Distributions of Large Mammal Assemblages in Thailand with a Focus on Dhole (Cuon alpinus) Conservation

DISTRIBUTIONS OF LARGE MAMMAL ASSEMBLAGES IN THAILAND

WITH A FOCUS ON DHOLE (*CUON ALPINUS*) CONSERVATION

A Dissertation Presented

by

KATE E. JENKS

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DEDICATION

In memory of Dr. Jo Gayle Howard, D.V.M., Ph.D.,

Theriogenologist, Smithsonian Institution National Zoological Park—scientist, conservationist, mentor. Her frequent flier miles first got me to Thailand and her fundraising efforts gave me the opportunity to open a new chapter of research and of my life in the country. Seeing the thrill in her eyes and passion for clouded leopards brought enthusiasm back to my outlook many times.

I am honored to have had the opportunity to work with Jo Gayle

and to be a member of a team doing exciting and valued work.

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I thank my friends and family for their endless support and encouragement during the challenges of this project. My family understood when I was not around for holidays and didn't complain about me living half-way around the world even though there were dangers of malaria, tsunamis, and civil unrest.

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Lastly, thanks to my parents, for always being supportive and cheering me on.

ABSTRACT

DISTRIBUTIONS OF LARGE MAMMAL ASSEMBLAGES IN THAILAND

WITH A FOCUS ON DHOLE (*CUON ALPINUS*) CONSERVATION

MAY 2012

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Biodiversity monitoring and predictions of species occurrence are essential to develop outcome-oriented conservation management plans for endangered species and assess their success over time. To assess distribution and patterns of habitat use of large mammal assemblages in Thailand, with a focus on the endangered dhole (*Cuon alpinus*), I first implemented a long-term camera-trapping project carried out with park rangers from October 2003 through October 2007 in Khao Yai National Park. This project was extremely successful and may serve as a regional model for wildlife conservation. I found significantly lower relative abundance indices for carnivore species, and collectively for all mammals compared to data obtained in 1999-2000, suggesting population declines resulting from increased human activity. I integrated this data into maximum entropy modeling (Maxent) to further evaluate whether ranger stations reduced poaching activity and increased wildlife diversity and abundances. I then conducted a focused camera trap survey from January 2008 through February 2010 in Khao Ang Rue Nai Wildlife Sanctuary to gather critical baseline information on dholes, one of the

predator species that seemed to have declined over time and that is exposed to continued pressure from humans. Additionally, I led a collaborative effort with other colleagues in the field to collate and integrate camera trap data from 15 protected areas to build a country-wide habitat suitability map for dholes, other predators, and their major prey species. The predicted presence probability for sambar (*Rusa unicolor*) and leopards (*Panthera pardus*) were the most important variables in predicting dhole presence countrywide. Based on my experience from these different field ecological surveys and endeavors, it became clear that local people's beliefs may have a strong influence on dhole management and conservation. Thus, I conducted villager interview surveys to identify local attitudes towards dholes, document the status of dholes in wildlife sanctuaries adjacent to Cambodia, and determine the best approach to improve local support for dhole conservation before proceeding with further field studies of the species in Thailand. A photograph of a dhole was correctly identified by only 20% of the respondents. My studies provide evidence that some protected areas in Thailand continue to support a diversity of carnivore speices of conservation concern, including clouded leopards (*Neofelis nebulosa*), dholes, and small felids. However, dholes' impact on prey populations may be increasing as tiger (*Panthera tigris*) and leopards are extripated from protected areas. The next step in dhole conservation is to estimate the size and stability of their fragmented populations and also focus on maintaining adequate prey bases that would support both large felids and dholes.

PREFACE

Thailand stretches nearly 2,000 km from north to south and the climatic diversity and topographic complexity result in a country rich in biodiversity. The country's biodiversity index ranked 9.8, the highest in Indochina (MacKinnon & MacKinnon 1997). Thailand supports approximately 120 species that are endemic to mainland Southeast Asia (ICEM 2003). Overall, vertebrates number at least 3,000 species, including 265 mammals (ICEM 2003). Thailand's biodiversity is conserved through a protected area system inaugurated in the 1960's. As of 2002 there are 81 terrestrial national parks encompassing 46,453 km^2 of the country, 55 wildlife sanctuaries covering 35,476 km^2, and 55 non-hunting areas that protect 4,409 km^2 (ICEM 2003).

Degradaton caused by rapid population growth continues to threaten wildlife habitats throughout Thailand, including the country's protected areas. The protected area system is fragmented with many areas too small to sustain viable populations of large mammals, such as tigers (*Panthera tigris*), leopards (*Panthera pardus*), elephants (*Elephas maximus*), and Asian bears (*Ursus thibetanus*; ICEM 2003). Conservation of these charismatic megafauna species may require targeted management of areas outside the protected area system, which probably is much too small to sustain substabtial populations of species with large area requirements. Although both national parks and wildlife sanctuaries explicitly prohibit agricultural use and extraction of forest products, these regulations frequently are not or cannot be effectively enforced on the ground. Habitat loss in combination with subsistence hunting and illegal wildlife trade continue to push many of Thailand's wildlife species towards extinction. These threats are prevalent throughout all of Thailand, including national parks and wildlife sanctuaries, despite increasing awareness and wildlife protection efforts by the government and civil society (Martin & Redford 2000, Corlett 2007).

Khao Yai National Park (KYNP) was the first national park established in Thailand in 1962 and has the potential to represent a regional model for wildlife conservation because of its status as the most visited park, its symbol of nature conservation to the Thai people, and the fact that park positions here are traditionally the jumping off point for higher positions in the government's Forest Department (Chape 2005). Since Khao Yai is only 200 km from Bangkok, Thailand's capital and largest city, it is a popular destination for Thai and foreign tourists.

The collaborative research efforts I undertook were designed to provide the park with a monitoring system that would allow park managers to identify wildlife conservation hotspots and to monitor wildlife trends. These data are useful for assessing the effectiveness of current park management actions and elucidating the impacts of poaching on wildlife populations. Beginning in October 2003, KYNP established a Carnivore Conservation Project (CCP), with support from the Smithsonian Institution and WildAid Foundation (now FREELAND). A monitoring team of KYNP park rangers conducted the project field surveys. The rangers were selected during a 12-day training course for rangers from the Dong Phayayen-Khao Yai Forest Complex. During the course, participants were challenged with topics covering the scope of the field research process, from planning field surveys, to systematic data collection and reporting of data, and adapting future survey plans based on findings. The course covered wildlife monitoring techniques including recce surveys, line transect surveys, and camera traps to increase the capacity of park rangers for biodiversity monitoring.

In **Chapter 1** I report on a large camera-trapping survey effort in KYNP from October 2003 through October 2007 and present these data as an example to demonstrate the usefulness of long-term camera-trapping by park staff. Our research design followed previous examples but significantly expanded sampling beyond the core area to include all zones and

edges of the park. This allowed us to compare relative abundance indices (RAIs) for mammals to data obtained in 1999-2000 from 34 similar survey sites, but also assess whether these core areas were significantly different in species composition, biodiversity, and relative abundance from areas along the park's edges. Finally, the stratification into core and edge areas allowed us to a) assess the relative impact of human activities on wildlife and b) evaluate the effectiveness of ranger stations located along the perimeter of KYNP in reducing poaching and increasing wildlife populations.

I used maximum entropy modeling (Maxent) to evaluate the impact of ranger stations on wildlife and poacher distributions in **Chapter 2**. Human activity beyond recreation zones in KYNP is a continuing threat for the park's wildlife and may be a widespread phenomenon. I determined the distribution of ungulates and poachers near ranger stations in the park and considered the impact of infrastructure development on human disturbance and poaching. I also assessed how the impact of increased patrolling and the magnitude of intruders could be continuously monitored using remote cameras.

During our field work in KYNP, the Thailand Department of National Parks, Wildlife, and Plant Conservation (DNP) expressed interest in dhole (*Cuon alpinus*) research citing a concern that large dhole packs could attack tourists. The dhole, or Asiatic wild dog, is an example of a Southeast Asian carnivore that is threatened with extinction, but overlooked with regards to conservation initiatives (Durbin et al. 2004). This knowledge gap stems from a lack of basic ecological information on the species and because dholes are overshadowed by other charismatic carnivores like tigers. No comprehensive population studies have ever been conducted for dholes, nor has there been an extensive threat evaluation because the species is rare and difficult to observe. And, although park staff believed the dhole is over abundant in

KYNP, I was concerned that their impressions were invalid. For example, the management at KYNP believed that dhole populations in the park were increasing rapidly with a negative effect on sambar deer. Senior rangers were debating culling as an option to curtail dhole populations to maintain a high density of prey species to support other predators such as tigers. However, there was no scientific evidence on dhole or prey populations that supoorted such management decisions, further highlighting the ad-hoc approach to management of this endangered canid.

In response to this lack of data on dholes, I initiated an intensive field study of dholes in Khao Ang Rue Nai Wildlife Sanctuary (KARN) in eastern Thailand. I chose KARN as the focal study area because it has a well-establish research station, is protected but does not allow high tourist numbers, and dholes are regularly seen inside the sanctuary. **Chapter 3** is an overview of our photo-trapping survey at KARN during January 2008 through February 2010. We sought to document dholes' activity and breeding status in KARN, measure mean daily distance traveled and activity patterns, and identify areas where dholes and domestic dogs use overlapping areas because domestic dogs can be an important reservoir for diseases that may spillover to threatened species. Data from this project could also be used in support of dholes as a non-threat to humans by documenting their range within the protected area through camera traps and visually showing that the packs do not range into villages.

To sustain viable populations of dholes, the availability of forest cover and prey species is important. To this end, in **Chapter 4** I report on my effort to map the country-wide distribution of dholes in Thailand. To delineate potential dhole distribution and provide a conservation basis for the species, I used Maxent to provide predicted probability of presence for dholes. The Maxent model also provides information on the significance of environmental variables in predicting dhole presense. I estimated the total land area in Thailand that is

potentially suitable for dholes and considered the prey base as an important factor determining the continued survival of dholes. Using the model, I also identified several potential areas where dholes have not been reported and status surveys are needed, and areas where dholes occur and future research of the species is needed.

Finally, to understand local people's beliefs before managers can make efforts to improve the conservation awareness of dholes, I conducted villager interview surveys to (1) identify local attitudes towards dholes, (2) document the status of dholes in wildlife sanctuaries adjacent to Cambodia, and (3) determine the best approach to improve local support for dhole conservation before proceeding with further field studies of the species in Thailand. I conducted 791 interview surveys at seven protected areas and report the results in **Chapter 5**. Respondents were asked to report sightings of dholes near all of the protected areas surveyed, but we also tested their ability to correctly identify dholes. In addition, we explored local people's attitudes toward dholes and if they believed the species should be protected in the park and surrounding forests.

The final chapter, **Chapter 6**, is an overview of my findings as they relate to future conservation efforts at KYNP and filling critical information gaps on the status of dholes.

The chapters of this dissertation were written in the form of a series of scientific papers that are structured around a common theme. They were meant to be published as individual manuscripts and therefore some information may be repeated among chapters. Research efforts are necessarily collaborative and chapters resulting from this work use the pronoun "we" instead of "I," though I am the first and corresponding author in all respects on each chapter. Co-authors are named at the beginning of each chapter. Content from Chapter 1 has been

published in *Tropical Conservation Science* (TCS). Copyrights of manuscripts published in TCS belong to the authors and fall under a Creative Commons Attribution License. Content from Chapter 2 is in press in *Biotropica*. Authors of articles published in *Biotropica* retain copyright in the Article and give the society or publisher an exclusive license to publish. Content from Chapter 3 is in press in *Canid News*. Articles in*Canid News* are published continuously as an issue-in-progress. From 2001 to the present, the entire journal has been published on-line. Content from Chapter 4 is in press in *Mammalia*. Authors of articles published in *Mammalia* retain copyright in the Article and give the publisher an exclusive license to publish. Appendix B has been published in *Small Carnivore Conservation*.

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USING RELATIVE ABUNDANCE INDICES FROM CAMERA-TRAPPING TO TEST WILDLIFE CONSERVATION HYPOTHESES – AN EXAMPLE FROM KHAO YAI NATIONAL PARK, THAILAND

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Abstract

Khao Yai National Park (KYNP) is well known for its biodiversity and has the potential to serve as a regional model for wildlife conservation. From October 2003 through October 2007, the managers of KYNP conducted a Carnivore Conservation Project to develop and implement long-term monitoring of their large mammal populations. We present these data as an example to demonstrate the usefulness of long-term camera-trapping despite data that cannot be fitted to mark/recapture or occupancy statistical frameworks. Overall, a relatively high number of

camera trap photographs was obtained for viverrids (four species; 44 photos) and ursids (two species; 39 photos). However, a relatively low number (range, one to eight) of camera trap photographs was obtained for each of the four felid species and two canid species. Of a total survey effort of 6,260 trap nights, no Tigers (*Panthera tigris*) were detected by camera traps, suggestive of at best a small, non-viable Tiger population. Compared to previous camera-trapping efforts at KYNP, we expanded intensive sampling beyond the core area to include all zones and edges of the park. We found significantly lower relative abundance indices (RAIs) for certain mammal species, and collectively for all mammals compared to data obtained in 1999-2000 from 34 similar survey locations, suggesting population declines linked to increased human activity. Information from long-term camera-trapping can provide critical information on the occurrence of elusive species, hotspots, the role of invasive or domestic species, and an indication of the effectiveness of patrolling and other management and conservation interventions.

Introduction

Camera-trapping has long been used to survey for and monitor the occurrence of wildlife species around the world (e.g. Carbone et al. 2001, Jackson et al. 2006, Li et al. 2010, Linkie et al. 2007, Morruzzi et al. 2002). Much attention has been focused on using camera-trapping to detect otherwise elusive species, including charismatic examples such as Tigers (e.g. Carbone et al. 2001), Snow Leopards (*Panthera uncia*; e.g. Jackson et al. 2006), and Giant Panda (*Ailuropoda melanoleuca*; Li et al. 2010). Initially, much of this camera-trapping was relatively untargeted and data collection was not standardized. Overtime, these efforts have been replaced by more systematic sampling approaches, often centered on identifying individual animals in a mark-recapture framework (e.g. Carbone et al. 2001, Jackson et al. 2006), or using

patch-occupancy approaches to assess detection probabilities for species presence/absence (e.g. Linkie et al. 2007). However, photos collected by less statistically sound sampling designs may still provide large amounts of useful data. The sheer volume and importance of this data is exemplified by a new internet site hosted by the Smithsonian Institution, where camera-trappers from around the world, including a wide range of contributors from scientists to the general public, can post their photos and data (http://siwild.si.edu). Using the example of Khao Yai National Park (KYNP) in Thailand, we illustrate the value and usefulness of camera trap photos from generic monitoring surveys. Camera traps can indicate relative abundance of a species with the assumption that photo detection rates are related to animal abundance (Morruzzi et al. 2002). We used monitoring data obtained by ranger-based surveys to 1) assess relative abundance indices (RAIs) for important wildlife species, 2) calculate what camera-trapping effort may be necessary to detect most large-mammal species to assess a sampling/monitoring strategy, and 3) identify how these data can be used to delineate carnivore hotspots for special management and protection inside protected areas.

KYNP is Thailand's first National Park established in 1962, and covers 2,168 km^2. It has been the focus of a few long-term wildlife monitoring programs (Poonswad et al. 2005, Brockelman et al. 1998), and has the potential to represent a regional model for wildlife management because of its status as one of the largest National Parks in this country, its importance to the Thai people (Chape 2005), and its status as part of the Dong Phayayen-Khao Yai Forest Complex (DPKYC), a UNESCO World Heritage site (UNESCO 2008). The DPKYC includes five protected areas totaling 6,155 km^2 of natural habitat supporting significant biodiversity components for Thailand, potentially including 391 bird and 60 mammal species (Lynam et al. 2006). Of the mammal species found within the complex, 46 species have been documented

within KYNP. There have been detailed studies in KYNP providing valuable information on carnivore species, including Tiger, Leopard Cat (*Prionailurus bengalensis*), and Clouded Leopard (*Neofelis nebulosa*; Austin & Tewes 1999, Suzuki et al. 2006, Lynam et al. 2003, Austin et al. 2007a,b). However, many of KYNP's mammalian species are understudied and information about them was obtained secondhand, often as part of Tiger surveys.

We present KYNP as an example to demonstrate how basic and continued wildlife monitoring using standard camera-trapping can be used as an integral tool for park management and anti-poaching efforts in protected areas of the region. We use the data to assess the spatial distribution of wildlife and identify potential conservation hotspots for carnivores. Such monitoring will prove extremely useful for site-level efforts to combat poaching and illegal wildlife trade. It can also provide baseline data for subsequent targeted studies using more specialized sampling and study designs such as mark/recapture and patch occupancy.

Methods

The Study Area

Surveys were conducted in KYNP (14º26'29''N; 101º22'11''E) at the western edge of the DPKYC, Thailand. Elevation at KYNP ranges from 100 m to 1,350 m. The climate is monsoonal, with distinctive wet (Jun.-Sep.), cool (Oct.-Jan.), and dry (Feb.-May) seasons. Annual rainfall is 2,270 mm; mean annual temperature is 27ºC. More than 80 percent of the park is forested. Vegetation types include tropical rainforest, dry evergreen forest, hill evergreen forest, mixed deciduous forest, dry dipterocarp forest, and grassland (Srikosamara & Hansel 2000). Mixed

deciduous forest is the dominant type with hill and dry evergreen forest occupying higher elevations.

