needs of elephants-or humans-must take priority over the other, and to achieve that in a manner that is based not only on reliable scientific data but also on a process of public reasoning. © 2015 Elsevier Ltd.

Dabare, P., C. Suduwella, A. Sayakkara, D. Sandaruwan, C. Keppitiyagama, K. De Zoysa, K. Hewage and T. Voigt (2015). Listening to the giants: Using elephant infra-sound to solve the Human-Elephant conflict.

The continuing human-elephant conict in Sri Lanka has resulted in loss of human as well as elephant lives. Detecting and localizing elephants is an essential component of any viable solution to this problem. Currently, we conduct feasibility tests on using low cost sensors to detect elephants from a long distance, leveraging the infra-sounds emitted by them. In this paper we present the test environment that we have set up for this purpose and some preliminary, but promising results.

Gunn, J., D. Hawkins, R. F. W. Barnes, F. Mofulu, R. A. Grant and G. W. Norton (2014). "The influence of lunar cycles on crop-raiding elephants; evidence for risk avoidance." African Journal of Ecology **52**(2): 129-137.

Long-term solutions to crop raiding by elephants (Loxodonta africana) should be based on an understanding of their behaviour and ecology. The real and perceived risks from humans have been shown to affect elephant behaviour. This is evidenced by elephants predominantly raiding crops at night, avoiding the height of human activity. If such human avoidance behaviours are apparent, it might also be expected that elephants avoid risks associated with higher visibility and increased human activity as may occur during the full moon. However, elephant nocturnal crop-raiding behaviour in relation to lunar cycles has largely been a neglected factor in studies of human-elephant interactions. In this study around Mikumi National Park, Tanzania, we apply circular statistics in this context for the first time to show a significant decrease in crop raiding during the full moon and apply this method retrospectively to data from another site in West Africa with similar results. Additionally, a greater proportion of farms raided was guarded during the full moon than any other moon phase. Our results indicate that variations in crop raiding with lunar phase could be a general feature of elephant behaviour and thus could be used to design and time mitigation efforts. © 2013 John Wiley & Sons Ltd.

Bohrer, G., P. S. Beck, S. M. Ngene, A. K. Skidmore and I. Douglas-Hamilton (2014). "Elephant movement closely tracks precipitation-driven vegetation dynamics in a Kenyan forest-savanna landscape." Mov Ecol **2**(1): 2.

BACKGROUND: This study investigates the ranging behavior of elephants in relation to precipitation-driven dynamics of vegetation. Movement data were acquired for five bachelors and five female family herds during three years in the Marsabit protected area in Kenya and changes in vegetation were mapped using MODIS normalized difference vegetation index time series (NDVI). In the study area, elevations of 650 to 1100 m.a.s.l experience two growth periods per year, while above 1100 m.a.s.l. growth periods last a year or longer. RESULTS: We find that elephants respond quickly to changes in forage and water availability, making migrations in response to both large and small rainfall events. The elevational migration of individual elephants closely matched the patterns of greening and senescing of vegetation in their home range. Elephants occupied lower elevations when vegetation activity was high, whereas they retreated to the evergreen forest at higher elevations while vegetation senesced. Elephant home ranges decreased in size, and overlapped less with increasing elevation. CONCLUSIONS: A recent hypothesis that ungulate migrations in savannas result from countervailing seasonally driven rainfall and fertility gradients is demonstrated, and extended to shorter-distance migrations. In other words, the trade-off between the poor forage quality and accessibility in the forest with its year-round water sources on the one hand and the higher quality forage in the low-elevation scrubland with its seasonal availability of water on the other hand, drives the relatively short migrations (the two main corridors are 20 and 90 km) of the elephants. In addition, increased intra-specific competition appears to influence the animals' habitat use during the dry season indicating that the human encroachment on the forest is affecting the elephant population.

Zeppelzauer, M., A. S. Stöger and C. Breiteneder (2013). Acoustic detection of elephant presence in noisy environments. 2nd ACM International Workshop on Multimedia Analysis for Ecological Data, MAED 2013, Barcelona, Association for Computing Machinery.

The automated acoustic detection of elephants is an important factor in alleviating the human-elephant conflict in Asia and Africa. In this paper, we present a method for the automated detection of elephant presence and evaluate it on a large dataset of wildlife recordings. We introduce a novel technique for signal enhancement to improve the robustness of the detector in noisy situations. Experiments show that the proposed detector outperforms existing methods and that signal enhancement strongly improves the robustness to noise sources from the environment. The proposed method is a first step towards an automated detection system for elephant presence. Copyright 2013 ACM.

Wakoli, E. N., H. Ipara, N. Sitati and P. Odwori (2013). Spatial and temporal patterns of elephant mortality in Narok County, Kenya. 34th Asian Conference on Remote Sensing 2013, ACRS 2013, Bali, Asian Association on Remote Sensing.

This study aimed at determining the spatial temporal patterns of elephant mortality in Narok County using data from Kenya Wildlife Service (KWS) and World Wide Fund for Nature- Human-elephant Conflict (WWF-HEC) project compiled over the last 11 years. Field monitoring for one year was also carried out and any dead elephant was identified and details recorded to determine causes of mortality and distribution. Data were entered in an Excel spreadsheet and then converted into dBASE IV format and imported to ArcGIS to create a point shape file of elephant mortality and associated attribute data. Graphs and map were generated linking mortality with other aspects. Data obtained using

qualitative research method was analysed using the Statistical Package for Social Sciences (SPSS). Frequencies obtained were calculated, and where appropriate, a chi-square test was used. A 0.05 level of significance was used to determine existing relationships between data categories. Results showed that most elephant mortality occurred outside the protected area (MMNR) and were due to trophy poaching (61.5%, n=13) which occurred during long rainy seasons and in dense bush lands. There was a significant difference in mortality cases during the short rain season ($\chi 2=4.500$, df=1, p=0.034). Kernel density analysis depicted Olesentu and Sitoka in TM as hotspot area for elephant mortality due to trophy poaching. Elephant mortality due to conflicts occurred mostly on agricultural land with 10 (50%) cases. From the results, it was evident that elephant the distribution and pattern of elephant mortality is determined by several factors among them, Rainfall, vegetation cover, proximity to water source, roads and human settlement.

Sugumar, S. J. and R. Jayaparvathy (2013). "An early warning system for elephant intrusion along the forest border areas." Current Science **104**(11): 1515-1526.

Man-animal conflict has been on the rise in the forest border areas with herds of wild pachyderms straying into human habitation. The surveillance and tracking of elephant herds are difficult due to their size and nature of movement. In this article, we present an analytical procedure to study the behaviour of elephants along forest border areas by taking migration data into consideration using a three-state Markov chain. The migration data over the whole year is divided into four different periods for the study. We also develop an intrusion detection system to detect the intrusion of herds of wild elephants from the forests into the human habitation and to send an early warning through SMS to the forest officials to take necessary action. We validate the analytical results in comparison with the data obtained from the Forest Department. We also present a multi-class classification algorithm for providing zero false alarm rate. Species classification accuracy percentage is found to be 91.25.

Hazarika, R. and A. Saikia (2013). "The pachyderm and the pixel: an assessment of elephant habitat suitability in Sonitpur, India." International Journal of Remote Sensing **34**(15): 5317-5330.

Remote sensing and geographic information systems (GISs) are increasingly being used in protected area monitoring and habitat suitability studies. In this article, Erdas Imagine's Expert Classifier tool was used to assess the specific trajectories of habitat suitability change during 1994-2007 in the Sonitpur elephant habitat, India. Sonitpur has been witness to increasing human-elephant conflict in the past decade. The suitability analysis took into account information relating to forest type and density, elevation, slope, source of water, human activities in terms of settlement, agriculture, tea plantations, roads, and railways. Satellite imagery, data from topographical maps, digital elevation data, and global positioning system readings formed the major data inputs that were incorporated into a GIS. Various decision rules were created and confidence levels assigned to the input layers to generate high, medium, and low habitat suitability. The area witnessed a sharp decline in suitability from 63% in 1994 to less than 38% by 2007. The high-suitability area declined by more than 50% during this period. The unique natural protected areas of Sonitpur, which are a mix of reserved forests, wildlife sanctuaries, and a national park, urgently need to be protected from further habitat degradation.

Sitati, N. W. and H. Ipara (2012). "Indigenous Ecological Knowledge of a Human-Elephant Interaction in Transmara District, Kenya: Implications for Research and Management." Advances in Anthropology **02**(03): 107-111.

Indigenous ecological knowledge (IEK) of the Maasai community in the context of their interaction with elephants around Masai Mara National Reserve (MMNR), Kenya is explored. Although Maasai commu- nity land sustains a huge elephant population, it is experiencing increased human-elephant conflict (HEC). Focus group discussions combined with scientifically collected data were used in assessing the relevance of IEK to elephant related ecological research. The Maasai narrated their experiences with elephants which were then formulated into hypotheses and tested scientifically by designing experiments that were monitored to prove the authenticity of IEK. Respondents had in-depth knowledge of some key ecological processes. Drunken people were more likely to be attacked by elephants, and elephant movement into ad- jacent group ranches increased with increasing wildebeest density. Elephants mainly raided ripe or mature crops while pupils within the elephant range performed poorly in national examinations. Based on this, there is strong evidence that IEK could be used to design sustainable conservation strategies. It is recom- mended that understanding of IEK in mitigating HEC and its subsequent integration into HEC decision support system is necessary in order to resolve conflicts.

Guo, X. M., Q. He, L. X. Wang, Z. B. Yang, Z. Y. Li and Z. Y. Zhu (2012). "Effects of Asian elephant food source base on the mitigation of human-elephant conflict in Xishuangbanna of Yunnan Province, Southwest China." Chinese Journal of Ecology **31**(12): 3133-3137.

Establishing food source base for Asian elephants is to attract them returning to the depths of nature reserve, and to reduce the human-elephant conflict (HEC). In 2005-2010, a statistical analysis was made on the monitoring data about the activities of Asian elephants in the Mengyang sub-reserve food source base of Xishuangbanna to analyze the activity rhythms of the elephants in the base, and, in combining the cause troubles of the Asian elephants in the surrounding villages of the base, the influences of the food source base on the Asian elephants and surrounding villages were studied, aimed to approach the mitigation effect of the food source base on human-elephant conflict. The food source base supplied large amount of foods to attract Asian elephants, playing definite roles in mitigating the HEC. The monthly and diurnal activity rhythms of the Asian elephants in the base were almost synchronous with the sowing and maturing periods of local crops and the time sequence of the farmers' routine work. During the period of food shortage, the elephants mainly fed on king grass, a kind of introduced alien plants, or raided into villages to feed crops. The nearer the distance between the food source base and the villages, the more Asian elephant-related cause troubles happened. Therefore, great attentions should be paid to the location layout and the appropriate plant species combination in the establishment of food source base for Asian elephants.

Graham, M. D., W. M. Adams and G. N. Kahiro (2012). "Mobile phone communication in effective human elephant-conflict management in Laikipia County, Kenya." Oryx **46**(1): 137-144.

Human-elephant conflict is a significant problem in Africa, undermining biodiversity conservation and development efforts. Early warning of crop raiding and a coordinated response from landholders and wildlife authorities are important for effective management of this conflict. Mobile phones have spread rapidly in rural Africa and could potentially be used to improve communication and increase the effectiveness of responses to crop raids by elephants. We analyse changes in patterns of communication around human-elephant

conflict incidents before and after the arrival of mobile phone technology in Laikipia County in north-central Kenya, and the performance of mobile phone communication in a trial at three sites. We show that mobile phones can improve communication and reduce human-elephant conflict where there is good mobile coverage and widespread adoption. Conservation projects have much to gain from engaging with mobile phone technology. © 2012 Fauna & Flora Internationa.

King, L. E., I. Douglas-Hamilton and F. Vollrath (2011). "Beehive fences as effective deterrents for crop-raiding elephants: Field trials in northern Kenya." African Journal of Ecology **49**(4): 431-439.

Increasing elephant populations in Kenya since 1989 have been widely praised as a conservation success story. However, where elephants and agricultural land overlap, incidents of human-elephant conflict are on the increase. Wildlife managers and farmers are now trying different farm-based deterrents to keep elephants out of crops. Here, we present data on the effectiveness of a novel beehive fence deployed in a Turkana community of 62 communally run farms in Kenya. Specifically, 1700m of beehive fences semi-surrounded the outer boundaries of seventeen farms, and we compared elephant farm invasion events with these and to seventeen neighbouring farms whose boundaries were 'protected' only by thorn bush barriers. We present data from 45 farm invasions, or attempted invasions, recorded over 2years. Thirteen groups of elephants approached the beehive fences and turned away. Of the 32 successful farm invasions, only one bull elephant broke through the beehive fences. These results demonstrate that beehive fences are more effective than thorn bush barriers at deterring elephants and may have a role to play in alleviating farmer-elephant conflict. Additionally, the harvesting of 106kg of honey during the trial period suggests that beehive fences may also improve crop production and enhance rural livelihoods through honey sales. © 2011 Blackwell Publishing Ltd.

He, Q., Z. Wu, W. Zhou and R. Dong (2011). "Perception and attitudes of local communities towards wild elephant-related problems and conservation in Xishuangbanna, Southwestern China." Chinese Geographical Science **21**(5): 629-636.

The problem of wild elephants, or human-elephant conflict (HEC), influences the daily life of local communities and hinders the conservation of wild elephants. The perception and attitudes of local communities who inhabited the frontiers between human activities and wild elephant movement are important to the mitigation of the HEC and conservation of wild elephants. To analyze the perception and attitudes of local communities, the Participatory Rural Appraisal (PRA) was used in the investigation of 423 interviewees from 22 villages in Xishuangbanna from July 2009 to February 2010. The results indicated that local communities had their views on the elephant-related problems. In field survey, we found that 66.5% of interviewees were willing to support, participate in, and assist in the conservation of wild elephants; 33.5% of interviewees were opposed or indifferent to such conservation, because their livelihoods and even their lives were endangered by wild elephants. These views and attitudes were influenced by local communities' perception of HEC, education level, gender and self-interest. Therefore, it is necessary to analyze the diverse views among local communities and balance profits and costs in addressing HEC. © 2011 Science Press, Northeast Institute of Geography and Agroecology, CAS and Springer-Verlag Berlin Heidelberg.

Davies, T. E., S. Wilson, N. Hazarika, J. Chakrabarty, D. Das, D. J. Hodgson and A. Zimmermann

(2011). "Effectiveness of intervention methods against crop-raiding elephants." Conservation Letters **4**(5): 346-354.

The raiding of crops by elephants is one of the major components of human-elephant conflict, causing loss of livelihood and retaliation against elephants. To mitigate this conflict, various intervention methods are in use by farmers across Africa and Asia; yet there have been few rigorous assessments of their effectiveness. We provide an assessment of the efficacy of interventions in use by communities in Assam from a 3-year survey dataset using Generalized Linear Mixed Modeling. We found spotlights, chili fences, and electric fences to be highly effective at preventing crop damage by elephants when used in isolation, but when used in combination with noise their efficacy was compromised. Our study highlights the importance of evaluating intervention methods to determine their effectiveness. We propose the use of fences and spotlights be promoted in Assam, in conjunction with long-term habitat protection and restoration strategies. ©2011 Wiley Periodicals, Inc.

Chartier, L., A. Zimmermann and R. J. Ladle (2011). "Habitat loss and human-elephant conflict in Assam, India: Does a critical threshold exist?" Oryx **45**(4): 528-533.

Human-elephant conflict in India, driven by habitat loss and an expanding human population, is a complex challenge for biodiversity conservation. Determining if, how and why this conflict has changed over time will be an important step towards managing landscapes where people and elephants Elephas maximus coexist. This study combines social surveys and remote sensing data to analyse patterns in human-elephant conflict and land-use change over time. The reported experience of conflict increased dramatically in the early 1980s, with 85% of those surveyed indicating that conflict began after 1980. The expansion of conflict showed a significant southward trend and was associated with forest cover dropping below 30-40%. Based on our results we propose that a critical habitat threshold for human-elephant conflict may exist at 30-40% forest cover. Below this level, conflict expanded across the landscape. The existence of such a deforestation threshold may have important implications for landscape management in elephant range states that seek to avoid or mitigate further conflict. Maintenance of remaining forest areas, reforestation, and the creation of habitat corridors are strategies that could help prevent further expansion of conflict. © 2011 Fauna & Flora International.

Ahlering, M. A., J. J. Millspaugh, R. J. Woods, D. Western and L. S. Eggert (2011). "Elevated levels of stress hormones in crop-raiding male elephants." Animal Conservation **14**(2): 124-130.