Zone-Based Monitoring and Seasonal Data Collection

A monitoring team of KYNP park rangers conducted the field surveys. The rangers were selected following a 12-day training course for rangers from DPKYC. During the course, participants were challenged with topics covering the scope of the field research process, from planning field surveys, to systematic data collection and reporting of data, and adapting future survey plans based on findings. The course covered wildlife monitoring techniques including line transect surveys and camera-traps to increase the capacity of park rangers for biodiversity monitoring.

Camera trap surveys were conducted from October 2003 through March 2007 with sampling conducted in each of KYNP's 22 management zones (Fig. 1.1). Management zones are of unequal size and approximately follow watershed boundaries. Teams surveyed two zones per month. We randomly selected survey zones each month, but ensured that all zones were monitored at least once during the study. We randomly chose four zones (KY04, KY15, KY18 and KY20) for repeated data collection across each season. We could only repeat four zones in each season because of time and staff constraints. The repeated data collection of four management zones did not involve replicated camera sample locations, rather new randomly selected grid-squares were chosen.

Camera Trapping

To detect and record wildlife, we employed 15 camera traps (CamTrakker® CamTrak South, Inc., Watkinsville, GA 30677 USA) with an infrared sensor to detect animal movement.

Camera traps did have visible flash which may have been detected by wildlife or people. During each month, four to eight camera traps were placed in each of the two survey zones dependent on the number of working cameras. We divided survey zones into 1-km^2 blocks and randomly chose blocks for camera locations. Within the block, teams set up camera traps along wildlife trails and stream beds. Thirty-four sampling locations were chosen because they had been used by a previous monitoring program (Lynam et al. 2003) and therefore we were interested in comparing our results with that study. We aimed to leave camera traps in the forest for three weeks since previous experience with this model (Lynam et al. 2003) indicated this was the expected life of the batteries. Due to work schedule conflicts, cameras were often picked up earlier or later, but were only retrieved after a minimum of 21 days. We conducted camera surveys at 217 locations (Fig. 1.1), resulting in 6,260 trap nights. Camera traps at an additional 44 locations did not yield data because they malfunctioned or were stolen, lost, or damaged by weather, Elephants (*Elephas maximus*), or poachers.

All camera traps were operational 24 hrs per day, recorded time and date for each exposure, and had a 20-sec delay between photographs. We placed camera traps on a tree ~50 cm from the ground and 1-2 m from the monitoring area. We aimed the sensor parallel to the ground to monitor a conical area approximately 1 m in diameter at 10 m distance. We report number of animal detections and an RAI for each species. To compute the RAI for each species, all detections for each species are summed for all camera traps over all days, multiplied by 100, and divided by the total number of camera trap nights. We calculated RAI for each species as the number of photo captures per 100 trap nights to facilitate comparisons with previous studies at the same site (Lynam et al. 2003) and other parts of the region. Animal detections were considered independent if the time between consecutive photographs of the same species

was more than 0.5 hours apart, a convention which follows O'Brien et. al. (2003). Rather than identifying individuals, our focus was on comparing photo rates between areas and seasons, so the arbitrary time between independent photos should not introduce bias toward either one of these factors. Furthermore, this time of independence was used for data collection during a previous survey (Lynam et al. 2003). Photos with more than one individual in the frame were counted as one detection for the species.

To evaluate the effect of season on wildlife RAIs, we used a Kruskal-Wallis test. For analyzing differences in mammal RAIs between the edge of the park (< 5 km from boundary) and the park's interior (≥ 5 km from boundary), we performed a two-sample t-test. Five kilometers was chosen for a buffer because it falls between the maximum distance from the edge and mean distance from the edge that Domestic Dogs were detected and serves as a proxy for the penetration of human-disturbance from the forest edge. To quantify the optimal number of camera trap locations (i.e., how many locations needed to be sampled to capture most of the diversity of KYNP), we plotted mammal species detected against sample locations and fitted a hyperbola curve. We repeated this analysis to obtain species accumulation curves for carnivores only and other mammal species, respectively. To understand the time required to detect mammals if they are present at a sampling location, we plotted the frequency distribution of nights to first detection for carnivore or non-carnivore species and used curve fitting to determine the peak. All curve fitting was done using SigmaPlot 10.0 (Systat Software, Point Richmond, CA).

To offer a baseline to interpret our camera-trapping results, we compared our RAIs for all photographed species to data from camera-trapping surveys done at KYNP during 1999-2000 (Lynam et al. 2003). It is difficult to compare RAIs between projects because of differences in

detection probabilities at different locations; therefore, we only included sample locations that we could pair directly with locations from the previous survey (located < 2.5 km apart; n = 34 pairs). We performed a Wilcoxon signed-rank test to test the null hypothesis that there is no difference in a species' RAI between our current surveys and the surveys conducted four to six years previously.

Camera traps also recorded human traffic (rangers, visitors, poachers, villagers) and Domestic Dogs. Poachers were identified if they were carrying a gun, a carcass or animal parts, a bag to transport plant material/tree bark, or were accompanied by a dog.

Spatial Modeling

To assess the spatial distribution of all wildlife qualitatively we selected a priori environmental factors to investigate their effect on wildlife spatial distribution. The environmental factors included distance (m) to nearest human or Domestic Dog photo detection (*Intruder)*, distance (m) to nearest ranger (*Staff*), distance (m) to nearest poacher, villager, or Domestic Dog (*NonStaff*), distance (m) to park boundary (*Edge*), and elevation (m; *Elev*). We used ArcGIS 9.2 Spatial Analyst, a Geographic Information System (GIS) software program developed by ESRI, to calculate all distances using the Euclidian distance function. Elevation was taken from a digital elevation map supplied by the park.

We then used multiple logistic regression to explore the associations between the detection/non-detection data for wildlife as the dependent variable and the five environmental factors as the independent variables. We used an information-theoretic approach and Akaike's Information Criterion (AIC) to choose the model with the highest likelihood value and to weight (through model averaging) the relative likelihoods (importance) of the different predictor

variables. We divided the data set into a 75 percent training subset and a 25 percent testing subset, which resulted in 144 wildlife detections from 215 survey locations (two survey locations were dropped due to incorrect GPS locations that were not located within the park).

We created a predictive occurrence map in ArcGIS using map algebra in the Spatial Analyst raster calculator. To delineate areas with better than by chance prediction of wildlife, we used a-priori prevalence values (144 wildlife detection locations out of 215 total locations) as the "presence" threshold (0.67 detection). We calculated the classification accuracy of the model using the testing subset in a contingency table.

Results

Species Accumulation, Sampling Effort, and Trap Nights

Camera traps recorded 650 photographs, of which 19.8% (n = 129) were of carnivores, 42.8% (n = 278) were of non-carnivore mammals, 22.9% (n = 149) were of birds, 8.2% (n = 53) were of humans, and 2.6% (n = 17) were of Domestic Dogs. We could not determine species in 3.7% (n = 24) of the photographs due to poor focus, lighting, or angle. Species captured on film included 26 mammals (14 carnivore species; 12 non-carnivore mammal species).

RAIs did not differ among seasons (Kruskall-Wallis: 1.704, p = 0.427). Inspection of species accumulation curves showed that the number of locations varied to capture 75 percent of non-carnivore mammals (23 locations), all mammals (53 locations), and carnivore species (75 locations) at KYNP (Fig. 1.2A). Time (nights) to first detection showed a skewed distribution for detecting non-carnivores (max: 1.5 days) and carnivore species (max: 2.7 days; Fig. 1.2B). After 14 days, 80 percent of all camera traps had captured at least one mammal species (Fig. 1.2B).

For individual species, days to first detection ranged from three (Binturong [*Arctictis binturong*]) to 23 (Palm Civet [*Paradoxurus hermaphroditus*]; Fig. 1.3).

Carnivores

Based on camera-trapping, we found 14 carnivore species in the park, including four viverrids, four felids, two canids, two ursids, one mustelid, and one herpestid (Fig. 1.4). Of these species, 10 were documented 10 times or less, and one species (Dhole [Cuon *alpinus*]) is globally threatened (Endangered; IUCN, 2008; Fig. 1.4). The number of photos per carnivore species ranged from one for Marbled Cat (*Pardofelis marmorata*; RAI = 0.02; Fig. 1.4) to 37 for Large Indian Civet (*Viverra zibetha*; RAI = 0.59; Fig. 1.4). Asiatic Black Bear (*Ursus thibetanus*; n = 21) was the second-most common carnivore species photographed (Fig. 1.4). Camera traps did not detect Tiger. The coat pattern of the Clouded Leopards that we observed in KYNP is similar to those of mainland Southeast Asia Clouded Leopards and different to the Clouded Leopard (*Neofelis diardi*) on Borneo and Sumatra (Kitchener et al. 2006; Fig. 1.5).

Non-Carnivorous Mammals

Barking Deer (*Muntiacus muntjak*; 60 photos) and Eurasian Wild Pig (*Sus scrofa*; 60 photos) were the two most common herbivore species detected during camera trap surveys (Fig. 1.4).

Human Traffic

In addition to documenting the presence and distribution of wildlife, camera traps also recorded human traffic (poachers, rangers, villagers, tourists) and Domestic Dogs inside the park (n = 70; Fig. 1.4). The majority of poacher photographs were taken on the eastern

boundary of the park (Fig. 1.6A); however, Domestic Dogs (most likely accompanied by people) intruded well into the interior of the park (mean distance from edge = 2.72 km; maximum distance from edge = 6.59 km; Fig. 1.6B).

Wildlife Distribution

We found a significant difference in wildlife RAIs between interior zones of the park and zones near the boundary (< 5km from the park boundary; $t(94.434)= 2.755$, $p=0.007$). More interior zones of the park supported a larger average RAI (0.141) than surrounding areas (0.078). Jackals (*Canis aureus*) were only detected at one location and were less widely distributed than Dholes (Fig. 1.6B). While both bear species and prey for mid- to large carnivores were distributed throughout the park, felids were found central and to the northwest corner of the park (Fig. 1.6C, D, E). In KY20, we photographed three felid species (Leopard Cat, Asiatic Golden Cat [*Pardofelis temminckii*], and Marbled Cat) at the same location within 12 days of each other. Additionally, KY09 yielded a location with at least four species of carnivores (Large Indian Civet, Binturong, Mongoose species [*Herpestes spp*.], and Asiatic Black Bear).

Our global model (before parameter selection) contained five co-variables. The best model fit included Elev (Table 1.1). Wildlife detections increased as elevation increased. We then produced a predictive occurrence map (Fig. 1.6F) from the logistic function of the chosen model (Table 1.2) and calculated the ability of the model to correctly predict wildlife presence for our sub-set of testing data. Overall, the model correctly predicted wildlife presence/absence at 60 percent of the 65 test locations used in the analysis. The total area of predicted wildlife presence is 1,344 km^2 which amounts to 62 percent of the total park area.

Comparison with Previous KYNP Data

Since differences in RAIs may be a result of a number of factors including differences in detection probabilities between surveys, we report only the strongest differences in RAI as indication of true differences in species abundance. In comparison with past surveys by Lynam et al. (2003) conducted in 1999-2000, we detected a significant difference in Clouded Leopard (Z=-1.992, p=0.046), Barking Deer (Z=-2.939, p=0 .003), all combined mammals (Z=-2.671, p=0.008), and overall intruders (any humans and Domestic Dogs; Z=-3.438, p=0.001; Table 1.3).

Discussion

Species Numbers

Our project built on previous wildlife monitoring in KYNP (Lynam et al. 2003) by including previously under-surveyed management zones close to the boundary of the park. Camera-trapping is one monitoring tool available to park authorities for evaluating the occurrence of some medium-large mammals, and to estimate relative abundance patterns across management zones for species that are highly detectable by camera traps. Fourteen out of the 19 carnivore species previously confirmed for KYNP (Lynam et al. 2006) were also detected by our camera traps. We did not photograph Small Indian Civet (*Viverricula malaccensis*), Masked Palm Civet (*Paguma larvata*), Yellow-throated Marten (*Martes flavigula*), Ferret-Badger (*Melogale sp*.), or Tiger. A previous monitoring program (Lynam et al. 2003) also did not detect these species (apart from Tiger). Yellow-throated Marten, Masked Palm Civet, and Ferret Badgers are primarily arboreal and so camera traps may not be effective in detecting these species. Small Indian Civet was detected in one photo in May 2007 in the Headquarters Zone during a short camera-trapping survey outside of our main survey efforts. While we did

not obtain photographic evidence of Tigers, the last footprint evidence of Tiger occurrence in KYNP is a record documented with a plaster cast and photograph taken by our team in the headquarters zone in October 2005 (47P 0754639 1599044; Fig. 1.7). Because Tigers were not recorded by camera-trapping, this adds evidence to the notion that the species has disappeared from the park other than perhaps transient individuals. Additionally, we supplemented park records with detections of previously unrecorded rare and elusive species: Large-Spotted Civet (*Viverra megaspila*) and Golden Jackal.

Wildlife Distribution Patterns

Distribution patterns detected in our study indicate that wildlife relative abundance in KYNP is significantly higher in central parts of the park than in marginal areas near park boundaries. This concurs with the findings of a previous study that found track encounter rates and camera trap rates for mammals decline with increasing distance from the park headquarters towards the park edge (Lynam et al. 2003). A similar pattern was documented for bears, elephants, and ungulate species in KYNP through universal kriging (Trisurat 1997).

Most carnivore species were not widely dispersed across sampling locations, but clustered in a few locations. Notably, we detected three felid species (Leopard Cat, Golden Cat, and Marbled Cat) with the same camera in zone KY20, adjacent to the park headquarters zone. The survey location was along a ridge-line which may have been a natural travel route for the felids. Additionally, the high elevation of the area may be less accessed by people, reducing human impacts. The three observations are in agreement with previous findings that small cat sympatry is the norm in Southeast Asian forests (e.g. Rabinowitz & Walker 1991, Nowell & Jackson 1996, Grassman et al. 2005b). These observations are of management interest because

the presence of three wild felids may indicate sufficient prey resources for all species, and/ or natural protection from humans that benefits all species along the ridge of this management zone.

Detecting Poachers and Domestic Dogs

Camera traps provided direct evidence of poaching including photos of individuals carrying turtles, birds, and other forest products, and/or carrying rifles at night using headlamps. Furthermore, nine camera traps were stolen or destroyed by poachers apparently concerned that they would be identified by authorities. These events were concentrated along the eastern border of the park furthest from the park headquarters, indicating human pressures are greatest in management zones KY04, KY05, KY06, KY07, KY08 and KY09 (Fig. 1.6A). While a significant portion of the poaching in Khao Yai is still carried out by people who live in villages adjacent to the protected area, some of the poaching for aloewood (*Aquilaria crassana*) and wildlife is carried out by Cambodian nationals who leave trash with identifiable Khmer script. These workers illegally enter Thailand, move into the park from the east, and extract wildlife products to sell in Cambodian and Thailand markets (Wongkorawutl 2006).

Camera traps recorded Domestic Dogs roaming as far as 7 km from the park boundaries. These are most likely hunting dogs entering the park alongside their owners, since domestic/feral dogs from surrounding villages would only forage short distances into the park on their own. However, wherever they are, dogs undoubtedly increase hunting pressure on prey species and also must be considered competitors of native scavengers (Butler & duToit 2002). In addition, they occasionally may kill other carnivore species such as Civets and Dholes (Williams 1935, Dahmer 2001). Finally, Domestic Dogs are well known carriers for diseases such

as rabies, canine distemper virus (CDV), and canine parvovirus that have led to epidemics in a variety of wild carnivore species, such as African Wild Dogs (*Lycaon pictus*), Lions (*Panthera leo*), and Ethiopian Wolves (*Canis simensis*; Alexander & Appel 1994, Roelke-Parker et al. 1996, Sillero-Zubiri et al. 1996, Laurenson et al. 1998, Appel & Summers 1995). Potential consequences of disease spill-over that Domestic Dogs might have on the wildlife of KYNP are far-reaching. For example, CDV, is reported to not only affect Canids, Felids, and Hyaenids, but also Mustelids (e.g. Otters), Procyonids (Raccoons), Ursids (Bears), and Viverrids (e.g. Civets; Appel & Summers 1995). Based on our documented dog ranging behavior into KYNP, and home range sizes for feral dogs reported to be up to 10.5 km^2 (Scott & Causey 1973), there is high potential for contact (direct or indirect) between Domestic Dogs and carnivores in KYNP that could lead to transmission of fatal, infectious diseases.

Changes in Relative Abundance

Overall mammal abundance is different in KYNP and perhaps has declined in the four to six years since the Khao Yai Conservation Project was initiated by Wildlife Conservation Society. While cause and effect have not been measured, our data showed significantly lower RAIs for Clouded Leopard, Barking Deer, humans, and mammals in KYNP. To evaluate our reported RAIs, it is helpful to consider that in Thailand's largest National Park, Kaeng Krachan National Park, where Asiatic Leopards (*Panthera pardus*) are the dominant large carnivore, Leopards were detected 3.71 times per 100 camera-trap nights (Ngoprasert et al. 2007), double the RAI of the most abundant carnivore at KYNP (Large Indian Civet, Table 1.3). This suggests that the relative abundances of mammalian predators and their prey in Khao Yai are suppressed, and this may be related to increased human activity. Supporting the possibility of impact from human activity is the relative variable importance calculated from the averaged model parameters of all possible

models. Elevation was the most important variable impacting wildlife presence and wildlife detections increased as elevation increased. This may be because higher elevations of the Park are less accessible to poachers.

In turn, the suppressed wildlife abundances in KYNP may be related to decreased or less effective patrol activity in the second phase of the Khao Yai Conservation Project compared to the first few years (2000 – 2003). Both Clouded Leopards and Barking Deer are common targets for poachers and subsistence hunters at Khao Yai (K. Jenks, unpublished interview data). Furthermore, even though total human RAI values were significantly lower in comparison with past surveys, we may have underestimated the amount of human traffic as it is highly likely that people became increasingly aware of the cameras and actively avoided them.

Estimating Abundance

RAIs are not synonymous with an actual index of relative abundance because they have not been correlated with data on population size of each species. However, it is still useful to explore patterns in our camera trap data since relatively little camera trap data has been published from this region. Much camera-trapping data that has been collected across Asia has been the result of opportunistic sampling. While this data does not qualify for statistical trend analysis in the same way as occupancy modeling, the presentation of the data itself is useful as it can be used to inform decision makers. For example, recorded presence of a rare species is valuable by itself. The evidence from KYNP is compelling and indicates that wildlife populations continue to decline in this protected area.

Mark/recapture and patch occupancy provide extremely useful tools for the detection of trends in wildlife population abundance and species presence/absence. The main advantages

they offer are explicit treatment of detection probabilities, error assessments, and estimation of confidence intervals (MacKenzie et al. 2006). However, not all data can be collected in this way for a wide range of reasons from lack of technical capacity to logistic, or simply that fact that we are dealing with legacy data that was collected before the application of the technique had found its way into general practice. Yet, data from these studies are still valuable and should be used to address research and conservation questions.

Our data represents one of the legacy projects, where the principal investigators at the time were not familiar with a patch occupancy framework for data collection and analysis. Post-hoc fitting of our sampling scheme into an occupancy analysis was not possible because of the small number of independent sample locations (fewer than six) in each zone during a sampling period and because of the violation of closure over such a long sampling period. However, we demonstrated how this presence data can be used in spatial modeling and regression analysis to study the spatial distribution of wildlife and human intruders. We also showed how it can be used to identify potential conservation hotspots for selected taxonomic groups, such as carnivores.

Implications for Conservation

Other Protected Areas and Carnivore Communities

Our monthly placement of camera traps provided a comparison across all seasons and also yielded useful information for future monitoring programs. Because of the lack of significant difference in RAIs among seasons, we recommend that future studies concentrate surveys during the dry season. This would greatly reduce the weather related camera malfunctions in the tropical environment, while not losing data on species detections.

We recommend that 75 randomly placed sample locations within a grid system throughout a large study area are enough to detect mammal species over an area of approximately 2,000 km^2 of similar forest type. Our data demonstrate that most of the mammal species at KYNP could likely be documented by sampling fewer than 75 locations, and based on our species accumulation curve, adding additional sampling locations would not have substantially changed our inferences about diversity patterns at KYNP. We caution, however, that the spatial distribution of our samples may be a strong factor in this conclusion.

Our data regarding average time to first photo capture for individual species (Fig. 1.3) may be helpful for researchers planning future camera trap studies of specific species in a similar habitat.

Management and Research Recommendations

Camera-trapping at KYNP should be carried out every year in the dry season in blocks of two-week surveys. Unlike many protected areas in Southeast Asia that have very restricted budgets and resources available for management, KYNP has hundreds of staff, and one of the largest annual budgets of all Thai protected areas available to commit to park management, especially with respect to tourism activities. However, despite the importance of wildlife for sustainable tourism, protecting and monitoring wildlife has historically been assigned a low priority at KYNP. We advocate the adoption of a system of regular monitoring using a range of methods by dedicated teams of rangers, separate from important anti-poaching patrols efforts. Our data indicate that on average, 80 percent of detections of mammals using camera traps were within 14 days. A two-week time period is therefore adequate for documenting the presence of mammals. We also recommend that in order to fully document diversity of

mammals at KYNP, camera-trapping will need to be augmented by other methods such as spotlight surveys to detect small carnivores such as primarily arboreal Civets, and rare species such as Ferret Badgers (Duckworth et al. 1999). Live trapping methods should be most useful for assessing the small mammal prey base of carnivores since this group is under-sampled with camera trap methodology (Srbek-Araujo & Chiarello 2005).

We suggest that zones KY09 and KY20 be recognized by managers as potential carnivore diversity hotspots warranting increased protection from illegal human activity. More intensive camera-trapping should be done in these areas to determine the reasons for the higher number of species detected there, and whether or not the pattern holds over the long term. Focusing additional anti-poaching resources in these zones would be a relatively easy-to-implement management step that should positively impact overall carnivore diversity at KYNP if done effectively. Our photos provide strong evidence that harmful or disruptive activities inside the park (such as active poaching, aloewood collection, and the simple presence of humans and dogs) are a continuing threat for KYNP and its wildlife. Increased patrolling along the park's eastern border, a potential major entry point for poachers, is also likely to be a deterrent to poaching.

Additionally, recovering tigers at KYNP will require a long-term commitment to protecting the vulnerable zones in the park. However, with the loss of Tigers, the Dhole has assumed the role as the functionally top predator in KYNP. Dholes are an endangered species that has historically not received appropriate conservation attention by KYNP park managers, but needs the same level of protection afforded by flagship species such as Tigers, Gibbons (*Hylobates spp*.), and Hornbills (*Buceros spp*.).

Conclusion

Despite continued threats and a decrease or near extirpation of Tigers, KYNP supports a diversity of carnivore species of conservation concern, including Clouded Leopards, Dholes, and small felids. Dedicated efforts to monitor wildlife using simple tools such as camera traps will be essential to KYNP's future mission as part of a World Heritage Area. An added benefit of these monitoring activities is the fact that they increase the visitation of remote areas by park staff. Continued monitoring will provide critical information on the occurrence of native species, threats, hotspots, the role of invasive or domestic species, and an indication of the effectiveness of patrolling and other management and conservation interventions.

Since the completion of our project, newly developed techniques have been developed combining camera trapping data with occupancy analysis (O'Brien et al. 2010) using a new biodiversity indicator, the Wildlife Picture Index (http://www.wildlifepictureindex.org/examples/demo_home.htm; O'Brien et al. 2010). These techniques may prove useful in the future for answering more detailed questions about wildlife distribution and conservation status, and might be suitable endeavors for researchers or graduate student projects.

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Table 1.1. Multiple regression models used to predict wildlife presence using five environmental variables. Models are ordered from the highest to the lowest AIC, with the top three models shown. Relative variable importance is also listed.

Model	**AIC**	**Relative variable importance**
*Intruder + Staff + NonStaff + Edge + Elev**	196.29	
NonStaff + Elev	190.6	
Intruder + Elev	190.7	
*Elev***	189.1	
Elev		0.89
Edge		0.28
NonStaff		0.23
Intruder		0.22
Staff		0.22

Distance (m) to nearest intruder (*Intruder*), distance (m) to nearest staff (*Staff*), distance (m) to nearest non-staff (*NonStaff*), distance (m) to park boundary (*Edge*), and elevation (m; *Elev*); AIC = Akaike Information Criterion; *Global Model; **Model chosen for modeling wildlife prediction; Relative variable importance calculated from averaged model parameters of all possible models.

Table 1.2. Parameters of model chosen to predict wildlife presence at Khao Yai National Park (n=150 training set observations).

	Coefficient	**Std. Error**	**z value**	**P value**
Intercept	0.0959865	0.3000046	0.320	0.7690
Elev	0.0013612	0.0005908	2.304	0.0212 *

Significance code: 0.01 '*' *Elev* = elevation

Table 1.3. Comparison of average wildlife relative abundance indices (photos/100 trap nights) at 34 camera trap survey locations between 1999-2003 and 2003-2007.

IUCN Status[1]	Species		Present survey[2]	Lynam et al. 2003[3]
EN	Tiger	*(Panthera tigris)*	0.00	0.14
V	Clouded Leopard	*(Neofelis nebulosa)*	0.06	0.48 *
NT	Asiatic Golden Cat	*(Pardofelis temminckii)*	0.00	0.07
LC	Leopard Cat	*(Prionailurus bengalensis)*	0.12	0.80
EN	Dhole	*(Cuon alpinus)*	0.02	0.45
LC	Golden Jackal	*(Canis aureus)*	0.12	0.00
NT	Large Indian Civet	*(Viverra zibetha)*	1.40	1.23
V	Large-spotted Civet	*(Viverra megaspila)*	0.10	0.00
LC	Common Palm Civet	*(Paradoxurus hermaphroditus)*	0.08	0.20
V	Binturong	*(Arctictis binturong)*	0.15	0.07
LC	Mongoose spp.	*(Herpestes spp.)*	0.37	0.27
LC	Yellow-throated Marten	*(Martes flavigula)*	0.00	0.54
NT	Hog Badger	*(Arctonyx collaris)*	0.10	0.71
V	Asiatic Black Bear	*(Ursus thibetanus)*	0.14	0.00
V	Malayan Sun Bear	*(Helarctos malayanus)*	0.27	0.73
LC	Eurasian Wild Pig	*(Sus scrofa)*	0.78	1.28
EN	Asian Elephant	*(Elephas maximus)*	0.42	0.25
V	Gaur	*(Bos gaurus)*	0.34	1.06
V	Sambar Deer	*(Rusa unicolor)*	1.85	2.43
LC	Barking Deer	*(Muntiacus muntjak)*	1.11	5.47 **
DD	Lesser Mouse-Deer	*(Tragulus javanicus)*	0.08	0.56
V	Mainland Serow	*(Capricornis milneedwardsii)*	0.06	0.00
LC	Malayan Porcupine	*(Hystrix brachyura)*	0.75	1.69
EN	Sunda Pangolin	*(Manis javanica)*	0.12	0.00
V	Pig-Tailed Macaque	*(Macaca nemestrina)*	0.58	2.50
LC	Total Human Traffic	*(Homo sapiens, Canis familiaris)*	1.59	5.66 *
	All Mammals		9.68	21.97 **

[1]IUCN status: LC=least concern; V=vulnerable; NT=near threatened; EN=endangered; DD=data deficient (IUCN 2010).

[2]These data represent a sub-set of data collected during the present survey (sub-set taken from October 2003-November 2006; n=1,017 trap nights). A total of 34 survey locations (within 2.5 km) was selected for comparison to data from Lynam et al. (2003). RAI's in bold represent a significant difference **$p<0.01$ and *$p<0.05$ in species' values in comparison to Lynam et al. (2003).

[3]Data from Lynam et al. (2003) collected from January 1999 through July 2000 (n=1,226 trap nights).

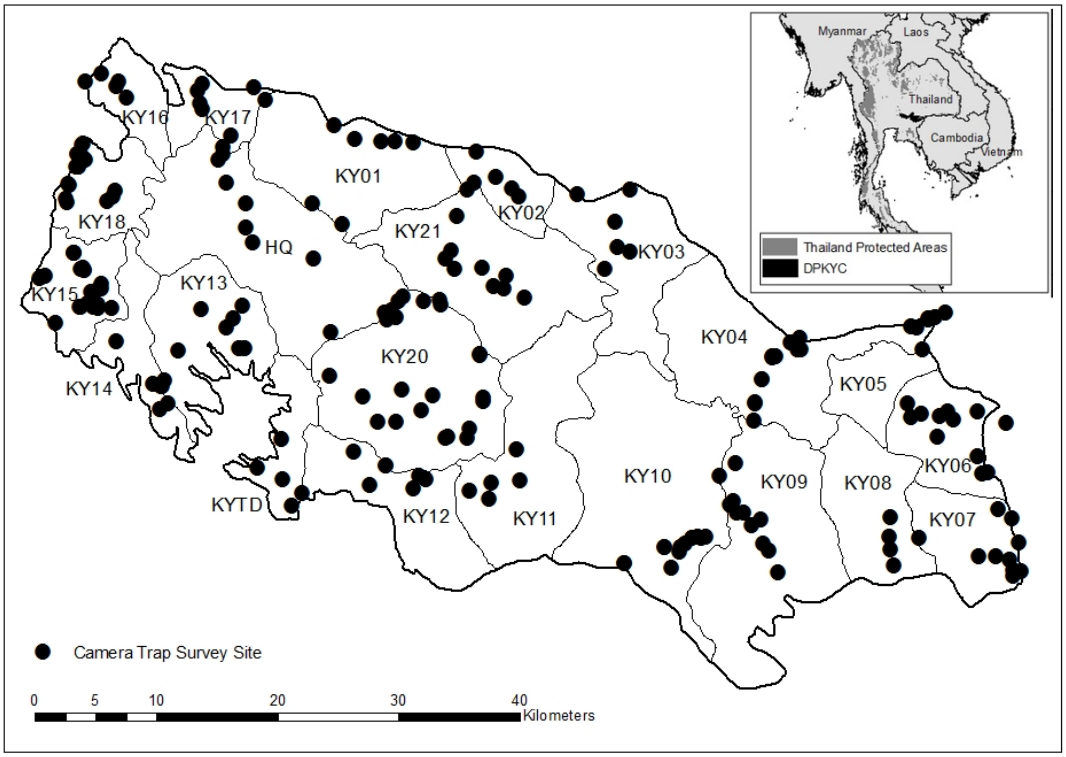

Figure 1.1. Khao Yai National Park (KYNP) is divided into 22 management zones that were used for monitoring. Locations of camera traps (n=217). Inset: KYNP is at the western side of the Dong Phayayen-Khao Yai Forest Complex (DPKYC) in central Thailand.

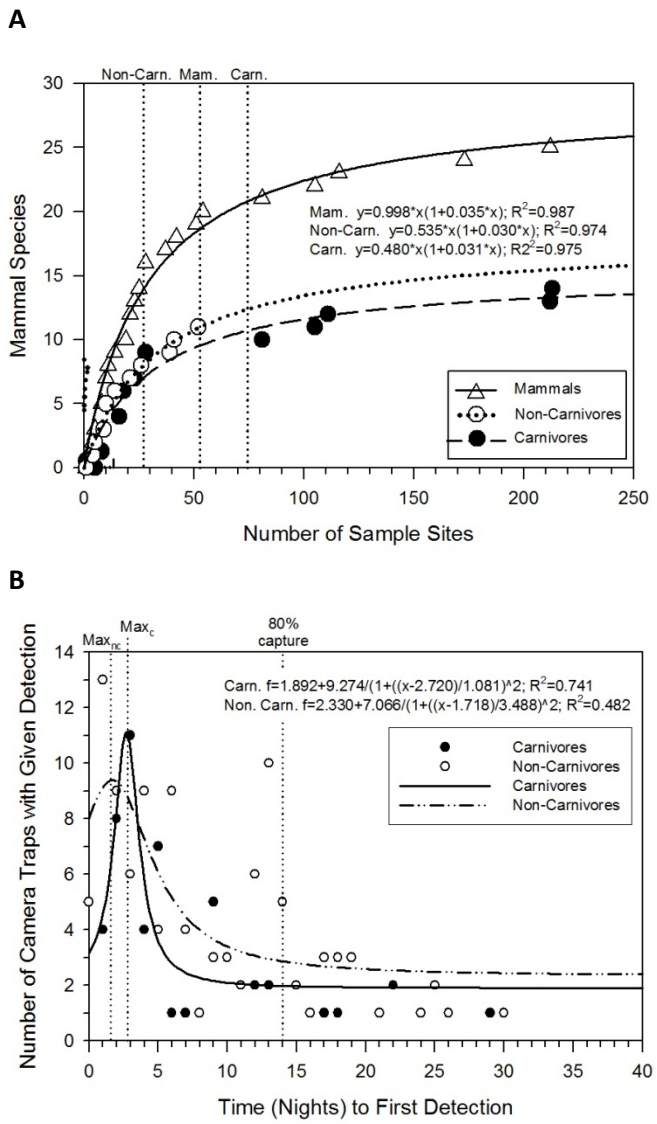

Figure 1.2. Camera trapping indices for species detection. Species accumulation curves to demonstrate the number of sampling sites needed for detection for all mammals, non-carnivore mammals, and carnivore species (A). Time to first detection for camera traps for detecting non-carnivore and carnivore species (B).