Crop raiding is one of the most common forms of human-elephant conflict. Deterring elephants from raiding crops requires an understanding of the factors influencing the behavior of the individuals involved. We collected fecal samples from five group ranches in southern Kenya where crop-raiding incidents had occurred (n=10) and two protected areas, Amboseli National Park (n=24) and Maasai Mara National Reserve (n=20). We used molecular sexing to sex the individuals and radioimmunoassay kits to determine the level of glucocorticoid metabolites (i.e. stress hormones) in their dung. All crop-raiding individuals were male and had a significantly elevated concentration of glucocorticoid metabolites as compared with the Amboseli elephants (W=12, P=0.0005). We detected no significant difference between Maasai Mara elephants and either Amboseli or the crop-raiding elephants when just males were compared. Our results suggest that crop raiding may be related to stress in elephants. © 2010 The Authors. Animal Conservation © 2010 The Zoological Society of London.

Santiapillai, C. and B. Read (2010). "Would masking the smell of ripening paddy-fields help mitigate human-elephant conflict in Sri Lanka?" Oryx **44**(4): 509-511.

Despite its small size and high human population Sri Lanka is home to c. 4,400 wild Asian elephants Elephas maximus. Human-elephant conflict around agriculture is severe, with > 100 elephants and c. 50 people killed annually. Elephants appear to be able to time their raiding of paddy-fields in Sri Lanka with the harvesting of the rice, as if they are responding to an olfactory trigger. It is the elephants sophisticated chemosensory system that may hold the key to resolving human-elephant conflict. Research is required to determine the odours associated with the various development stages of rice, using gas chromatography, and to find a suitable substance that could be used to mask the specific odour of ripening rice. The use of chemosensory-based methods, if feasible, will not be a universal panacea for the mitigation of human-elephant conflict but, in combination with other methods, could reduce conflict and make it easier for farmers to harvest their crops in safety. Such a combination of methods could be useful across the range of both Asian and African elephants. © 2010 Fauna & Flora International.

Graham, M. D., B. Notter, W. M. Adams, P. C. Lee and T. N. Ochieng (2010). "Patterns of crop-raiding by elephants, Loxodonta africana, in Laikipia, Kenya, and the management of human-elephant conflict." Systematics and Biodiversity **8**(4): 435-445.

Recorded incidence of conflict between humans and elephants, in particular crop-raiding, is increasing in rural Africa and Asia, undermining efforts to conserve biological diversity. Gaining an understanding of the underlying determinants of human-elephant conflict is important for the development of appropriate management tools. This study analysed crop-raiding by African elephants (Loxodonta africana) in Laikipia District, covering 9700 km2 in north-central Kenya to identify spatial determinants of crop-raiding by elephants at different spatial extents. On average crop-raiding incidents occurred within 1.54 km of areas of natural habitat where elephants could hide by day undisturbed by human activities ('daytime elephant refuges'). The occurrence of crop-raiding was predicted by settlement density, distance from daytime elephant refuges and percentage of cultivation. However the relationship between crop-raiding and six candidate variables varied with sampling extent, with some variables diminishing in importance at a finer spatial scale. This suggests a tiered approach to human-elephant conflict management, with different interventions to address factors important at different spatial scales. Our results show that small-scale farms are particularly vulnerable to crop-raiding at settlement densities below approximately 20 dwellings per km2, above which crop-raiding declines. Land-use planning is therefore critical in preventing settlement patterns that leave farms vulnerable to crop-raiding by elephants. Where human-elephant conflict exists, efforts should focus on identifying and managing elephant refuges, through the use of electrified fences where resources are sufficient to construct, maintain and enforce them. This approach has been adopted for mitigating human-elephant conflict in Laikipia and with a major investment in resources and human capital it has been successful. Where such resources and human capital are not available then efforts should instead focus on the application of farm-based deterrents among vulnerable farms. © 2010 The Natural History Museum.

Ogra, M. (2009). "Attitudes toward resolution of human–wildlife conflict among forest-dependent agriculturalists near Rajaji National Park, India." Attitudes toward resolution of human-wildlife conflict among forest-dependent agriculturalists near Rajaji National Park, India **37**: 161-177.

Understanding local attitudes towards human-wildlife conflict (HWC) is key to developing successful conflict mitigation strategies. In this paper, in-depth interview and

questionnaire data about resolution of HWC in Uttarakhand, India are examined from both qualitative and quantitative approaches (n = 70). Responses are differentiated between and within three subgroups: gender, literacy status, and relative wealth. Overall, the plurality of respondents said that fencing is the best solution, that the Forest Department should take leadership, and that villagers would be willing to participate in a cooperative management institution. However, cooperative action was only actively supported by 27.4% of respondents, suggesting that comanagement of this protected area will require significant capacity building and trust building activities. Intragroup differences show that all three factors are significant, and underscore the importance of addressing gender differences in attitudes about HWC in particular. Women were less likely than men to support compensation, more likely to prefer that the village take leadership, and less willing to participate in a cooperative management institution. The study illustrates the value of mixed-method research, and suggests a number of specific entry points for action.

Muccio, Z. and G. P. Jackson (2009). "Isotope Ratio Mass Spectrometry 111." Analyst **134**(2): 213-222.

Isotope Ratio Mass Spectrometry (IRMS) is a specialized technique used to provide information about the geographic, chemical, and biological origins of substances. The ability to determine the source of an organic substance stems from the relative isotopic abundances of the elements which comprise the material. Because the isotope ratios of elements such as carbon, hydrogen, oxygen, sulfur, and nitrogen can become locally enriched or depleted through a variety of kinetic and thermodynamic factors, measurement of the isotope ratios can be used to differentiate between samples which otherwise share identical chemical compositions. Several sample introduction methods are now available for commercial isotope ratio mass spectrometers. Combustion is most commonly used for bulk isotopic analysis, whereas gas and liquid chromatography are predominately used for the real-time isotopic analysis of specific compounds within a mixture. Here, highlights of advances in instrumentation and applications within the last three years are provided to illustrate the impact of this rapidly growing area of research. Some prominent new applications include authenticating organic food produce, ascertaining whether or not African elephants are guilty of night-time raids on farmers' crops, and linking forensic drug and soil samples from a crime scene to a suspected point of origin. For the sake of brevity, we focus this Minireview on the isotope ratio measurements of lighter-elements common to organic sources; we do not cover the equally important field of inorganic isotope ratio mass spectrometry

Metcalfe, S. and T. Kepe (2009). ""Your elephant on our land": the struggle to manage wildlife mobility on Zambian communal land in the Kavango-Zambezi transfrontier." The Journal of Environment & Development **17**(2): 99-117.

King, L. E., A. Lawrence, I. Douglas-Hamilton and F. Vollrath (2009). "Beehive fence deters crop-raiding elephants." African Journal of Ecology **47**(2): 131-137.

Previous work has shown that African elephants Loxodonta africana will avoid African honeybees Apis mellifera scutellata. Here we present results from a pilot study conducted to evaluate the concept of using beehives to mitigate elephant crop depredation. In Laikipia, Kenya, we deployed a 90-m fence-line of nine inter-connected hives, all empty, on two exposed sides of a square two-acre farm that was experiencing high levels of elephant crop depredation. Compared with a nearby control farm of similar status and

size, our experimental farm experienced fewer raids and consequently had higher productivity. Socioeconomic indicators suggest that not only was the concept of a beehive fence popular and desired by the community but also that it can pay for its construction costs through the sale of honey and bee products. We are calling for experiments testing this concept of a 'guardian beehive-fence' to be conducted rigorously and scientifically in as wide a range of agricultural settings as possible to evaluate jointly its effectiveness and efficiency. © 2009 Blackwell Publishing Ltd.

Graham, M. D., I. Douglas-Hamilton, W. M. Adams and P. C. Lee (2009). "The movement of African elephants in a human-dominated land-use mosaic." Animal Conservation **12**(5): 445-455.

Land outside of gazetted protected areas is increasingly seen as important to the future of elephant persistence in Africa. However, other than inferential studies on crop raiding, very little is understood about how elephants Loxodonta africana use and are affected by human-occupied landscapes. This is largely a result of restrictions in technology, which made detailed assessments of elephant movement outside of protected areas challenging. Recent advances in radio telemetry have changed this, enabling researchers to establish over a 24-h period where tagged animals spend their time. We assessed the movement of 13 elephants outside of gazetted protected areas across a range of land-use types on the Laikipia plateau in north-central Kenya. The elephants monitored spent more time at night than during the day in areas under land use that presented a risk of mortality associated with human occupants. The opposite pattern was found on large-scale ranches where elephants were tolerated. Furthermore, speed of movement was found to be higher where elephants were at risk. These results demonstrate that elephants facultatively alter their behaviour to avoid risk in human-dominated landscapes. This helps them to maintain connectivity between habitat refugia in fragmented land-use mosaics, possibly alleviating some of the potential negative impacts of fragmentation. At the same time, however, it allows elephants to penetrate smallholder farmland to raid crops. The greater the amount of smallholder land within an elephant's range, the more it was utilized, with consequent implications for conflict. These findings underscore the importance of (1) land-use planning to maintain refugia; (2) incentives to prevent further habitat fragmentation; (3) the testing and application of conflict mitigation measures where fragmentation has already taken place. © 2009 The Authors. Journal compilation © 2009 The Zoological Society of London.