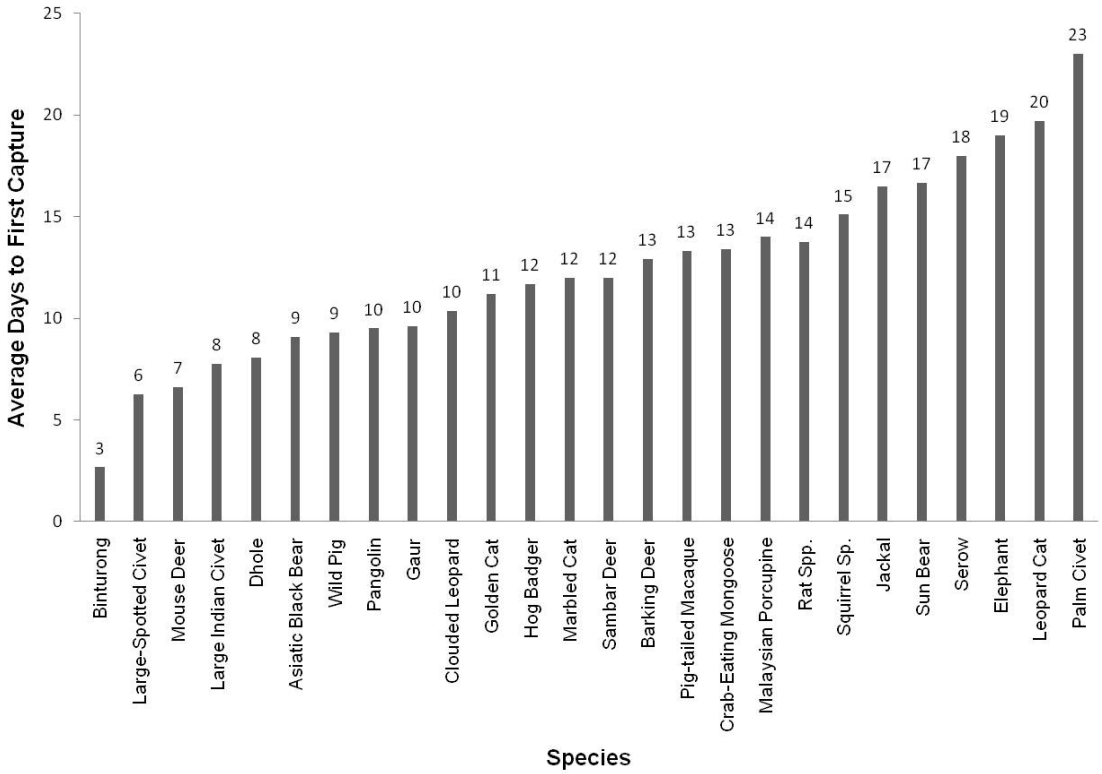

Figure 1.3. Average day to first photographic detection for species in Thailand's Khao Yai National Park.

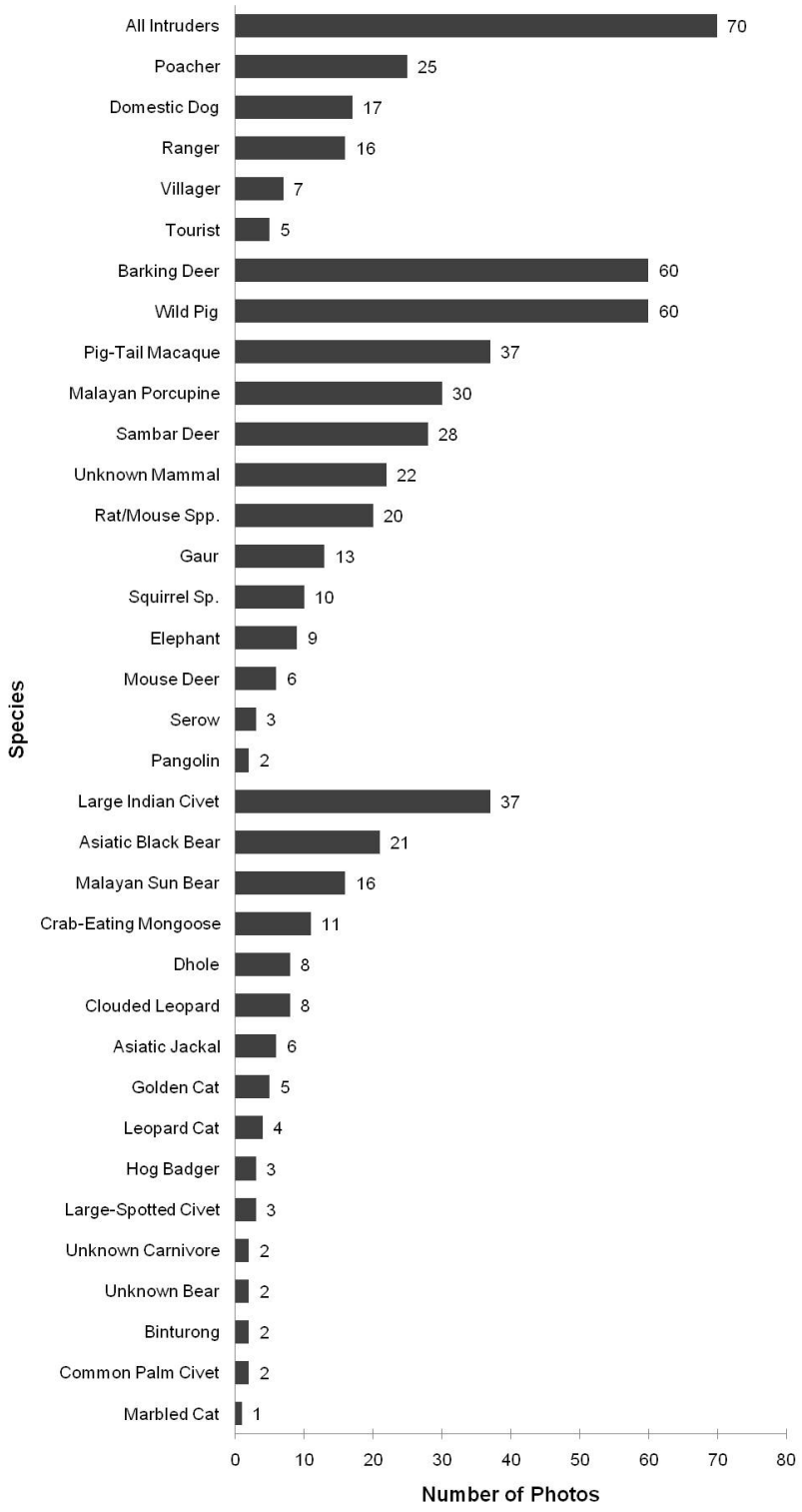

Figure 1.4. Frequency of photo captures (October 2003 through March 2007) for wildlife and human traffic in Thailand's Khao Yai National Park.

Figure 1.5. Zoomed camera trap photograph of a clouded leopard.

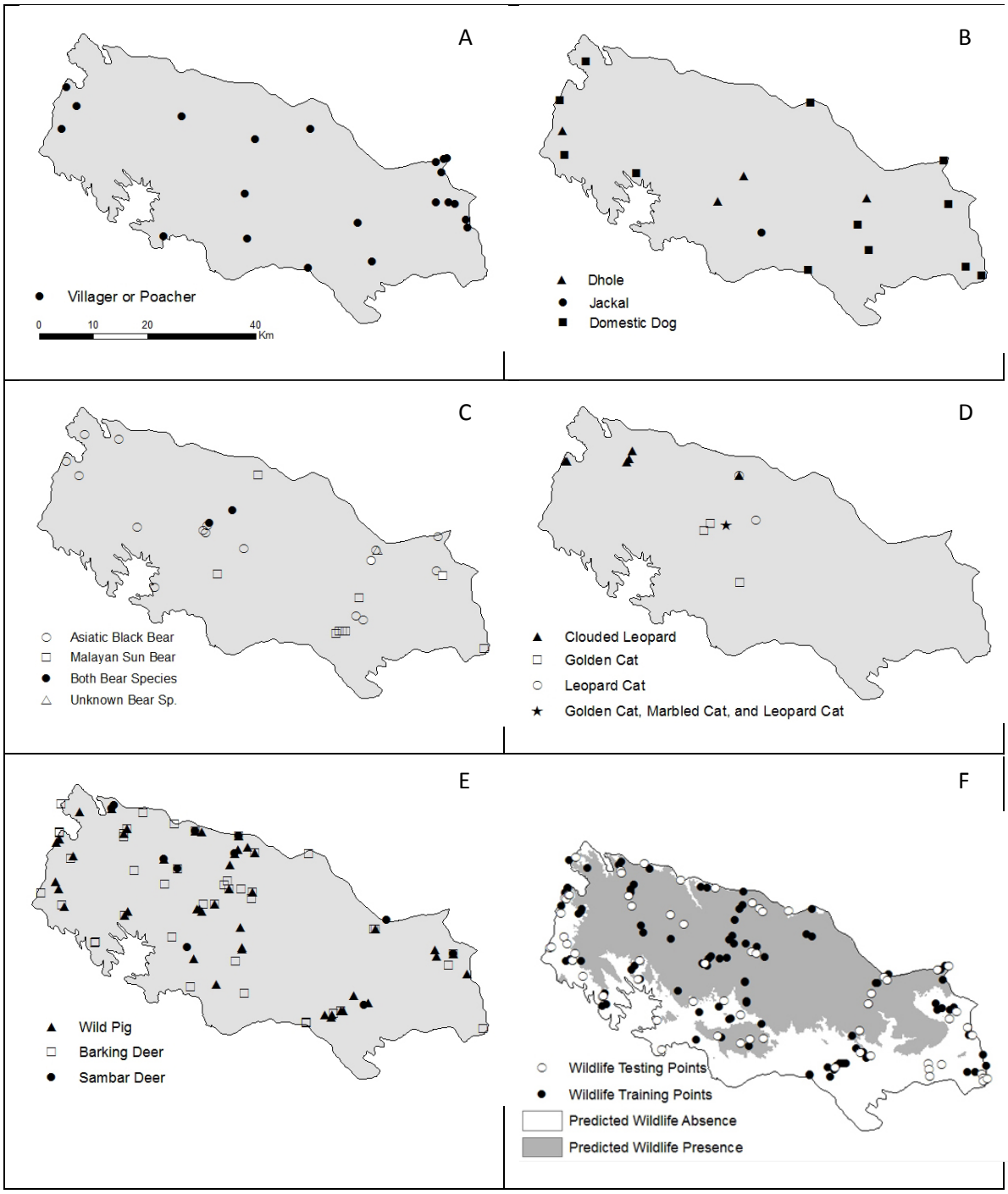

Figure 1.6. Distribution maps of (A) villages and poachers, (B) canids, (C) bears, (D) felids, (E) prey for mid-to large carnivores, and (F) model surface predicting wildlife presence. We counted a photographed person as a poacher if they were carrying a gun, a carcass or animal parts, a bag to transport plant material/tree bark, or were accompanied by a dog.

Figure 1.7. Footprint evidence of Tiger in the Headquarters Zone of Khao Yai National Park, October 2005. Photo Credit: T. Redford/FREELAND

CHAPTER II.

DO RANGER STATIONS DETER POACHING ACTIVITY IN NATIONAL PARKS IN THAILAND?

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Abstract

As protected areas become more accessible via transportation networks, fragmentation, and encroachment from the borders, carnivores in these areas frequently decline. To counter these pressures, patrolling and active wildlife enforcement are widely accepted as fundamental conservation strategies. Using the case example of Khao Yai National Park (KYNP) and data from a camera trap survey, we modeled and evaluated the effectiveness of ranger stations in reducing human access and illegal activities, and in increasing prey and predator presence. This type of data and analysis are needed to monitor, evaluate enforcement effectiveness, and develop adaptive management strategies. At KYNP, we used camera-trapping data as a proxy to evaluate whether or not a positive impact of ranger stations on wildlife distribution could outweigh edge effects from human disturbance. We assessed factors affecting the distribution of poachers and wildlife using Maxent. Our analysis was based on 217 camera trap locations (6,260 trap nights) and suggests that ungulates and poachers persist nearby ranger stations. Rangers should increase patrolling efforts of border areas; however, increasing wildlife

patrolling in inaccessible areas with mobile range units may be more effective than establishing more ranger stations along park boundaries.

Introduction

Carnivores and their prey are threatened by poaching throughout Southeast Asia (Karanth & Chellam 2009). This threat is prevalent even in national parks and wildlife sanctuaries despite increasing awareness and wildlife protection efforts (Martin & Redford 2000, Corlett 2007). Poaching often is fueled by demand from the traditional Chinese medicine trade. Examples of the devastating impact from such trade are the illegal but prevalent collection of gall bladder bile from Asian bears (*Ursus thibetanus*) and bones from tigers (*Panthera tigris*; e.g. Lee 1996, Kenney et al. 1995). Recently, poachers have shifted their focus from large carnivores such as tigers to medium-sized and small carnivores, such as clouded leopards (*Neofelis nebulosa*) and marbled cats (*Pardofelis marmorata*; Martin 1997). This shift of target species for the wildlife trade was documented by undercover surveys of illegal markets in the Thai-Myanmar border region (Martin 1997). In 2006, investigators counted bones and pelts for sale in the market town of Tachilek, Myanmar, and estimated the parts represented 22 clouded leopards and one tiger (Sheperd & Nijman 2008). In a second survey the same year, an undercover film crew documented more than 80 clouded leopard pelts in one stockpile (T. Redford, pers. comm.). As recently as March 2007, handbags made from clouded leopard pelts were for sale at the popular Chattuchak Weekend Market in Bangkok (K. Jenks, pers. obs.). It is unclear how many of these specimens were obtained by illegal wildlife poaching in Thailand's protected areas.

Beyond the highly publicized poaching of charismatic predator species in the wildlife trade, prey species are also regularly hunted, usually for human consumption. An indication is the thriving trade in wild bushmeat from pigs (*Sus scrofa*), gaur (*Bos gaurus*), sambar deer (*Rusa unicolor)*, and red muntjac (*Muntiacus muntjak*) along the border towns of Thailand, Cambodia, and Myanmar (Butchan 2006). No taxon seems unaffected; Royal Thai Customs officers regularly confiscate songbirds, primates, and snakes from traders (ASEAN-WEN 2010).

Protected areas, designed to keep endangered species and their habitats protected, are far from safe from poachers. This is especially true as protected areas become more fragmented and surrounded by developed land (Peres 2001). Fragmentation opened access to once remote areas in Africa and resulted in an increase in bushmeat trade (e.g., Wilkie et al. 2000, Laurance et al. 2006). Khao Yai National Park (KYNP)—Thailand's oldest and most popular park (2,168 km^2) —faces similar pressures at the park edge. Once almost completely surrounded by forests, KYNP now is an island connected to other forests and protected areas only along its small eastern border with Thap Lan National Park. The two parks are further separated by a heavily used highway.

An edge effect at the administrative boundary as observed in African protected areas (Woodroffe & Ginsberg 1998) is present in KYNP. Wildlife in KYNP is threatened because of the park's increased isolation from other forests and increased accessibility for people. Access to the park at the edges allows poachers to remove wildlife. We obtained photographic evidence of poaching during a survey conducted in KYNP from October 2003 through March 2007. The photos document poachers carrying bamboo, frogs, and turtles, and travelling with domestic dogs in the forest at night. In July 2005, our team captured a man with a freshly hunted gaur trophy. Although poaching of large mammals at KYNP is difficult to document, there is ample

evidence for the illegal removal of the highly valued aloewood (*Aquilaria crassna*) used to produce incense for Middle East markets (Zhang et al. 2008, Brodie et al. 2009). Poachers targeting aloewood not only spend weeks in the forest and rely on trapping of prey species for food, but they may also opportunistically hunt for larger and more valuable carnivore species. Such a dual-threat was well documented in the north-east Indian park of Namdapha where illegal hunting decimated the prey base and left the park empty of tigers (Datta et al. 2008).

Poaching can be effectively combated through anti-poaching efforts in conservation areas (Hilborn et al. 2006, Dajun et al. 2006). KYNP has a well-developed system of ranger stations distributed throughout 22 management zones. Rangers from these stations usually conduct anti-poaching patrols monthly. It is difficult to measure the impact of protection efforts in KYNP because information on patrolling routes and poacher captures are unavailable. However, researchers encountered the highest rates of wildlife signs closest to the park headquarters, but documented declines in signs as they moved farther away (Lynam et al. 2003).

The majority of ranger stations are positioned near the boundary of KYNP. The placement of the stations should be ideal for rangers to patrol the park edges and stop the access of poachers. However, the effectiveness of these stations has never been monitored. We hypothesized that (1) presence of ungulates in KYNP is positively associated with ranger stations representing park protection; and (2) presence of poachers is negatively associated with ranger stations. Our objective was to support a camera-trapping project at KYNP conducted by park rangers that was specifically designed to acquire systematic information on large mammals for management and protection planning. We used Maxent to model wildlife distribution as

well as poaching threats. Based on final model outputs, we developed conservation management recommendations.

Our research provides general principles about how the location of ranger stations, wildlife distribution, and distribution of potential poachers are related in protected areas throughout much of Asia. Our results offer insights to the effect of ranger stations over a four year time period in KYNP—a topic generally little measured or understood. Based on our research we developed suggestions for improving the effectiveness of protection at KYNP. These results may also prove useful for many other protected areas in Southeast Asia where patrolling is carried out.

Methods

Study Area

KYNP is located in central Thailand (14º26'29''N; 101º22'11''E; Fig. 2.1). Elevation ranges from 100 to 1,350 m (Chayamarit 2006). Mean annual rainfall is about 2,270 mm, which falls mainly during the monsoon between May and October, with temperatures averaging 23°C. Most of the park's terrain is hilly and dominated by mixed deciduous forest, with dry evergreen forest occupying higher elevations. The park and surrounding forest complex supports a diverse fauna of an estimated 60 mammal and 391 bird species (Lynam et al. 2006).

Camera Trapping

From October 2003 through March 2007, KYNP ranger teams conducted camera-trapping surveys to detect carnivore species and their prey. The teams were formed under the Carnivore Conservation Project (CCP), a collaboration between KYNP staff, the non-

governmental organization PeunPa/FREELAND, and the Smithsonian Institution. Cameras were set up in 217 locations over 6,260 trap nights.

During the surveys, the teams used CamTrakker® (Cam Trak South, Inc., Watkinsville, GA 30677 USA) cameras which rely on an infrared beam to detect motion and differences in temperature to trigger cameras when wildlife or people pass in front of the beam (e.g. Griffiths & van Schaik 1993, Moruzzi et al. 2002). We placed camera traps on a tree ~50 cm from the ground. While this may have biased our results against primarily arboreal species, any bias is consistent across zones. We aimed to leave camera traps in the forest for three weeks at each station since previous experience with this model (Lynam et al. 2003) indicated this was the expected life of the batteries. Due to work schedule conflicts, cameras were often picked up earlier or later, but were only retrieved after a minimum of 21 days. Furthermore, Jenks et al. (2011) demonstrated that 80% of detection of mammals in KYNP using camera traps was within 14 days, so we do not believe that our results were biased by small differences in number of trap nights among stations.

Park rangers deployed cameras throughout the park in a randomized-block design utilizing KYNP's 22 management zones. In this design, two zones were chosen randomly without replacement for each survey. Each zone was surveyed at least once during the study period. The team further delineated each zone into 1-km^2 grid squares and randomly chose grid squares for camera placement. Four to six grid squares in each zone were selected based on the number of working cameras. Once a grid square was selected, teams set up actual camera locations within a square based on areas where high numbers of wildlife were likely to be detected (*i.e.*, along wildlife trails and waterways). We counted a photographed person as a poacher if they were carrying a gun, a carcass or animal parts, a bag to transport forest products/animals, or

were accompanied by a dog. These attributes were common among people arrested by park rangers (K. Jenks, pers. obs.) and therefore we feel are ample identification for poachers. However, poachers often dress in camouflage uniforms identical to those worn by park rangers. So, we showed all photographs of potential poachers to our ranger team to check whether or not the person was an active employee of the park. All rangers in the park know all other rangers and are a close group of employees. We did not identify any park staff on these pictures; i.e. rangers were not accidently counted as poachers.

Modeling Poacher and Wildlife Spatial Distribution

We selected *a-priori* environmental factors to investigate their effect on poachers, prey, medium carnivores, and small cat distributions. The management and environmental factors included distance (m) to park headquarters (*HQ*), distance (m) to nearest ranger station (*Ranger*), distance (m) to the park edge (*Edge*), and elevation (m; *Elev*). Park headquarters was used as a separate factor from ranger stations because the area physically impacts more land area and hosts a higher number of people. The headquarters is the location of the greatest number of rangers and is the center hub for the majority of tourism activities (including camping) in the park. We used ArcGIS 9.2 Spatial Analyst, a Geographic Information System (GIS) software program developed by the Environmental Systems Research Institute (ESRI) to calculate all distances using the Euclidian distance function. Elevation was extracted from a 100 m Digital Elevation Model (DEM) provided by the Department of National Parks, Wildlife, and Plant Conservation and can be used as a proxy for forest types instead of broad vegetation categories. Forest types in Thailand are broadly defined by the elevation at which they occur (Gardner et al. 2000).

We used only detection records to model species distributions using Maxent 3.3.1 (Phillips et al. 2006; www.cs.princeton.edu/~schapire/maxent). Maxent minimizes the relative entropy between the probability density of the presence data and the probability densities from the environmental variables defined in covariate space (Elith et al. 2011). Maxent was chosen because our data have low numbers of locations where categories of wildlife were detected (e.g. n=6 for small cats) and Maxent requires few locations (in some cases only five locations) to construct useful models (Baldwin 2009). The program was run with the "auto features" option checked and all other parameters at their default settings (Phillips & Dudik 2008; Fig. 2.2). We randomly selected 25% of the presence locations for each of the models (e.g. poachers, sambar, red muntjac, small prey, medium carnivores, and small cats) to use for testing model performance. Model performance was measured by the area under the curve (AUC) of the receive operating characteristic (ROC) plot, which in this context, is the probability that a randomly chosen presence site is ranked above a random background site (Phillips et al. 2006). Values with an area under the ROC curve (AUC) above 0.75 were considered adequate (Elith 2002). Standard errors and confidence intervals for each of the models were calculated in R v2.11.1 Development Core Team 2010) using ROCR (Singh et al. 2009), vcd (Meyer et al. 2010), and boot (Canty & Ripley 2010) packages.

Following the modeling procedure described above, we first produced predicted distributions separately for the two prey species sambar deer and red muntjac, and for a combined group of small prey: mouse deer (*Tragulus kanchil*), Malayan porcupine (*Hystrix brachyuran*), Sunda pangolin (*Manis javanica*), rodents, and all birds except raptors. The resulting layers (called *Sambar*, *Red Muntjac*, and *SmPrey*) were included as predictor variables in a poacher and medium carnivore model. We grouped dholes (*Cuon alpinus*) and clouded

leopards together as medium carnivores. We did not include Asiatic jackals (*Canis aureus*) in this grouping because we assumed they ate mostly smaller prey (Mukherjee et al. 2004).

Small cats (leopard cat [*Prionailurus bengalensis*], marbled cat, and golden cat [*Pardofelis temminckii*]) were modeled using the following predictor variables: the four variables (*HQ, Edge, Ranger*, *Elev*) and small prey (*SmPrey*).

We chose these particular groupings for analysis because we assumed that sized-based carnivore guilds and small prey might loosely respond to the presence of rangers and poachers in a similar way. For example, dholes and clouded leopards are both elusive species that may be wary of any humans. Dholes have been persecuted for stealing chickens (K. Jenks, unpublished data) and clouded leopards are targeted by poachers for their pelts (Shepard & Nijman 2008). Furthermore, grouping carnivores based on their size allowed us to include relevant prey based on size as a variable. We combined all bird species and other small mammals to estimate their distribution as a proxy for the distribution of available prey for small carnivores. We also calculated individual distribution models for bear species (*Helarctos malayanus, Ursus thibetanus*), wild pig, Malayan porcupine (*Hystrix brachyura*), gaur, and elephant (*Elephas maximus*) because these are species that may be targeted by poachers in some capacity. However, these models performed poorly with AUC values less than 0.60, and were omitted from further analysis. The models may have performed poorly if the variables we chose to predict wildlife distribution were not important to these species. For example, Ngoprasert et al. (2011) successfully modeled bear distribution which appeared to be related mostly to fruit abundance.

We also created a predictive occurrence map in ArcGIS and delineated areas of presence/absence values for each target species model using threshold values maximizing the training sensitivity and specificity. Manel et al. (2001) and Hernandez et. al. (2006) recommend this threshold selection. We then calculated the classification accuracy of each model in a contingency table using our entire dataset of 217 locations including both presence and absence locations.

Predictor variable importance was assessed using a Jackknife operation, and the variable contributions and variable permutation importance calculated in Maxent. The percent contribution of each variable is computed based on how much the variable influenced the increase in the regularized model gain as averaged over each model run. To calculate variable permutation, for each predictor in turn, the values of that predictor on training presence and background data are randomly varied and the resulting change in training AUC is shown normalized to percentages (Maxent Tutorial, http://www.cs.princeton.edu/~schapire/maxent/).

Results

We obtained a total of 650 photos, of which 129 captured carnivores, 278 non-carnivore mammals, 149 birds, 53 humans, and 17 domestic dogs. We could not determine species in 24 photographs due to poor focus or angle. Species detected include 14 carnivore species and 12 non-carnivore mammal species (Table 2.1). Large Indian civet (*Viverra zibetha*; n=38) was the most common carnivore species photographed. Eurasian wild pig (n=60) and red muntjac (n=60) were the most common non-carnivore species photographed. In addition to documenting the presence of wildlife, camera traps also recorded human traffic (poachers, villagers, park staff, tourists) and domestic dogs inside the park (n=69; Table 2.1). Human traffic

(all humans and domestic dogs) had the second most widely distributed detections (after wild pigs) with photo-captures at 43 (20%) of the 217 camera-trapping locations.

Distribution models for sambar, red muntjac, small cats, and poachers were judged to have performed well on the basis of moderately high AUC values (Fig. 2.2). However, the small sample sizes of the small cat model (10 photos, < 8 locations) resulted in a standard error of zero and an inability to calculate a confidence interval. Therefore, the accuracy of this model should be questioned. We still included the model because of the paucity of information on these species. Models of small prey and medium carnivores (Table 2.2; Fig. 2.2) were weak, but still included because the outputs offer some insight and we used the small prey distribution layers as a variable in other models.

Distribution models for sambar, red muntjac, and small prey showed distance to ranger stations having the highest contribution for modeling their predicted presence (Table 2.3). Distance from ranger stations (*Ranger*) was the most important variable in predicting prey presence with the highest gain for all three models based solely on *Ranger*, and the highest loss in gain if it was excluded from the models (Fig. 2.3A,B,C). This was a negative correlation so as distance from ranger stations increased the probability of presence for the ungulates decreased (Fig. 2.4).

Medium carnivores were chiefly found in areas where red muntjac were detected and also influenced by elevation (Table 2.3). The jackknife test of variable importance shows the highest gain when the variable *Red Muntjac* is used in isolation, which therefore appears to have the most useful information by itself (Fig. 2.3D). However, the variable that decreases the gain

the most when it is omitted is *Elev*, which indicates that it has the most information that is absent in the other variables (Fig. 2.3D).

The model for small cats did not assign a high percent contribution of small prey (Table 2.3), but the felids were strongly concentrated around the headquarters (Table 2.3, Fig. 2.5E, Fig. 2.6). Distance from the headquarters (*HQ*) was the most important variable in predicting small cat presence with the highest gain for models based solely on *HQ*, and the highest loss in gain if it was excluded from a full variable model (Fig. 2.3E).

Poachers were influenced by distance to the park headquarters and to ranger stations (Table 2.3). Poachers were predicted at higher probability less than one kilometer from the park headquarters, but then increased further away from the headquarters (Fig. 2.6). They were found within five kilometers of ranger stations and on the eastern boundary of the park (Fig. 2.4; Fig. 2.5F). The jackknife test of variable importance shows the highest gain when the variable *SmPrey* is used in isolation, which therefore appears to have the most useful information by itself (Fig. 2.3F). However, the variable that decreases the gain the most when it is omitted is *HQ*, which indicates that it has the most information that is absent in the other variables (Fig. 2.3F).

Discussion

Human access beyond recreation zones in KYNP is a continuing threat for the park's wildlife. Human traffic has a major impact because it is widely distributed, with photo-captures at 43 (20%) of the 217 camera-trapping locations (Table 2.1). Even though 78 percent of the park is zoned as a strict nature reserve/primitive area (United National Environment Programme 2005), villagers continue to enter the park collecting mushrooms, bamboo, and other forest

products. Poachers targeting aloewood and large mammal trophies spend weeks in the forest and set up semi-permanent field camps (K. Jenks, pers. obs.). They rely on trapping of prey species for food and enter with domestic dogs which may disrupt wildlife even if they are not directly hunted.

If park protection efforts are working, we would expect to see a high occurrence of ungulates in areas where rangers are based. We reasoned buffer areas around the park headquarters and ranger stations represent areas likely to provide refuge from poachers and/or attract a higher concentration of ungulates that easily habituate to human presence. For example, Dajun et al. (2006) identified muntjac (*Muntiacus reevesi*) and tufted deer (*Elaphodus cephalophus*) in China positively associated with the location of conservation substations. Our predictive distribution models for sambar, red muntjac, and small prey at KYNP support this hypothesis, illustrating prey species are found closer to ranger stations. There is a high probability of presence for ungulates close to ranger stations (Fig. 2.4; Fig. 2.5 A,B,C). These species easily habituate to humans and also forage on human trash (K. Jenks, pers. obs.).

Protection efforts in KYNP, however, may be ineffective because there appears to be a high probability of poachers even in the closest vicinity of the headquarters and ranger stations (Fig. 2.4, Fig. 2.5F, Fig. 2.6B). Poaching around the headquarters may be heavily influenced by the location of aloewood trees. Within approximately 1 km from the headquarters, there is a 30 ha research forest plot where all of the trees have been measured, tagged, and mapped. The density of aloewood trees is 238 per 30 ha and mortality due to poaching has been estimated at 1.3 percent per year despite the proximity to the headquarters (Zhang et al. 2008). Poaching may also originate from the headquarters and ranger stations because the road infrastructure allows for easier access, even at night, which goes relatively undetected. Poaching near the park

headquarters needs further investigation because it could involve the complicity of individual park staff if poachers are successfully able to use the major access roads without detection.

In general, poachers avoid the area around the headquarters (with the exception of the immediate area <1km), but occur at higher densities on the east side of the park (Fig. 2.5F). We do not have information on levels of patrolling in this area, but ease of access may play a role because there is a large highway that runs parallel to the east edge of the park. The magnitude of ease of access is further evident from the high predicted probability of poachers being depicted as a black ring or edge effect around the entire park in the model (Fig. 2.5F).

Carnivores rely heavily on prey species and their distribution is less influenced by protection and poachers. In particular, carnivores are neutral in response to distance to ranger stations, but may benefit from the park headquarters. While medium carnivores were most impacted by the availability of red muntjac, small cats were predicted to be concentrated around the headquarters (Fig. 2.5E; Fig. 2.6). The majority of our photo captures were of golden cats and leopard cats, and at least leopard cats have been shown to be unaffected by vehicle traffic in the park (Austin et al. 2007b). Therefore, though based on small sample sizes, our assumption is that high tourist activity may not distress small cats and may have the positive impact of deterring poaching of cats in the park's interior.

Conclusion and Management Recommendations

Like many national parks, KYNP has a dual commitment to both biodiversity conservation and tourism. Our data indicate ranger stations have not been able to sufficiently reduce poacher presence. Purported presence of poachers near ranger stations may outweigh any positive impact of the clustering of ungulates around ranger stations. Infrastructure

development, especially the development or roads into the protected area to service ranger stations may also provide undue access for human disturbance and poaching. Future such development under the guise of "tourism enhancements" should be questioned.

Increased patrolling along the park's eastern border is likely to reduce poaching in the park. Evidence from Africa suggests that poaching declines can be achieved through increased anti-poaching efforts and increased patrol performance through annual evaluations (Hilborn et al. 2006, Jachmann 2008). However, we suggest that increasing wildlife patrolling in inaccessible areas with mobile range units may be more effective than establishing more ranger stations along park boundaries. Additionally, there needs to be support for sufficient resources for the park service to increase anti-poaching efforts and a focus on increasing staff morale.

Increased patrols alone, however, will not improve the situation because there is poaching which occurs very close to the headquarters where park staff is most concentrated. So, an increase in patrolling may offer only modest improvements to the problem in the east. Instead, there are perhaps broader and more fundamental issues of park management that need to be addressed. Approaches to wildlife conservation often involve the development of economic benefits for the local people so that protecting wildlife is in their best interest. Rural development projects such as alternative income projects involving organic mushroom cultivation (www.FREELAND.org) should continue to receive high priority. Other issues that need to be addressed to limit poaching involve local corruption and poaching consequences being followed through by law enforcement (e.g. Keane et al. 2008).

The impact of increased patrolling and the magnitude of intruders can be continuously monitored using remote cameras. Unless edge effects in the form of human disruption are

curtailed, wildlife populations in KYNP will only shrink progressively into smaller and smaller core areas of the park.

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Table 2.1. List of mammal species detected at 217 locations surveyed with camera traps at Khao Yai National Park from October 2003 through March 2007. Species are listed in the order of number of locations where they were detected.

Name Common	**Scientific Name**	**No. Photo Detections**	**No. of Locations**
Marbled Cat	(*Pardofelis marmorata*)	1	1
Large-spotted Civet	*(Viverra megaspila)*	3	2
Common Palm Civet	*(Paradoxurus hermaphroditus)*	2	2
Binturong	*(Arctictis binturong)*	2	2
Hog Badger	*(Arctonyx collaris)*	3	2
Sunda Pangolin	*(Manis javanica)*	2	2
Leopard Cat	*(Prionailurus bengalensis)*	4	3
Golden Jackal	*(Canis aureus)*	6	3
Sumatran Serow	*(Capricornis sumatraensis)*	3	3
Asiatic Golden Cat	*(Pardofelis temminckii)*	5	4
Dhole	*(Cuon alpinus)*	8	5
Crab-eating Mongoose	*(Herpestes urva)*	11	5
Clouded Leopard	*(Neofelis nebulosa)*	8	6
Lesser Mouse-Deer	*(Tragulus kanchil)*	6	6
Rodent Spp.		30	8
Asian Elephant	*(Elephas maximus)*	9	9
Gaur	*(Bos gaurus)*	13	9
Sambar Deer	*(Rusa unicolor)*	28	11
Malayan Sun Bear	*(Helarctos malayanus)*	16	12
Asiatic Black Bear	*(Ursus thibetanus)*	21	19
Malayan Porcupine	*(Hystrix brachyura)*	30	20
Large Indian Civet	*(Viverra zibetha)*	38	24
Pig-Tail Macaque	*(Macaca nemestrina)*	37	25
Red Muntjak	*(Muntiacus muntjak)*	60	42
Human Traffic	(poachers, villagers, park staff, tourists, and domestic dogs)	69	43
Eurasian Wild Pig	*(Sus scrofa)*	60	44

Table 2.2. Model performance measured by the area under the curve (AUC) of the receiver operating characteristic (ROC) plot, standard error (S.E.), 95% confidence interval (CI), threshold of occurrence, and overall classification accuracy.