Datta-Roy, A., N. Ved and A. C. Williams (2009). "Participatory elephant monitoring in South Garo Hills: Efficacy and utility in a human-animal conflict scenario." Tropical Ecology **50**(1): 163-171.

We evaluate the efficacy of community based elephant monitoring programme in South Garo Hills, Meghalaya (India). Major objectives of the programme are to understand the ranging and habitat utilization patterns of free ranging Asian elephants in a human interspersed habitat with frequent human - elephant conflicts. We collected information on elephant presence in the landscape through participatory wildlife monitoring techniques by modifying an existing model for African elephants from six 'akings' or clan villages which are worst affected by human-elephant conflict (HEC). A total of 201 visits were recorded in six 'akings' during June 2005 to July 2006, of which solitary elephants accounted for 100 visits. The visits were found to peak during the two main harvesting periods in the Garo hills indicating a definite seasonality pattern in the visits. Information from individual 'akings' also indicate that some 'akings' were particularly prone to visits by solitary

animals indicating the complexity in the dynamics of elephant ranging patterns within the landscape. We note that participatory elephant monitoring can be a useful tool to collect basic data on elephant presence in tropical ecosystems where traditional line transect method is restricted by considerations of terrain, access and resources. Other advantages, limitations and conservation implications are discussed. © International Society for Tropical Ecology.

Sutton, W. R., D. M. Larson and L. S. Jarvis (2008). "Assessing the costs of living with wildlife in developing countries using willingness to pay." Environment and Development Economics **13**: 475-495.

The costs of living with wildlife are assessed using Namibian subsistence farmers' willingness to pay (WTP) for deterrents to attacks on crops and livestock. A utility-theoretic approach jointly estimates household WTP for deterrent programs in two 'currencies': maize and cash. This has a double payoff. Use of a non-cash staple increases respondent comprehension and provides more information about preferences, improving the accuracy of results. The household shadow value of maize is also identified. Significant costs from living with elephants and other types of wildlife are demonstrated. Compensation for farmers may be warranted on equity and efficiency grounds. Uncontrolled domestic cattle generate even higher costs to farmers than wildlife, highlighting the need to clarify property rights among these farmers.

Okello, M. M. and D. E. D'Amour (2008). "Agricultural expansion within Kimana electric fences and implications for natural resource conservation around Amboseli National Park, Kenya." Journal of Arid Environments **72**(12): 2179-2192.

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Fencing has become a key strategy in mitigating human-wildlife coflicts and promoting agricultural production in Kenya. However, it can have negative long-term consequences for wildlife conservation as well as human development, especially if the fence is poorly maintained. Such is the case of the Kimana and Namelok fences in the Kimana Group Ranch. This study assessed the influence of fences on agricultural expansion, environmental and wildlife conservation. In both fences, irrigated agriculture was a dominant land use and occurred along riverbanks, causing drying downstream. Most farmers in both fences were noticing a decline in water quantity and time of access to it, as well as increasing human-wildlife conflicts. Wildlife sightings within both fences provided evidence that the inadequate fence maintenance allows wildlife to freely access the fenced areas. Both wildlife and humans were blamed for fence deterioration in both fences. Irrigated agriculture inside both fences is expanding at an unmanageable rate. While the fences have spurred socio-economic activities in the area, they are not only ineffective in reducing human-wild life coflicts but have given rise to other critical conflicts. Fencing appears to be a short-term remedy for human-wildlife conflicts and it is crucial to explore other mitigation strategies.

Jackson, T. P., S. Mosojane, S. M. Ferreira and R. J. Van Aarde (2008). "Solutions for elephant Loxodonta africana crop raiding in northern Botswana: Moving away from symptomatic approaches." Oryx **42**(1): 83-91.

Conflict between people and elephants in Africa is widespread yet many solutions target the symptoms, rather than the underlying causes, of this conflict. To manage this conflict better the underlying causes of the problem need to be examined. Here we examine factors underlying spatial use by elephants and people along the Okavango Panhandle in

Ngamiland, northern Botswana, to provide ways to address the causes of the conflict between elephants and people. We found that (1) elephant spatial use was a function of season, (2) spatial use did not differ between breeding herds and bull groups, (3) spatial use by elephants and people only overlapped significantly at night, during the dry season, (4) crop raiding by elephants was a function of season and social grouping, and (5) crop raiding by elephants had social and economic implications. Based on these results we suggest measures to manipulate elephant spatial use to reduce the causes of this conflict. We also reflect on present compensation measures for elephant crop damage and advocate that a more direct performance payment approach may benefit both the Botswana Government and local farmers. © 2008 Fauna and Flora International.

Graham, M. D. and T. Ochieng (2008). "Uptake and performance of farm-based measures for reducing crop raiding by elephants Loxodonta africana among smallholder farms in Laikipia District, Kenya." Oryx **42**(1): 76-82.

Human-elephant conflict, in particular the damage caused by elephants to smallholder crops, is a major challenge to the conservation of African elephant Loxodonta africana. Conventional tools used to address this problem are capital intensive and require high levels of expertise. In recent years simple, affordable farm-based elephant deterrents, using locally available materials, have been encouraged by a number of human-elephant conflict researchers. There are very few published studies demonstrating the performance of these deterrents, however, and little is known about levels of uptake among smallholder farmers. We trialled a number of such farm-based elephant deterrents with local farmers in three sites within Laikipia District, Kenya. Levels of crop raiding declined after the introduction of treatments but not significantly when compared with control farms. Variable levels of uptake among the participating farmers made it difficult to draw clear conclusions from the trials. However, participating farmers were positive about the deterrent effect of the tools introduced, corroborated by their willingness to make financial commitments towards sustaining future trials. Availability of household labour, local politics, and insecurity were identified as important barriers to uptake of some of the deterrents introduced. Household labour availability should be a key consideration in future endeavours to trial farm-based elephant deterrents. © 2008 Fauna and Flora International.

Chatterjee, R. (2008). "Protecting farmlands and conserving elephants." Environ. Sci. Technol **42**(19): 7029.

Bechert, U., S. Southern and M. Chase (2008). Minimally invasive molecular health analysis in elephants. Proc American Associaton of Zoo Veterinarians and Assoc of Reptile and Amphibian Veterinarians.

This paper describes the application of a new assay platform called Stress Response Profiling (SRP) to the analysis of health status in elephants. SRP assays use a large biomarker panel as an indicator of chronically perturbed physiologic homeostasis ("chronic stress"),1,2 which is a known predictor of increased morbidity, infertility and mortality rates.3-8 SRP assays have a broad-based sensitivity to diverse types of stressors in multiple species of vertebrates.2 A minimally invasive SRP assay is based on skin microsamples obtained using routine biopsy procedures.9 The skin SRP assay was applied to captive African elephants with clinically diagnosed gastrointestinal infections and to healthy wild elephants.10 The elephant health status was classified using a reference database of SR biomarker profiles corresponding to eight species of normal and stressed

animals. The biomarker profiles were converted into pathway profiles indicating that the molecular mechanism of the elephant gastrointestinal infections preferentially involved responses to misfolded proteins and DNA lesions. To rapidly and economically screen samples from 70 free-ranging African elephants sampled in Northern Botswana, we used a multiplexed SRP assay called multi-SRP.1,2 Statistical analysis of the multi-SRP scores showed correlations with population density, movements, and human-elephant conflict reports. In
summary, this paper documents that SRP and multi-SRP assays are suitable for the elephant skin and relevant to both symptomatic diseases and asymptomatic effects of environmental and anthropogenic stressors. We anticipate that the SRP technology might have a wide range of potential applications in veterinary medicine and ecosystem conservation.

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Zimmermann, A., S. Wilson and N. Hazarika (2006). Managing human-elephant conflict in Assam: An integrated approach. Proceedings International Elephant Conservation & Research Symposium.

Talukdar, B. K., J. K. Boruah and P. Sarma (2006). Multi-dimensional mitigation initiatives to human-elephant conflicts in Golaghat district and adjoining areas of Karbi Anglong, Assam, India. Proceedings International Elephant Conservation & Research Symposium.

Ramakrishnan, B., P. Durairasu, R. Saravanamuthu and K. Kalidasan (2006). Effectiveness of mitigating measures against human-elephant conflict in and around the Coimbatore Forest Division, Tamil Nadu, South India. Proceedings International Elephant Conservation & Research Symposium.

Parker, G. E. and F. V. Osborn (2006). "Investigating the potential for chilli Capsicum spp. to reduce human-wildlife conflict in Zimbabwe." Oryx **40**(3): 343-346.
Human-wildlife conflict has negative implications for wildlife conservation, and current crop protection methods are not sufficient to address the problem. Alternative livelihood strategies may provide the ultimate solution to this conflict but they are not always feasible in the short-term. We test the viability of using chilli Capsicum spp. as an

unpalatable cash crop to
reduce human-wildlife conflict. Our trials indicate that chilli is less vulnerable to wildlife than other crops and is also economically viable.

Lee, P. C. and M. D. Graham (2006). "African elephants (Loxodonta africana) and human-elephant interactions: implications for conservation." International Zoo Yearbook **40**: 9-19.
African elephants face an uncertain future. Politics, war, sustained media campaigns, corrupt, weak or absent institutions supporting conservation, land-use planning or general governance, and greed ar all bringing elephants into direct conflict with humans. Although elephant populations have declined considerably relative to their historical size and range, human populations have expanded to occupy and intensively use remaining elephant areas. Strategies to minimize perceptions of conflict and the implementation of land-use planning with biodiversity protection as its goal could help to sustain at least some populations of elephants. Here, we review threats to elephants, with an emphasis on those resulting from human perceptions of conflict, and suggest some mechanisms for grappling with these threats.

Lahkar, B. P., J. P. Das, N. K. Nath, S. Nath, P. K. Sarma and S. Brahma (2006). Habitat evaluation of Asian elephant (Elephas maximus) and spatial aspects of human elephant conflict in Manas National Park using Remote Sensing/GIS. Proceedings International Elephant Conservation & Research Symposium.

Corea, R., H. Gammanpila, Z. Khalid, N. Dharmasiri, C. Fernando and C. Corea (2006). Saving elephants by helping people establishing a model for sustainable research, capacity building and community development for the protection of elephants in Sri Lanka and to resolve human elephant conflicts. Proceedings International Elephant Conservation & Research Symposium.

Barnes, R. F. W., U. F. Dubiure, E. Danquah, Y. Boafo, A. Nandjui, E. M. Hema and M. Manford (2006). "Crop-raiding elephants and the moon." African Journal of Ecology **45**(1): 112-115.
The problem of crop-raiding elephants has become particularly acute around the Kakum Conservation Area (KCA) in southern Ghana where the surrounding communities suffer severe losses each year (Dudley, Mensah-Ntiamoah & Kpelle, 1992; Barnes, Azika & Asamoah-Boateng, 1995). The frequency of crop-raiding by elephants is affected by the ecological conditions within their forest refuge and by the farming landscape outside (Barnes, 2002; Barnes et al., 2003; Danquah, 2003; Chiyo et al., 2005). In addition, physical features of the environment play a role. For example, Dickinson (1998) suspected that the Kakum elephants raided less frequently at the full moon. Here we test Dickinson's (1998) hypothesis for the Kakum elephants using data from an investigation of crop-raiding around KCA (Barnes et al., 2003, 2005). An exploratory analysis of the data revealed that rainfall was another physical variable that influenced crop-raiding, and here we show how rainfall and lunar phase together predict the risk from elephants.

Baishya, H. K., S. Dey, P. Sharma, A. Sharma, A. Sharma, T. Aziz, G. Areendam and A. C. Williams (2006). Human elephant conflict mitigation in North Bank Landscape, north east India. Proceedings International Elephant Conservation & Research Symposium.

Bairagi, S. P., C. S. Baruah, U. Dutta and D. Saikia (2006). Resolving human-elephant conflict in the northern areas of Asom, India a discouraging endeavour. Proceedings International Elephant Conservation & Research Symposium.

Venkataraman, A. B., R. Saandeep, N. Baskaran, M. Roy, A. Madhivaran and R. Sukumar (2005). "Using satellite telemetry to mitigate elephant-human conflict: An experiment in northern West Bengal, India." Current Science **88**(11): 1827-1831.

Satellite tracking of animals has advantages in the study of species that migrate across international borders, have large home ranges and occupy remote and inaccessible areas. The efficacy of this technology in dense tropical forests may, however, be limited. At the same time, its use in mitigating wildlife-human conflict has not been examined so far. Here we report the movement patterns and habitat utilization of an adult male Asian elephant, and a preliminary assessment of the potential use of satellite technology as an 'early warning system' for conflict mitigation. Data on the location of the animal were obtained from a Platform Transmitter Terminal mounted on an elephant in Jaldapara, West Bengal, the first if its kind used on this species in India. We found that the animal preferred forest and forest plantations during the day, making visits to cultivated lands at night. There was some predictability, in the movement of this animal, suggesting that,similar technologies such as the more advanced Global Positioning System can be used for near 'real-time tracking' of problem elephants.

Fernando, P., E. Wikramanayake, D. Weerakoon, L. K. A. Jayasinghe, M. Gunawardene and H. K. Janaka (2005). "Perceptions and patterns of human-elephant conflict in old and new settlements in Sri Lanka: Insights for mitigation and management." Biodiversity and Conservation **14**(10): 2465-2481.

Human-elephant conflict poses a major threat to elephants in many parts of Asia, including Sri Lanka. We studied human-elephant conflict in two areas with contrasting scenarios of landuse and conflict, Kahalle and Yala. Kahalle was developed and settled under the Mahaweli irrigation project and the main agricultural practice was irrigated agriculture, with two annual growing seasons. The area was a mosaic of settlements, agriculture, and small forest patches with ill defined human- and elephant-use areas. Elephants ranged within the habitat mosaic year round, occupying remnant forest patches and raiding adjacent crops at night. In contrast, Yala was dominated by a large protected area complex, and the main agricultural methods were slash-and-burn agriculture and rain-fed paddy cultivation. Human- and elephant-use areas were well defined and segregated. The protected area provided elephants with a refuge and food during the rainy season, when the single annual crop was grown. During the dry season, elephants moved into slash-and-burn areas and utilized leftover crops and pioneer vegetation in fallow fields. The landuse pattern and agricultural practices in Yala facilitated co-existence, whereas that in Kahalle led to year round conflict. We suggest that areas managed according to traditional landuse practices should be part of an elephant conservation strategy, where people and elephants have to share resources.

Deem, S. L., J. L. Brown, L. Eggert, C. Wemmer, W. Htun, T. Nyunt, S. Murray and P. Leimgruber (2005). Health and management of working elephants in Myanmar (Burma). Procedings American Association of Zoo Veterinarians.

Myanmar has approximately 6,000 working elephants. Remaining wild elephants are declining, partly because of live-capture for captivity. Through health and reproductive assessments, genetic analyses and GPS tracking of captive and wild elephants, we are exploring linkages between the two populations and conducting studies to reduce morbidity and mortality of captive elephants. Captive elephants live and work in Myanmar's forests in close proximity and contact to the remaining wild herds. We propose

that reducing morbidity and mortality in the captive elephants will decrease the need for live-capture, and the risk of disease transmission, to wild elephants.

Introduction

There are an estimated 6,000 working elephants in Myanmar - half owned by the government operated Myanmar Timber Enterprise (MTE) and half owned privately.[5] This may be one of the largest captive elephant populations in the world and its management will have a significant impact on remaining wild herds in Myanmar.[4,6,8] With mortality rates higher than birth rates, the working population is probably maintained by supplementing it with elephants captured from the wild.[5] There is evidence that continued harvest of wild elephants may have reduced the remaining wild populations of Myanmar. Recent surveys of wild populations in two of Myanmar's protected elephant ranges revealed extremely low dung counts, indicative of small and declining herds. Constant contact with captive elephants in Myanmar's forests may exacerbate the threat to Myanmar wild elephants by increasing the transmission of disease between these two groups. For both the above reasons, we believe that the conservation of wild elephants in Myanmar will require significant improvements in the care and management of currently existing captive populations.

Elephants owned by MTE receive veterinary care from the Burmese veterinarians that work for the timber company and travel extensively throughout the country to sites were the elephants are located.[1] There is a dire need for veterinary supplies and laboratory capabilities in the country. Currently, veterinary practices are based on the extensive field experience of lead MTE veterinarians. However, MTE veterinarians frequently rely on older published work [3,7] and would benefit significantly from training that incorporates new insights into elephant health and new veterinary techniques. Similarly, because of their close-up experience of elephant health problems in the forests, MTE veterinarians may be able to make important new contributions to the care and management of elephants elsewhere.