Maxent Model	**AUC**	**S.E.**	**95% CI**	**Threshold[a]**	**Accuracy[b]**
Sambar	0.946	0.033	0.881, 1.000	0.583	80%
Red Muntjac	0.711	0.069	0.559, 0.845	0.369	43%
Small Prey	0.632	0.048	0.521, 0.722	0.501	60%
Medium Carnivore	0.663	0.015	0.633, 0.691	0.517	60%
Small Cat	0.998	0	Unable to calculate	0.391	80%
Poacher	0.892	0.062	0.774, 1.000	0.525	78%

[a] Threshold maximizing training sensitivity and specificity as calculated in Maxent.
[b] Classification accuracy based on presence and absence locations.

Table 2.3. Estimates of relative percent contribution (RC) and permutation importance normalized to percentages (PI) for variables used in Maxent modeling of species distributions in Khao Yai National Park, Thailand.

	Maxent Model											
	Sambar		**Red Muntjac**		**Small Prey**		**Medium Carnivore**		**Small Cat**		**Poacher**	
Variables	**RC**	**PI**	**RC**	**PI**	**RC**	**PI**	**RC**	**PI**	**RC**	**PI**	**RC**	**PI**
HQ	2.7	10.9	9.7	20.4	0.9	4.2	0	0	72.6	100	41.7	59.1
Edge	1.6	1.8	8.1	8.5	10.7	5.0	0	0	26.5	0	20.0	13.6
Ranger	95.7	87.3	78.3	60.2	50.1	54.9	0	0	0.9	0	19.7	9.8
Elev	0	0	3.8	11	38.3	35.8	42.7	86.9	0	0	0	0
Sambar							0	0			0	0
Red Muntjac							56.6	9.5			15.4	13.4
SmPrey							0.7	3.6	0	0	3.2	4.1

Maxent, maximum entropy. *Sambar, Red Muntjac, SmPrey* = predicted layer of distribution of Maxent modeling for each species. *HQ* = distance (m) to headquarters station; *Edge* = distance (m) to park boundary; *Ranger* = distance (m) to ranger station; *Elev* = elevation (m). Cells with no value indicate variables were omitted as predictor variables.

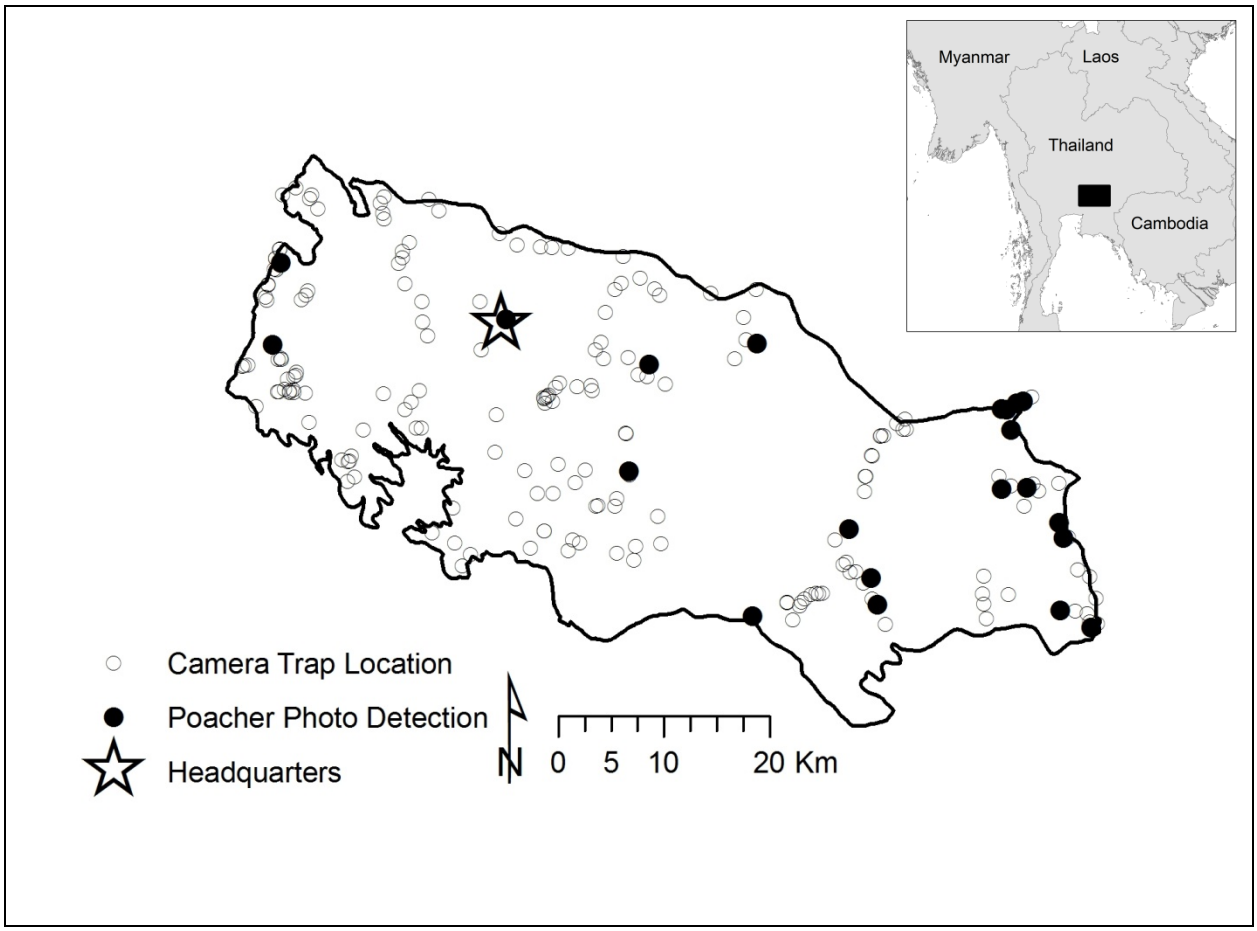

Figure 2.1. Location of park headquarters, camera traps, and photographs of poachers in Khao Yai National Park (KYNP), Thailand. Inset: Black rectangle identifies the location of KYNP within Thailand.

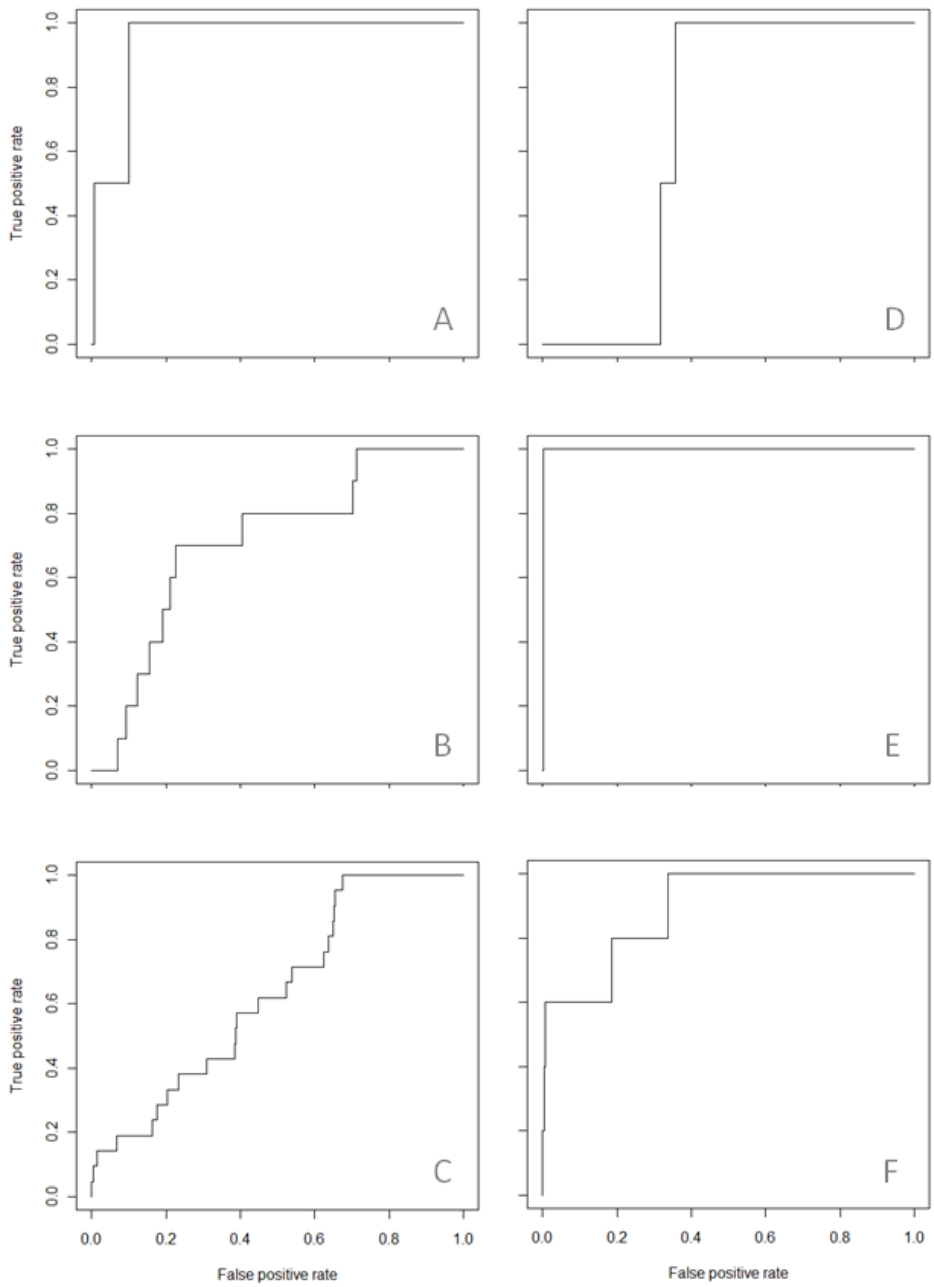

Figure 2.2. Model performance measured by the tradeoffs between false positive and true positive rates of the receiver operating characterisitc (ROC) plot of the Maxent model for sambar (A), red muntjac (B), small prey (C), medium carnivores (D), small cats (E), and poachers (F).

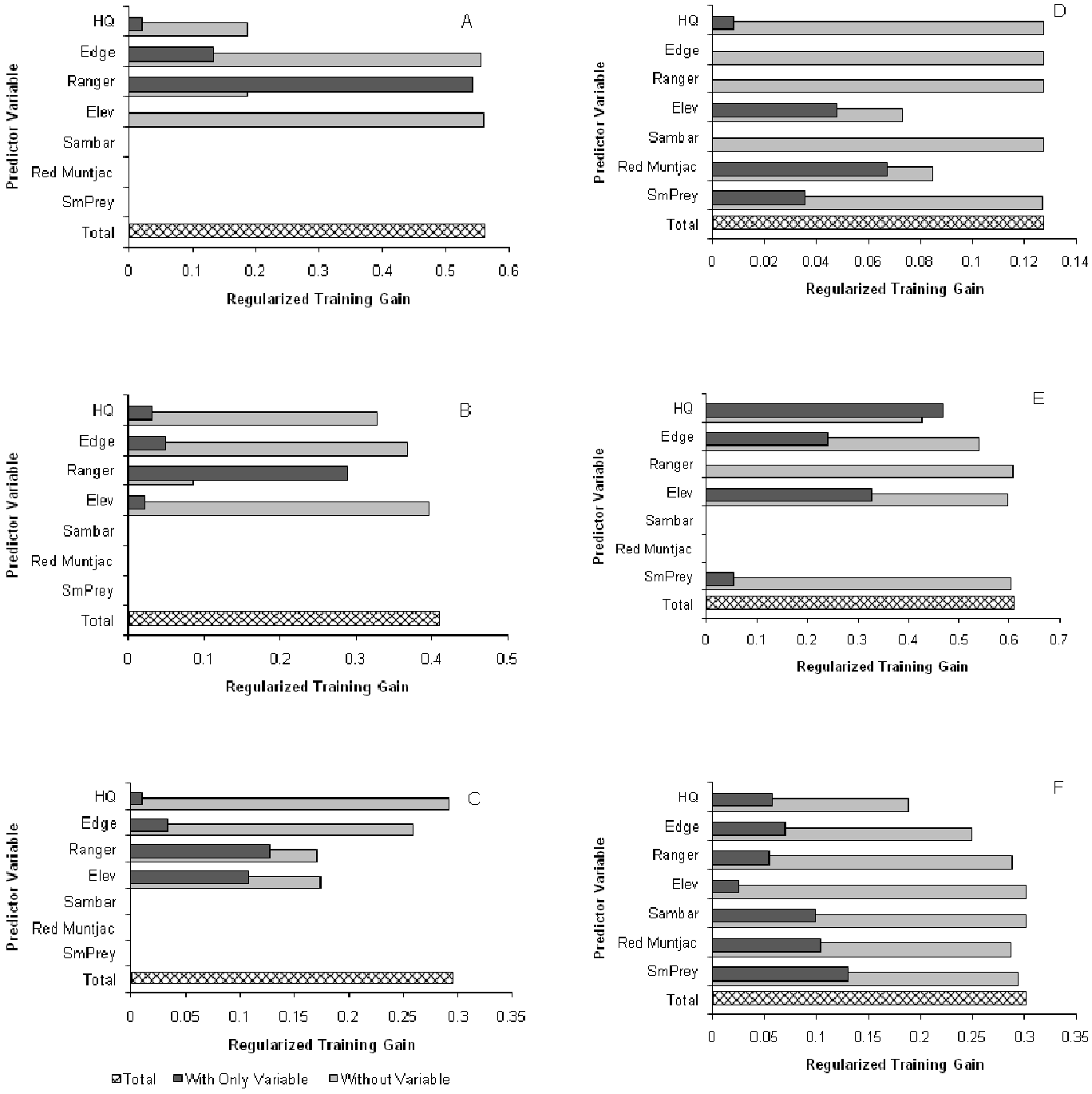
A
B
C
D
E
F
HQ
Edge
Ranger
Elev
Sambar
Red Muntjac
SmPrey
Total
Predictor Variable
Regularized Training Gain
Total
With Only Variable
Without Variable

Figure 2.3.

Figure 2.3. Jackknife analyses of individual predictor variables importance in the development of the full model for sambar (A), red muntjac (B), small prey (C), medium carnivores (D), small cats (E), and poachers (F) in relation to the overall model quality or the " regularized training gain." Black bars indicate the gain achieved when including only that variable and excluding the remaining variables; grey bars show how much the total gain is diminished without the given predictor variable. HQ = distance (m) from headquarters ranger station; Edge = distance (m) to park boundary; Ranger = distance (m) to ranger station; Elev = elevation (m); Sambar, Red Muntjac, and SmPrey = Maxent predictive occurrence layers.

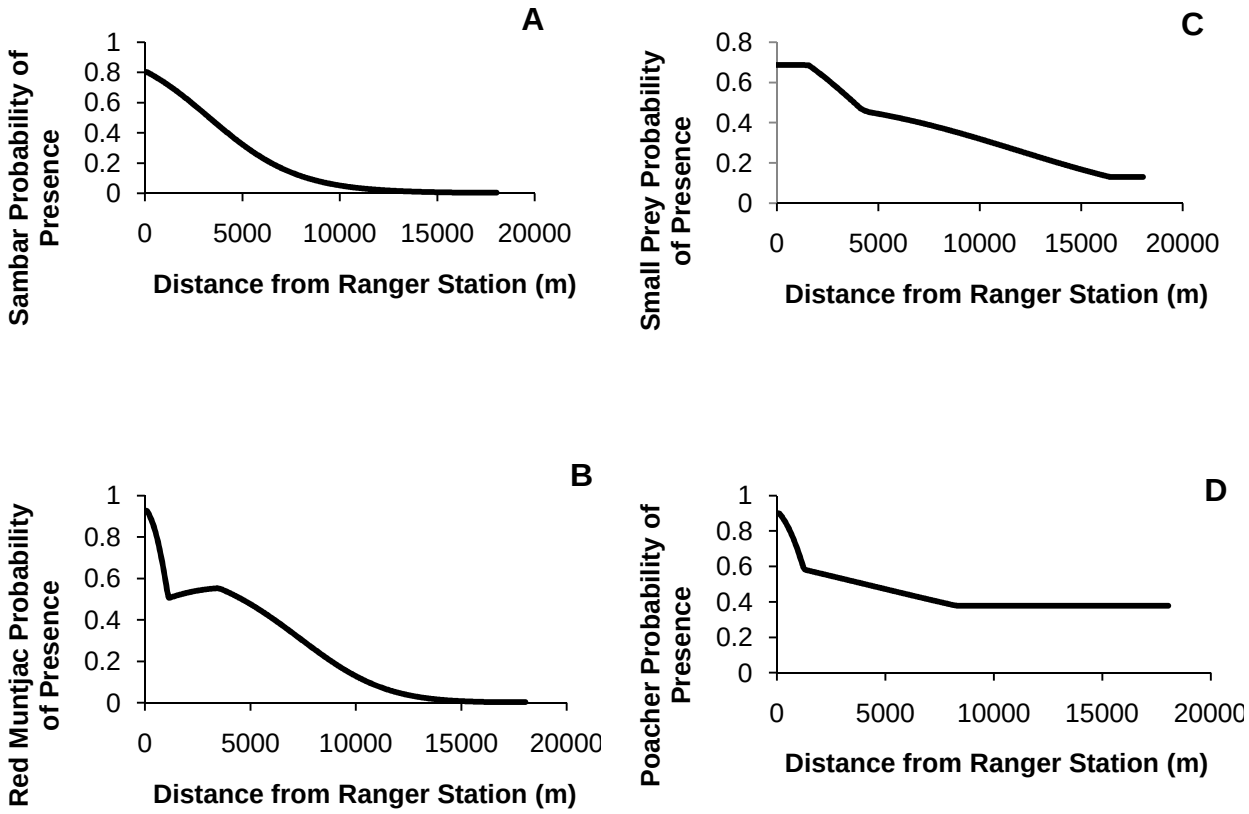

Figure 2.4. Correlation between probability of presence for sambar (A), red muntjac (B), small prey (C), or poachers (D) and distance from ranger station in Khao Yai National Park, Thailand.