The overall objective of our study is to work jointly with MTE veterinarians to develop long-term captive population management strategies to reduce mortality and increase births in the working timber elephants and stop the continued off-take of animals from the wild to supplement captive herds.

Methods

The health component of this study has five major objectives. These are to:

1 Conduct a training workshop, in conjunction with MTE veterinarians, on elephant management and veterinary care.
2 Develop protocols so that the MTE veterinarians can collect samples for reproductive, genetic, and health status assessments.
3 Analyze samples and provide data to MTE veterinarians to improve husbandry, preventive care and disease treatment of working elephants.
4 Develop a comprehensive bibliography of all published information on the health and management of Myanmar elephants.
5 Perform an epidemiologic evaluation of records available on the historic and current working elephant population.

Specific steps to achieve these objectives include:

1 Determine causes and rates of morbidity and mortality of captive MTE elephants.
2 Determine causes of low rates of reproduction in captivity.
3 Develop a genetic profile of the captive herds.
4 Develop a protocol to assess oozies-Burmese mahout-expertise in parallel with endocrine and health assessments to determine quality of care and potentially related stress.

5 Develop small population viability models to assess how current mortality effects long-term survival of the captive population and what supplementation from the wild is needed for short- and long-term sustainability.
6 Use population viability models to demonstrate how supplementation from the wild will negatively affect that population.
7 Get baseline health parameter data on free-ranging elephants.
8 Quantify habitat/space use using GPS and satellite tracking of captive and wild elephants.

Results and Discussion

During an initial exploratory visit in November 2004, we learned that the annual mortality rate for MTE working elephants was 2.4% (66) in 2003. Deaths occurred in all age groups (>18 yr, n = 40; 4 - 17 yr, n = 11; <4 yr, n = 15) and included preventable diseases (i.e., poor nutrition, heat stroke, diarrhea, dystocia, infectious and parasitic agents). Additionally, we collected samples for performing health, genetic and endocrine analyses of 22 elephants maintained in one of the working camps (results to be presented). A relationship also was established with the veterinary staff at the Yangon Zoo, including follow up donations of veterinary literature and journals to the zoo. We provided medical advice for the care of an orphaned elephant calf and other animals housed at the zoo during our brief visit. We are seeking funds for a training course to be conducted in late 2005 and hope to perform health evaluations on a larger number of zoo and working elephants during that visit.

The National Zoo already has an extensive conservation program for wild elephants in Myanmar.[4,6,8] This program has focused on assessing wild elephant populations in protected areas and satellite-tracking of four wild elephants to learn more about their conservation status and ecology in Myanmar. Currently this work is being extended to a national elephant survey. Part of this work included collecting fecal samples for genetic and health assessments**.**

The Smithsonian team of researchers involved in this project includes a veterinarian, reproduction physiologist, geneticist, conservation biologist, and landscape ecologist. All members of this multidisciplinary team have extensive experience working with elephants and together provide the necessary expertise to study and understand the numerous factors affecting Myanmar's captive elephants and the long-term survival of elephants in Myanmar. These challenges range from human land use and elephant population fragmentation, human-elephant conflict, poor reproduction and health care of captive elephants and lack of information on the health status of the wild elephants. A viable conservation initiative for the elephants of Myanmar requires that health issues be addressed as one component of a comprehensive program to address the anthropogenic pressures on both working and wild elephants.[2]

The elephants of Myanmar are an excellent example of the fine line that exists between captive and wild animals, especially as it relates to health. Captive and wild elephants are regularly in direct and indirect contact. The working elephants live with their oozies who may expose them to diseases, such as tuberculosis. The working elephants in turn may encounter wild elephants at night in the forests where they forage and live during non-working hours. In fact, the majority of captive born calves are said to be sired by wild bulls. Potentially, the use of working elephants in selectively extracting valuable timber provides new strategies for the conservation of elephants and forests. Most likely, "elephant-logging" is less damaging than machine-operated timbering projects that tend to clear-cut areas and also damage the soil and streams. However, decreasing the negative impact of such practices (i.e., minimizing off-take of elephants from the wild, decreasing disease risks to the wild elephants) is imperative.

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4 Kelly, D.S. 2005. Habitat selection in declining elephant populations of Alaungdaw Kathapa National Park. Masters Thesis. George Mason University.
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Chiyo, P. I., E. P. Cochrane, L. Naughton and G. I. Basuta (2005). "Temporal patterns of crop raiding by elephants: a response to changes in forage quality or crop availability?" Afr. J. Ecol. Temporal patterns of crop raiding by elephants were studied for 13 months in 1996/1997 at Kibale Forest National Park, Uganda. To determine the influence of environmental factors on the timing of raiding, we tested for correlations between crop raiding patterns and the quality of natural forage within the forest as well as crop availability beyond park boundaries. Crop raiding occurred throughout the year with peaks in dry seasons when crop availability was high. Bananas and maize were the main crops raided. Variations in forage quality were moderate with small seasonal fluctuations and peaks in dry seasons. Monthly crop raiding incidences were not influenced by forage quality but by ripening of maize. Comparison of forage quality and temporal distribution of crop raiding between savanna and forest habitats suggests that crop availability is more important in forest habitats, whereas in savanna habitats large seasonal fluctuations in forage quality have a greater influence on temporal patterns of crop raiding.

Bloom, A., R. Zalinge, I. M. A. van Heitkonig and H. H. T. Prins (2005). "Factors influencing the distribution of large mammals within a protected central African forest." Oryx **39**(4): 381-388. This paper presents the analyses of data obtained from eight permanent 20 km transects to determine the relative effect of local human populations and ecological factors on the distribution of large mammals within the Dzanga sector of the Dzanga-Ndoki National Park and the adjacent area of the Dzanga-Sangha Dense Forest Special Reserve in south-west Central African Republic. Principal component analysis indicated that human activities significantly influence the distribution of large mammals, even within this protected area. Distance from the village and the main road as well as the distance from secondary roads appeared to have the greatest influence. Elephants in particular were significantly less common in areas related to human use. Our study showed that poachers use roads, both primary and secondary, to penetrate into the National Park. Thus increasing anti-poaching efforts along these roads could be an effective protection measure.

Osborn, F. V. (2004). "Seasonal variation of feeding patterns and food selection by crop-raiding elephants in Zimbabwe." African Journal of Ecology **42**(4): 322-327.

Elephants and humans are increasingly coming into conflict because of the conversion of elephant habitat into agricultural areas. In order to identify trends that influence raiding behaviour, the nutritional makeup of food items consumed by crop-raiding elephants over a 2-year period were analysed and a trigger for crop raiding was identified. The point at which the quality of wild grasses declines below the quality of crop species corresponded to the movement of bull elephants out of a protected area and into fields. This finding may have wider implications for developing predictive models of elephant/human interactions.

Horan, R. D. and E. H. Bulte (2004). "Optimal and open access harvesting of multi-use species in a second-best world." Environmental and Resource Economics **28**(3): 251-272.

Expansion of human populations and activities has caused increased conflicts between wildlife and humans. As a result, the distinction between resource and pest species has become blurry. We propose an economically-based classification of species based on a multi-use bioeconomic model. The classification of the steady state population of a species is shown to depend on both species' density and economic factors. We extend earlier work on multi-use (resource-pest) species by applying the theoretical model to a developing country context where property rights to wildlife are imperfectly enforced, so that second-best trade measures are often applied by the international community to promote conservation. Upon calibrating the model using data for the African elephant, we derive three further results. First, when comparing the optimal stock of a multi-use species to the open access stock, we find that the ranking in terms of abundance is ambiguous. Second, and consistent with existing literature on resource management in a second-best world, our case study supports the idea that trade bans have ambiguous effects on wildlife abundance. Third, due to a bifurcation effect characterizing the multi-use model's solution, strategic and temporary subsidizing by the North may enable them to free ride on conservation efforts of the South henceforth.

Bandara, R. and C. Tisdell (2004). "The net benefit of saving the Asian elephant: A policy and contingent valuation study." Ecological Economics **48**: 93-107.

Reports results from a contingent valuation (CV) survey of willingness to pay (WTP) for the conservation of the Asian elephant of a sample of urban residents living in three selected housing schemes in Colombo, the capital of Sri Lanka. Face-toface surveys were conducted using an interview schedule (IS). A non-linear logit regression model is used to analyse the respondents' responses for the payment principle questions and to identify the factors that influence their responses. We investigate whether urban residents' WTP for the conservation of elephants is sufficient to compensate farmers for the damage caused by elephants. We find that the beneficiaries (the urban residents) could compensate losers (the farmers in the areas affected by human-elephant conflict, HEC) and be better off than in the absence of elephants in Sri Lanka. Therefore, there is a strong economic case for the conservation of the wild elephant population in Sri Lanka. However, we have insufficient data to determine the optimal level of this elephant population in the Kaldor-Hicks sense. Nevertheless, the current population of elephant in Sri Lanka is Kaldor-Hicks preferable to having none.

Weladji, R. B. and M. N. Tchamba (2003). "Conflict between people and protected areas within the Benoue Wildlife Conservation Area, North Cameroon." Oryx **37**(1): 72-79.

Knowledge of conflicts between people and protected areas is required for the design of sustainable conservation strategies for the management of most protected areas. This study identifies the causes of conflicts between local people and the Benoue Wildlife Conservation Area (BWCA), which includes the Benoue National Park, in northern Cameroon. Informal interviews and questionnaires were administered to 114 households in three communities, and to 17 park staff and 7 professional hunting guides from July-October 1997. Crop damage affected 86% of the surveyed households, with 31% of crop income lost on average, and with the damage varying significantly between communities. Elephants, baboons, patas monkeys, warthogs and green parrots accounted for 97% of crop damage, with the staple foods maize and millet being most affected. Of the respondents, 28% experienced livestock depredation, with 18% of livestock income lost on average. The civet cat was the main predator. The involvement of local people in illegal activities, their lack of access to natural resources, and damage by wildlife were identified as principal causes of conflicts. Local people, park staff and professional hunting guides had diverse and differing perceptions about the causes of the conflicts, and made various suggestions for reduction of wildlife damage including animal scaring and controlled shooting. We conclude that, under current wildlife policy, conflict between people and BWCA is difficult to resolve. To reduce conflicts and promote sustainable conservation, we suggest co-management of wildlife involving all stakeholders, establishment of crop damage control teams, and promotion of tangible benefits to local people. There may be a requirement for site-specificity in management strategies.

Sukumar, R. (2003). The Living Elephants, Oxford University Press.

Sitati, N. W., M. J. Walpole, R. J. Smith and N. Leader-Williams (2003). "Predicting spatial aspects of human–elephant conflict." Journal of Applied Ecology **40**: 667-677.

Human-elephant conflict (HEC) in Africa occurs wherever these two species coincide, and poses serious challenges to wildlife managers, local communities and elephants alike. Mitigation requires a detailed understanding of underlying patterns and processes. Although temporal patterns of HEC are relatively predictable, spatial variation has shown few universal trends, making it difficult to predict where conflict will take place. While this may be due to unpredictability in male elephant foraging behaviour (the male behaviour hypothesis) it may also be due to variations in the data resolution of earlier studies. This study tested the male behaviour and data resolution hypotheses using HEC data from a 1000-km2 unprotected elephant range adjacent to the Masai Mara National Reserve in Kenya. HEC incidents were divided into crop raiding and human deaths or injuries. Crop raiding was further subdivided into incidents involving only male elephants or family groups. A relatively fine-resolution, systematic, grid-based method was used to assign the locations of conflict incidents, and spatial relations with underlying variables were explored using correlation analysis and logistic regression. Crop raiding was clustered into distinct conflict zones. Both occurrence and intensity could be predicted on the basis of the area under cultivation and, for male elephant groups, proximity to major settlements. Conversely, incidents of elephant-induced human injury and death were less predictable but were correlated with proximity to roads. A grid-based geographical information system (GIS) with a 25-km2 resolution utilizing cost-effective data sources, combined with simple statistical tools, was capable of identifying spatial predictors of HEC. At finer resolutions spatial autocorrelation compromised the analyses. Synthesis and applications. These results suggest that spatial correlates of HEC can be identified, regardless of the sex of the elephants involved. Moreover, the method described here is fully transferable to

other sites for comparative analysis of HEC. Using these results to map vulnerability will enable the development and deployment of appropriate conflict mitigation strategies, such as guarding, early warning systems, barriers and deterrents. The utility of such methods and their strategic deployment should be assessed alongside alternative land-use and livelihood strategies that limit cultivation within the elephant range.

Osborn, F. V. and G. E. Parker (2003). "Towards an integrated approach for reducing the conflict between elephants and people: a review of current research." Oryx **37**(1).

Managers attempting to reduce crop damage by elephants encounter a range of complex technical and social issues. Subsistence farmers bear the costs associated with maintaining wild elephant populations and this can confound interventions designed to improve the livelihood security of farmers. We present a review of the issues that influence the success and failure of methods used to reduce crop damage, and suggest that an integrated, community-based, low-tech approach will be the most sustainable solution to this conflict.

Mikota, S. K., H. Hammatt and M. Finnegan (2003). Occurrence and prevention of capture wounds in Sumatran elephants (*Elephas maximus sumatranus*). Proc Amer Assoc Zoo Vet.

The capturing of elephants in Indonesia began in 1986 as an attempted solution to human-elephant conflict. The intent was to train "problem" elephants for use in agriculture, logging and tourism. The initial captures were conducted under the guidance of Thai mahouts and Thai koonkie elephants (trained elephants used for capture). A number of the Indonesians that were originally trained in capture techniques still work for the government forestry department (KSDA). The younger pawangs (elephant handlers) that participate in captures have learned from their peers. There is no formal training program. The actual mortality rate associated with elephant captures in Sumatra is unknown as official reports are lacking. The age structure of the existing ~ 400 captive elephants is young (most under 25) which suggests that smaller, younger elephants are preferentially captured and / or that adult elephants do not survive the capture and training processes. Our personal experiences (Mikota and Hammatt) in Sumatra show that mortality in newly captured elephants is high.In 2001, with endorsement from the World Wide Fund for Nature-Indonesia (WWF), the Wildlife Conservation Society (WCS), Fauna and Flora International (FFI), and the International Elephant Foundation (IEF), we requested a two-year Moratorium on elephant captures during which time capture techniques would be improved and alternative conflict mediation techniques evaluated. A Moratorium against placing additional elephants into the Elephant Training Centers has been issued by the central government, however capture for translocation is still sanctioned. Unfortunately, the provincial governments have increasingly acted in their own interests since the government of Indonesia began a de-centralization process a few years ago. Riau Province is thought to have the largest remaining populations of wild Sumatran elephants.Fifty-seven, human-elephant conflicts occurred in Riau between 1997-2000. Although Riau is a hotbed of conflict, problems are occurring throughout Sumatra and we are aware of conflicts and captures in Bengkulu and North Sumatra. In October 2002, we were invited by KSDA (the provincial forestry department) to accompany their team into the field as they attempted to capture a large bull that had been raiding a palm oil plantation. This opportunity was invaluable as we were able to observe first hand the techniques being used and where improvements were needed. As a result of this and other experiences with newly captured elephants we observed: ·Equipment (Palmer) is old, poorly maintained, and used improperly. ·Essential supplies are lacking or homemade

substitutes are used.