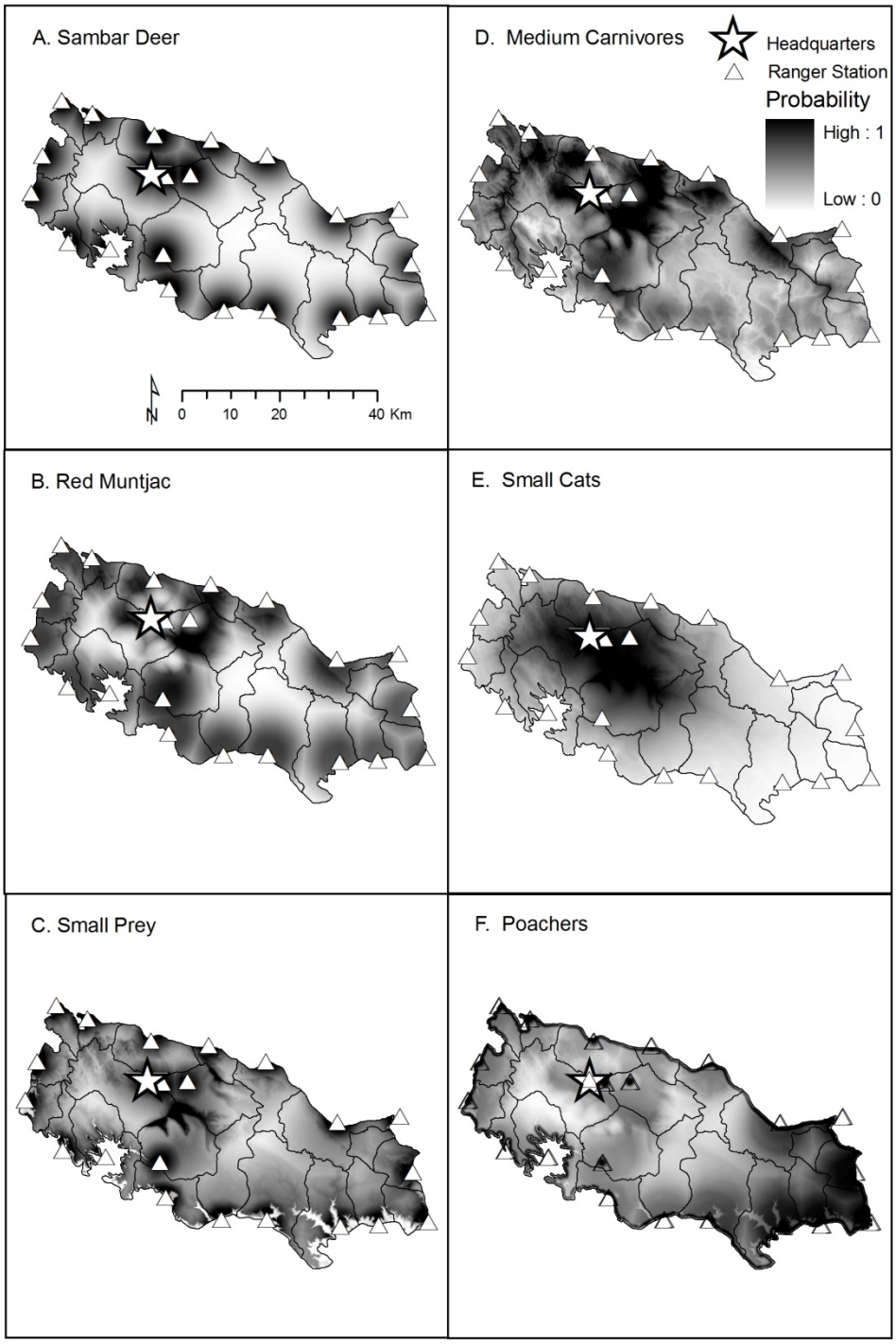

Figure 2.5. Predicted probability for presence of sambar deer (A), red muntjac (B), small prey (C), medium carnivores (D), small cats (E), and poachers (F) within Khao Yai National Park, Thailand. Based on Maxent modeling.

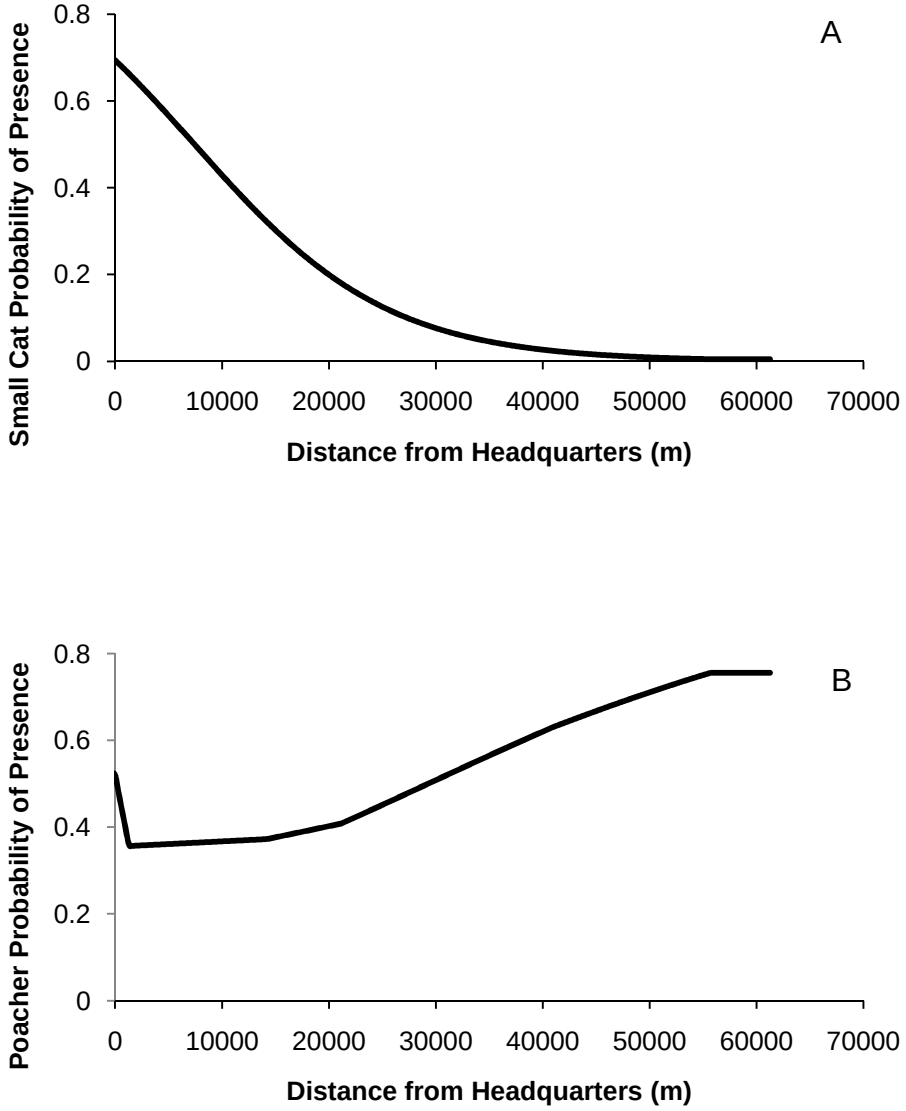

Figure 2.6. Correlation between probability of presence for small cats (A) or poachers (B) and distance from park headquarters in Khao Yai National Park, Thailand.

CHAPTER III.

CAMERA TRAP RECORDS OF DHOLES IN KHAO ANG RUE NAI WILDLIFE SANCTUARY, THAILAND

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Abstract

In response to a lack of data on dholes *Cuon alpinus*, we initiated an intensive field study of dholes in Khao Ang Rue Nai Wildlife Sanctuary (KARN) in eastern Thailand to gather critical baseline information on the factors influencing dhole presence. Dholes have declined over time, are exposed to continued pressure from humans, yet are taking over the role of top-predator in many Thai protected areas with the extirpation of tigers *Panthera tigris*. During January 2008-February 2010, we obtained 67 independent photographs (n = 4,505 camera-trap nights) of dholes along with photos of 27 mammal species in KARN. To evaluate factors determining dhole presence we used a zero-inflation Posisson regression model. We did not detect any significant influence of human activity on dhole presence. However, our photos confirmed that dholes and domestic dogs use overlapping areas at KARN. The presence of domestic dogs could have implications for competition or disease spillover. The presence of wild pigs had a significant negative relationship to sites of dhole photos, while bait had a significant positive relationship. Based on camera trapping efforts, we found that the one reproducing dhole pack detected during our study was mostly crepuscular, and their minimum 1-day movement averaged 2,597 m (n= 6 consecutive-day photos). Photo capture rates of dholes were highest in the cool season

(Oct-Jan). While we confirmed that there was at least one healthy dhole pack in KARN, this is far from establishing the presence of a healthy population in this protected area.

Introduction

In October 2007, stakeholders from various governmental, non-governmental, and academic organizations participated in the first Wild Canid Conservation Workshop in Thailand with the aim of assembling all knowledge about dholes *Cuon alpinus* and Asiatic jackals *Canis aureus* in this country. For the endangered dhole (IUCN 2010), the main conclusions were straightforward; even considering the two previous field studies of dholes in Thailand (Austin 2002, Grassman et al. 2005a), there was a serious lack of basic information on dhole ecology that is essential to understanding population status and conservation threats. Additionally, specialists recognized an urgent need to design and implement systematic studies to generate ecological and behavioral baseline data, with the expectation that findings will confirm the value of this carnivore to maintaining viable Thai ecosystems.

In response to this lack of data, we initiated a field study of dholes in Khao Ang Rue Nai Wildlife Sanctuary (KARN) in eastern Thailand to generate baseline information that will aid decision-makers in developing effective management plans for the species. Here we report on our camera trapping efforts, the aim of which was to gather baseline data on dhole activity and movements in KARN and to elucidate factors influencing photo rates, and thus, presence of, dholes. The dhole is a Southeast Asian predator that preys on medium to large ungulates. The species has been associated with negative connotations, for which conflicts with humans were a leading cause of historical population decimation (Durbin et al. 2004). Therefore, we

hypothesized that photo rates of dholes were (1) negatively correlated to human activity, and (2) positively correlated to prey availability and the presence of bait.

Study Area

Khao Ang Rue Nai Wildlife Sanctuary (KARN) in eastern Thailand (13°00′–13°32′N, 101°40′–102°09′E) encompasses 1,079 km^2 (Fig. 3.1). The climate is monsoonal, with distinctive wet (Jun-Sep), cool (Oct-Jan), and dry (Feb-May) seasons. Average annual rainfall is 1,500 mm, and temperature is 28ºC (Thai Meteorological Department 2011). The majority of the vegetation is lowland rainforest at < 200 m elevation, although our study site, centered at Chachoengsao Wildlife Research Station, was within patches of secondary forest.

Human activity varies throughout the sanctuary and is influenced by ranger patrols, tourist groups, and villagers entering the protected area. Illegal hunting targeting birds and small mammals occurs occasionally throughout the sanctuary. Additionally, there have been cases of larger mammals such as gaur *Bos gaurus* and banteng *Bos javanicus* being injured by snares (K. Jenks unpublished data).

Methods

Gathering Baseline Activity and Movement Data

We conducted surveys in KARN using camera traps (Moultrie Model MFH-I-40, EBSCO Industries, Inc., Birmingham, AL 35201-1943 USA) from 30 January 2008 through 2 February 2010 (e.g., Karanth et al. 2004). We used cameras to consistently monitor a dhole pack known to frequent a water reservoir near the Research Station, to examine daily movements, and

provide insights for future capture and collaring. Cameras were placed at locations where dhole signs (prints or feces) were detected or along wildlife trails. As a result, the study area and camera trap site selection concentrated in a central location within the sanctuary, logistically close to the sanctuary Research Station. We undertook a continuous sampling effort of 4,505 trap nights, placing cameras at 227 sites >500 m apart (to maintain independence between sites and decrease the probability that the pack would be detected by multiple cameras in one day) and distributed within a core area of approximately 300 km^2 (Fig. 3.1). We also monitored 13 sites further south (approximately 22 km) in an effort to capture additional dhole packs (Fig. 3.1). Cameras were set approximately 50 cm above ground, 1-5 m from the targeted monitoring area, and camouflaged with foliage. Thirty-nine cameras were baited with sambar deer *Rusa unicolor* road kill and 24 were baited with commercial scent lures (Minnesota Trapline Products, Pennock, MN 56279 USA). Independent detections (recorded as photo counts) were calculated following the protocol of O'Brien et al. (2003) who defined independence as (a) consecutive photos of different individuals of the same species, (b) consecutive photos of different species, (c) consecutive photos of individuals of the same species taken > 30 minutes apart, and (d) nonconsecutive photos of individuals of the same species. If a group of animals was captured in one frame it was counted as one count of the species.

Each photograph was printed with date and time so we made use of this information to document the activity level of dholes at KARN. Since cameras were operational 24 hr per day, we assumed that the more active dholes were in the area, the more frequently they would come into contact with cameras, and the more photographs would be taken. Thus, we pooled time periods into one-hour intervals and measured the activity level of dholes by the percentage of the total photographs. We also measured minimum daily distance travelled between camera

locations when dholes were captured on consecutive days. We assumed that consecutive photos were of the same pack based on the locations being within their estimated home range and consistent with previous movement patterns of this pack observed by field workers. We also performed a Kruskal-Wallis test to evaluate the effect of season on dhole photograph counts.

Evaluating Factors Determining Dhole Presence

A zero to represent dhole absence was assigned to photos with no animals or those that included other non-target species. Our spatial count data exhibited a high number of zeros (85%), representing pictures with no dholes. To address this problem we employed a zero-inflation Poisson regression model (ZIP) that allowed for complex sets of hypotheses involving species counts given site suitability (Lambert 1992, Welsh et al. 1996). ZIP has been applied to model the number of sightings of a rare possum species (Welsh et al. 1996) and to herbivore responses to water and bomas (Ogutu et al. 2010). The ZIP model also allows for two different kinds of zero counts; those due to unsuitable sites and those due to the observed counts (Kery 2010). The coefficients in the zero-inflation model are included as predictors of excess zeros (i.e. the probability that no dholes are present at a site because it is not suitable). The coefficients in the count model are usually used to determine abundance for a species. In this case, our counts were equivalent to the frequency of site use (how many times we detected dholes at certain areas). The majority of our camera trap sites were concentrated in the northern portion of the sanctuary and we do not know if all covariates (e.g., prey abundance) were similar to the rest of the sanctuary. Extrapolation to the entire park beyond our study area was inappropriate; therefore, for the ZIP analysis, we removed 13 southern sites and used a

subset (n=214) to characterize only the core area of use (approximately 100 km^2) for one dhole pack.

We explored covariates for their impact on predicting site suitability for dholes and counts. A total of seven environmental variables was measured at each camera site. An offset (similar to a weight) was included to compensate for the variation in the response resulting from differing search effort (number of camera trap nights). Five covariates were taken from camera photo detections (number of sambar deer, barking deer *Muntiacus muntjak*, wild pigs *Sus scrofa*, humans, and domestic dogs *Canis familiaris*). We assumed that the following covariates were indicators of human activity: counts of humans, dogs, and nearest distance to the headquarters. All distance measures were obtained in ArcGIS 9.2 (ESRI, Redlands, CA, USA). The final covariate was a baited or non-baited camera site. We formulated one global model to explore hypothesized effects of site variables with no interaction between explanatory variables. Before running the model we scaled continuous explanatory variables to improve convergence in the model.

The ZIP analysis was performed using a Monte-Carlo Markov Chain Bayesian framework in WinBUGS 14.3. We used the program R (version 2.11.1) with the package R2WINBUGS (Sturtz et al. 2005) to relay the data to WinBUGS.

Results

Baseline Data

In 4,505 trap nights we recorded a total of 1,906 independent photographs; these included 31 “unidentified mammal” photos. Of the total photos, 18% (n=350) were of carnivores, 52% (n=991) were of non-carnivore mammals, 10% (n=186) were of birds, 2% (n=34)

were of reptiles, 3% (n=61) were of domestic dogs, and 13% (n=253) were human traffic photos including park staff, tourists, poachers, villagers, and vehicles.