·The dose of xylazine is very high compared to wild elephant capture doses used in India and Malaysia. The same dose is often used regardless of the size of the elephant. ·The needles are too short to reach muscle; open-ended needles are used which can become plugged with tissue, thus preventing injection. ·Neither the correct charge nor the correct load is selected. We observed that many darts bounced making it difficult to ascertain the amount of drug injected or its depth of penetration. Selection of an inappropriate charge results in unnecessary trauma. ·The preparation and use of darts, needles, and syringes lacks basic hygiene. ·Dart wounds are not treated and antibiotics are not administered. ·There is no understanding of stress or capture myopathy. ·The capture team was not aware that sternal recumbency severely compromises respiration in elephants and that they can quickly die in this position. ·It is believed that elephant restraints must inflict pain to prevent wild elephants from escaping once captured. ·There is no veterinarian on the capture team. The current capture techniques result in leg wounds from unprotected chains, neck wounds from "kahs" (neck yokes made of wood and wire), and abscesses from inappropriately administered darts. Leg and neck wounds often become maggot infested. Infections from dart wounds are, however, the primary cause of capture-related mortality. These abscesses can drain for several months, even with treatment, and often progress to a necrotizing fasciitis, acute sepsis, and death. The Riau Province KSDA Team has been receptive to suggested changes to minimize wounds. Provision of heavier chains has alleviated the fear that elephants will escape. Covering the chains with fire hose or heavy plastic minimizes injuries to legs and use of the kah has been discontinued. A basic dart wound treatment protocol has been established. In June 2003, a comprehensive Elephant Immobilization and Translocation Workshop for Sumatra is planned to retrain all of Sumatra's field teams and to upgrade equipment. Sumatra's wild elephant population probably numbers fewer than 3000 and is under continued threat. With so few elephants left, the preservation of as many viable herds as possible takes on increased urgency. The Moratorium achieved in 2001 has set the groundwork for KSDA to choose translocation of wild elephants rather than capture and placement into already over-crowded and under-resourced Elephant Training Centers. We cannot guarantee that Sumatra will capture elephants only for translocation, and it is inevitable that many more elephants will end up in captivity. Regardless, all of the elephants that must suffer the interruption of their lives at the hand of man deserve, at the very least, humane treatment. Translocations are neither simple nor a complete panacea. Identifying suitable translocation areas and insuring that elephants remain there are significant challenges. WWF-Indonesia is continuing its efforts to secure the lowland forest of Tesso Nilo in Riau Province as a "safe haven" for at least some of Sumatra's wild elephants (see WWF AREAS Program – Riau, Sumatra: http://www.worldwildlife.org/species/attachments/riau_profile.pdf). The identification of interim release sites, together with improved capture techniques, offers the hope that fewer elephants will be removed from the wild. ACKNOWLEDGMENTS: Our work in Sumatra has been supported by the Guggenheim Foundation, a CEF grant from the American Zoo and Aquarium Association, the International Elephant Foundation, Oregon Zoo, Columbus Zoo, Disney, Peace River Refuge, the Elephant Managers Association, the Riddles Elephant and Wildlife Sanctuary, Tulsa Zoo, Toronto Zoo, Niabi Zoo, San Antonio Zoo, Denver Zoo (AAZK Chapter), Milwaukee Zoo (AAZK Chapter), the Audubon Nature Institute (Youth Volunteers), Buttonwood Park Zoo, Melbourne Zoo, and private donors. Special thanks to Harry Peachey, John Lehnhardt, Holly Reed, Kay Backues, Mike Keele, Steve Osofsky, and Heidi and Scott Riddle.

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Review from Publishers Weekly: In this solid introduction to the world of elephants, Meredith covers all the major topics including biology, social behavior, recent scientific discoveries, ancient elephantology, the devastating ivory trade, the truth about elephant graveyards and the insistent threat of extinction. Meredith demonstrates that human involvement in elephantine affairs has been disastrous to the pachyderm: the quest for ivory had caused the extinction of all Syrian herds by 500 B.C.; many ancient cultures took elephants to war; and Romans used the animals in their blood sports. Much of the book follows the history of the European exploitation of Africa's three treasures: gold, slaves and ivory. The quantities of murdered elephants and descriptions of killing methodologies are deeply affecting. Once Meredith's history reaches modern times, the shock of population counts is astounding in comparison with the numbers of elephants that roamed free in the past. Aristotle's treatise on the animals' anatomy, behavior, diet and reproduction was the beginning of a long line of nterest, but only recently has science uncovered the answers to mysteries such as how separate herds coordinate movement over many miles. Meredith's primer on elephantine
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Conflict with humans over livestock and crops seriously undermines the conservation prospects of India's large and potentially dangerous mammals such as the tiger (Panthera tigris) and elephant (Elephas maximus). This study, carried out in Bhadra Tiger Reserve in south India, estimates the extent of material and monetary loss incurred by resident villagers between 1996 and 1999 in conflicts with large felines and elephants, describes the spatiotemporal patterns of animal damage, and evaluates the success of compensation schemes that have formed the mainstay of loss-alleviation measures. Annually each household lost an estimated 12% (0.9 head) of their total holding to large felines, and approximately 11% of their annual grain production (0.82 tonnes per family) to elephants. Compensations awarded offset only 5% of the livestock loss and 14% of crop losses and were accompanied by protracted delays in the processing of claims. Although the compensation scheme has largely failed to achieve its objective of alleviating loss, its implementation requires urgent improvement if reprisal against large wild mammals is to be minimized. Furthermore, innovative schemes of livestock and crop insurance need to be tested as alternatives to compensations. Centre for Ecological Research and Conservation, 3076/5, IV Cross, Gokulam Park, Mysore 570 002, India. mdm@ncf-india.org

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Crop raiding by wild elephants is one of the most significant sources of park-people conflict in Sumatra, Indonesia. The distribution, impact and conservation implications of elephant crop-raiding in 13 villages that border Way Kambas National Park in southern Sumatra were studied for 18 months. The data are based on rapid village and field assessments, data logs maintained by village observers and a quantitative household survey. Elephants raided crops year-round at a mean rate of 0.53 elephants per day for the entire study area. The frequency of crop raiding was related to vegetation type along the park border, the size and presence of rivers, and the distance to the park's Elephant Training Center (ETC), which houses about 150 captive elephants. Wild elephants damaged at least 450,000 sq m of corn, rice, cassava, beans and other annual crops, and close to 900 coconuts, banana and other perennial trees in the area surveyed. Elephants killed or injured 24 people over a 12-year period in villages near the park. Villagers try to reduce elephant damage by guarding fields, digging trenches between the park and their fields, and modifying their cropping patterns. Elephant-human conflict decreases the probability of support from local people for conservation efforts. We suggest methods to improve the effectiveness of existing elephant trenches, the need to consider electric fences, external support to affected villages, and compensation to villagers for any damage caused.

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With increasing frequency, the management of elephants outside protected areas in Africa has to address the problem of conflict between elephants and people in rural, agricultural situations. In the last decade, three major changes have occurred in the process of human-elephant interaction: the conflict interface has generally increased, even where the elephant range has contracted; elephants have acquired a much greater economic value; and wildlife management is becoming decentralised, with emphasis on utilisation for economic benefit. In Zimbabwe's unprotected areas, elephants are now simultaneously the most valuable wildlife resource and the greatest wildlife pest species. This paper outlines a systematic, more efficient approach to dealing with the problem of conflict, while still conserving elephant populations. It involves a simple system of assessing problem elephant activity over large areas, and using the information to formulate a district strategy which ameliorates, but does not eliminate, the burden of "problem" elephants. The relative merits and disadvantages of various traditional and contemporary methods of dealing with problem elephants are also discussed. Mention is made of research being conducted on the ecological nature of the interactive processes between human and elephant populations.

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The Sumatran elephant (*Elephas maximus sumatranus*) is the smallest of the three subspecies of the Asian elephant. Its numbers are estimated to be anything between 2,800 and 4,800 (Blouch & Haryanto 1984; Blouch & Simbolon 1985). Once widely distributed throughout the eight provinces of Sumatra, the animal has almost disappeared from two provinces and is under threat in the rest of the island from a host of development programmes such as logging, human resettlement, establishment of large-scale plantation estates, oil exploration, mining, irrigation and agriculture. The conversion of primary forest into agricultural holdings has been one of the causes of conservation problems in Sumatra and the elephant has been among the large mammals most seriously affected by it. Development programmes have led to the annual elimination of tens of thousands of hectares of elephants habitat. As their traditional migratory routes are blocked, habitats fragmented, the elephants are becoming increasingly confined to patches of forests that are surrounded by cultivated land. As Laws (1981) points out in the situation in East Africa, the situation in Sumatra too is reversing gradually "from one in which human islands existed in a sea of elephants, to a sea of people with elephant islands." These conditions have led to a dramatic increase in the scale of elephant depredations in Sumatra. In some cases the success of the development programmes has been threatened as a result of which, there has been a change in attitude by the planners in recognizing the need to take into consideration the ecological requirements of the elephant during the planning stage of any development programme. In return, the Directorate of Forest Protection and Nature Conservation (PHPA) which is primarily responsible for the conservation of elephant must match this recognition by the planners with realistic proposals to ensure the conservation of the species without leading to unacceptable conflicts. This paper is an attempt to reconcile elephant conservation with economic development in Sumatra.

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Full: Pelawatte Sugar Industries is located in the dry zone. The annual rainfall varies between 1000mm and 1350mm, with a mean annual temperature about 30`C. Until 1982 this area was a defuse secondary forest interspersed with grass land and thorny scrub. Elephants were present in this area previously but at a very low density until 1984 when sugar cane became the main cash crop of farmers living in this area. The problem aggregated this year with the elephant population increasing due to migratory herds. There were 3 to 4 human deaths per month while damages to houses were at much higher rate. It was decided to identify, capture and translocate 10 animals from the area as the first phase of this operation. This paper describes the methods used in capturing, securing and translocation of these animals to a sanctuary 70Km away.

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