We captured 27 mammal species (17 carnivore species and ten non-carnivore species; Table 3.1). The carnivores included five mustelids, four viverrids, three felids, three canids, and two ursids. Of these species, six were documented ten times or less. Large-spotted civets *Viverra megaspila* (n=73) and dholes (n=67) were the most common carnivores. Elephants *Elephas maximus* (n=361) and sambar deer (n=218) were the most common non-carnivore mammals recorded by cameras.

We photographed a dhole pack of six individuals, and dholes and domestic dogs using overlapping areas of the sanctuary. We confirmed that dholes were breeding in KARN; two pups were first photographed in May 2008 when approximately six months old (estimated based on size) and young adults were recorded near the same location in June 2009. Dholes have similar pelage, which makes it difficult to identify individuals. However, we were able to identify the pups based on their size proportions from one year to the next and because they were photographed with the same adult female who was identified by her "docked" tail (Fig. 3.2).

Activity and Movement Data

Dholes were mostly crepuscular, exhibiting peaks in their daily activity in the early morning and the late afternoon (Fig. 3.3). The mean photo time was 14:11 h (95% CI 11:52-16:31). The capture rates of dholes differed significantly among seasons (Kruskall-Wallis: 19.778, $p<0.001$), with the majority of detections (77.6%) occurring in the cool season (Oct-Jan). Dholes were photographed on consecutive days six times for a mean minimum 1-day movement of 2,597 m (range = 969 – 4,682 m).

Factors Determining Dhole Presence

All of the posterior distributions for covariates included in the zero-inflation model overlapped zero (Table 3.2). This indicated that we did not detect any covariates impacting site suitability for dholes. Posterior distributions for wild pigs and bait in the count model did not overlap zero (Table 3.2) indicating these covariates did impact the dhole count. We found a negative association between wild pig photos and frequency of site count by dholes and a positive association between baited sites and dholes (Table 3.2). We did not detect any significant influence of human activity on dhole presence (Table 3.2).

Discussion

Our aim was to gather baseline data on activity and movement patterns for dholes at KARN and evaluate factors determining dhole presence at individual camera sites. We hypothesized that photo rates of dholes were (1) negatively correlated to human activity, and (2) positively correlated to prey availability and the presence of bait. The relatively high number of dhole photos we obtained was not an indication of population density, but probably a reflection of the fact that we set up camera traps with the intention of consistently monitoring our target pack. Additionally, the pack size of six was a minimum as it is highly possible that not all members of the group were in the one photo frame; it was difficult to identify individuals and thus confidently estimate how many total individuals we photographed. Observer sightings of packs were extremely uncommon during our study due to dense forest vegetation and the elusive nature of the species.

Dhole mean daily distance traveled was similar to distances observed in telemetry studies of Thailand dholes in Phu Khieo Wildlife Sanctuary (PKWS; 2.6 km; Grassman et al.

2005a) and in Khao Yai National Park (KYNP; 1.4 km; Austin 2002). Dhole crepuscular activity patterns in KARN were also similar to dholes observed in PKWS and KYNP (Austin 2002, Grassman et al. 2005a). While Karanth and Sunquist (2000) believed that dholes synchronized their activity with diurnal prey, we observed three dholes hunting sambar deer diurnally (ca. 16:00h) by chasing the deer into a water reservoir. In the same week, our team found a fresh sambar kill, the remains of a dhole hunt that was observed by one of the sanctuary rangers at 22:00h.

Cameras documented the presence of at least three prey species that dholes are known to consume (Grassman et al. 2005a): sambar deer, barking deer, and wild pig, but we found a negative relationship between wild pig and frequency of site use by dholes. This was surprising as wild pigs have been well documented as a target prey for dholes (Austin 2002, Grassman et al. 2005a). Perhaps this result was biased by the low sample size of wild pig photos (n = 29), but on the other hand we did not find any information on whether or not wild pigs actively avoid areas with high dhole activity. We did find that baited sites were positively correlated with frequency of site use by dholes, and this matched our hypothesis and was expected because the majority of bait used was sambar deer, a preferred food of dholes.

Dholes (and potentially domestic dogs) are likely the carnivores with the largest impact on medium to large-sized prey species in KARN. Tigers *Panthera tigris* and leopards *Panthera pardus* were not documented in KARN by our camera surveys and thought to be extirpated there (S. Wanghongsa, head of Chachoengsao Wildlife Research Station at KARN, pers. comm.). Additionally, our camera trap photos confirmed that dholes and domestic dogs use overlapping areas at KARN. The presence of domestic dogs in the sanctuary could also have implications for direct competition with dholes and with native scavengers (Butler & duToit 2002). Furthermore,

direct and indirect contact (via urine, fecal, or other body fluids) was likely. This is significant because domestic dogs can be an important reservoir for diseases that may spillover to threatened species. For example, Daszak et al. (2000) classified canine distemper virus as an emerging infectious disease due to spillover from domestic dogs that greatly reduced African wild dog *Lycaon pictus* and black-footed ferret *Mustela nigripes* populations. This situation should be monitored closely. We photographed a solitary dhole that appeared in poor health, possibly due to disease, and was never photographed with the rest of the pack.

Dholes are highly social pack hunters that live in extended family packs averaging eight individuals (Johnsingh 1981), and we documented a pack of six dholes in KARN. In camera trap photographs, all members appeared well-fed with sleek coats, and the pack was reproducing. While we confirmed that there was a healthy dhole pack in KARN, this is far from establishing the presence of a healthy population in this protected area. For example, if a typical pack range is 50-100 km^2, three to six packs should range over about 1/3 of the sanctuary. Although we did not detect any significant impact of humans or domestic dogs on dhole counts, our camera sites were in the core of the sanctuary. Dhole packs with home ranges closer to the forest edges may be more greatly impacted by human presence. To sustain viable populations of canids the availability of forest cover and prey species are important (Humphrey & Bain 1990). Information gaps surrounding dhole prey and spatial requirements must be bridged, and further information on dhole mortality threats must be gathered to facilitate plans for their future survival.

Acknowledgements

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Table 3.1. Mammal species identified from camera trap records at Khao Ang Rue Nai Wildlife Sanctuary, Thailand from January 2008 to February 2010, sampling time required to obtain the first photograph, and number of independent pictures obtained (n=226).

Species		**Nights to 1st Photo**	**Total Number of Photos**
Asian Elephant	*(Elephas maximus)*	1	361
Sambar Deer	*(Rusa unicolor)*	1	218
Barking Deer	*(Muntiacus muntjak)*	1	94
Crab-eating Mongoose	*(Herpestes urva)*	183	12
Domestic Dog	(*Canis familiaris*)	222	61
Gaur	*(Bos gaurus)*	225	20
Banteng	*(Bos javanicus)*	227	52
Large Indian Civet	*(Viverra zibetha)*	230	26
Malayan Porcupine	*(Hystrix brachyura)*	230	163
Large-spotted Civet	*(Viverra megaspila)*	395	73
Lesser Mouse-Deer	*(Tragulus javanicus)*	458	9
Dhole	*(Cuon alpinus)*	466	67
Hog Badger	*(Arctonyx collaris)*	701	33
Pig-Tailed Macaque	*(Macaca nemestrina)*	807	15
Smooth-coated Otter	*(Lutrogale perspicillata)*	817	10
Small Indian Civet	*(Viverricula indica)*	848	14
Common Palm Civet	*(Paradoxurus hermaphroditus)*	1089	22
Eurasian Wild Pig	*(Sus scrofa)*	1099	29
Leopard Cat	*(Prionailurus bengalensis)*	1217	22
Small Asian Mongoose	(*Herpestes javanicus*)	1258	10
Yellow-throated Marten	*(Martes flavigula)*	1290	8
Asiatic Black Bear	*(Ursus thibetanus)*	1356	12
Sunda Pangolin	*(Manis javanica)*	2847	2
Malayan Sun Bear	*(Helarcots malayanus)*	3616	3
Clouded Leopard	*(Neofelis nebulosa)*	3910	3
Asiatic Jackal	*(Canis aureus)*	3993	9
Golden Cat	*(Pardofelis temminckii)*	4178	1
Unidentified Mammals			84

Table 3.2. Mean, standard deviation (SD), and 95% credible interval of posterior distributions of parameters for zero-inflated Poisson regression model (n=213).

	Mean (SD)		2.5% Credible Interval	97.5% Credible Interval
Count model coefficients:				
(predicting dhole frequency of site use)				
intercept	-3.073 (1.867)	*	-6.607	-0.241
sambar deer	0.460 (0.583)		-0.683	1.147
wild pig	-0.792 (0.391)	*	-1.595	-0.092
barking deer	0.149 (0.375)		-0.612	0.675
domestic dog	1.176 (1.227)		-1.180	2.902
human	-0.029 (0.730)		-0.995	1.440
distance from headquarters	0.185 (0.382)		-0.638	0.735
bait	1.596 (0.662)	*	0.304	2.799
Zero-inflation model coefficients:				
(predicting site suitability)				
intercept	0.884 (5.894)		-9.515	9.680
sambar deer	-2.381 (3.982)		-7.977	5.413
wild pig	2.275 (2.672)		-2.466	8.550
barking deer	-1.922 (2.171)		-5.440	2.306
domestic dog	-2.904 (4.215)		-9.639	4.907
human	4.918 (4.584)		-5.810	9.874
distance from headquarters	-1.984 (2.236)		-5.774	1.985
bait	-3.789 (3.593)		-9.518	2.345

*posterior distribution does not overlap zero

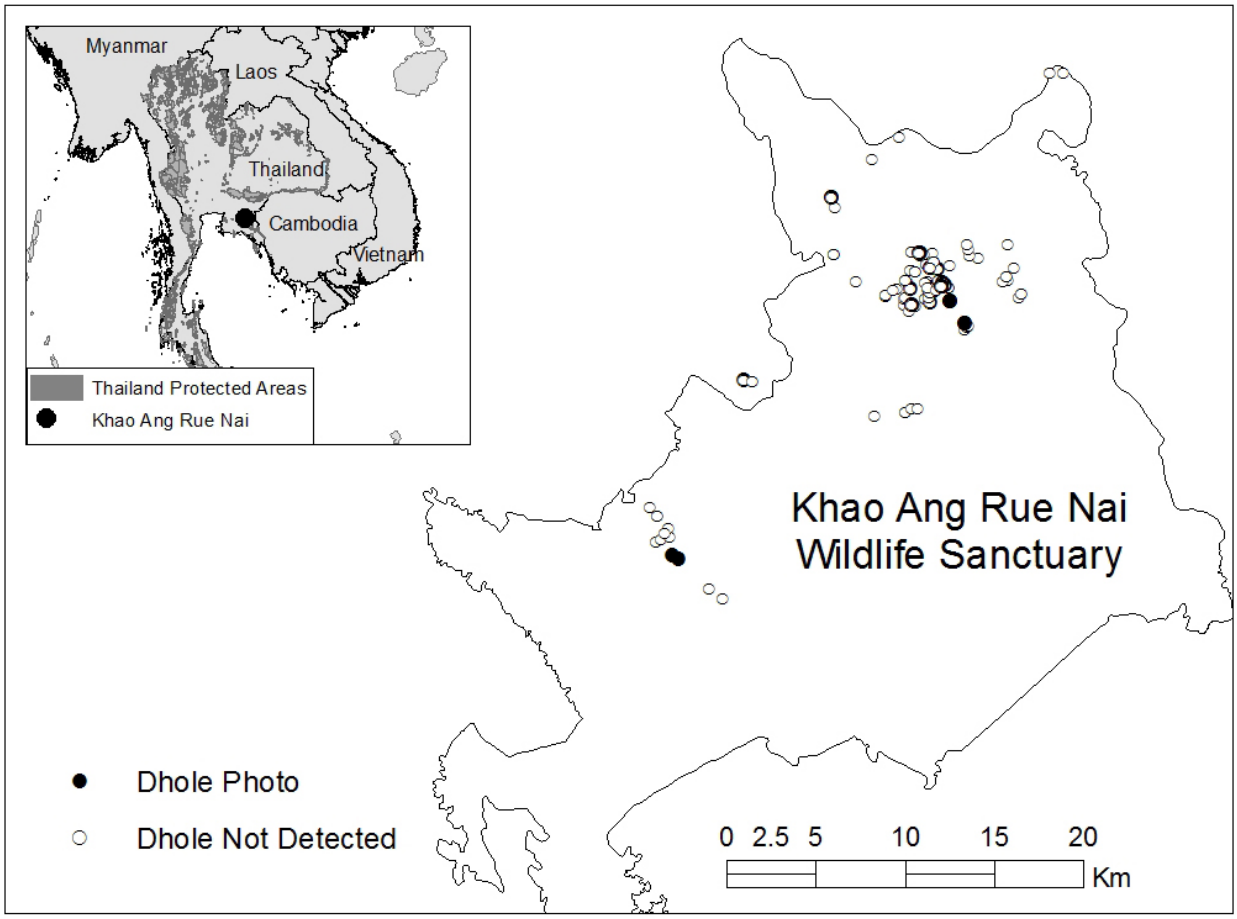

Figure 3.1. Location of Khao Ang Rue Nai Wildlife Sanctuary in Thailand (insert), the locations of camera survey sites (all circles) and dhole detection sites.

Figure 3.2. Camera-trap photo of adult female with docked tail, 3 adult dholes, and 2 pups. Arrows point to individual dholes and the visible eye-shine of the pups.

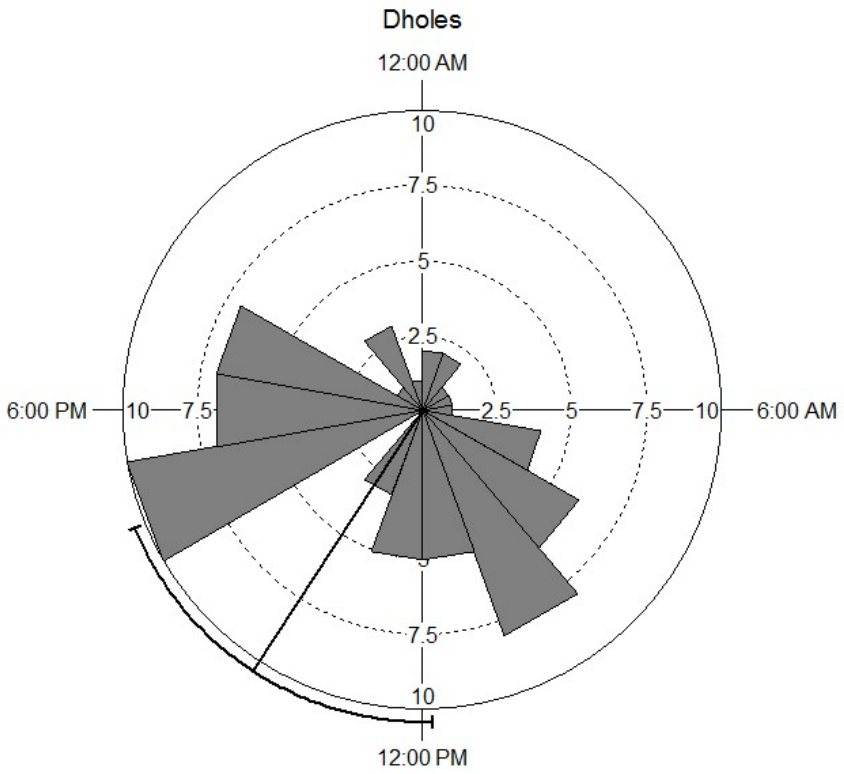

Figure 3.3. Times of dhole activity based on pooled camera trapping records in Khao Ang Rue Nai Wildlife Sanctuary, Thailand (January 2008 to February 2010). Numbers on concentric circles represent sample sizes. Bold line represents mean vector (14:11 h). Arc outside the circle represents 95% CIs of the mean vector.

CHAPTER IV.

MAPPING THE DISTRIBUTION OF DHOLES, *CUON ALPINUS* (CANIDAE, CARNIVORA), IN THAILAND

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Abstract

No recent attempt has been made to survey dhole (*Cuon alpinus*) distribution, or to estimate remaining population numbers. We surveyed 15 protected areas in Thailand with camera traps from 1996 through 2010. We used the photo locations of dholes (n=96) in Maxent along with six environmental variables to model current dhole distribution, as well as species predictive occurrence layers for sambar (*Rusa unicolor*), red muntjac (*Muntiacus muntjak*), wild boar (*Sus scrofa*), tiger (*Panthera tigris*), and leopard (*Panthera pardus*). The Maxent model identified the predicted probability of presence of leopards and sambar as positive and the most important variables in modeling dhole presence, indicating that maintaining a sufficient prey base may be the most important factor determining continued survival of dholes. Roughly 7% of the total land area in Thailand is potentially suitable for dholes. However, surveys to date have focused on protected areas, which make up just a third of the potential suitable areas for dholes. Only in four protected areas do they occur across the entire landscape, suggesting that in the majority of places where they occur, habitats are not uniformly suitable. Using the model we identified several potential areas where dholes have not been reported, and therefore status surveys are needed, and where future research of the species might be focused.

Introduction

The dhole *Cuon alpinus* (Pallas 1811) is a medium-sized social canid which once occurred over a wide geographic range from the Tian-Shan and Altai Mountains in central Asia and easternmost Siberia to India and Indochina (Cohen 1978, Durbin et al. 2004). Although listed as endangered (IUCN 2010), little is known about current dhole population sizes and distribution across its current geographic range. India is thought to be the current stronghold for dholes,

although existing information on the species primarily stems from Johnsingh's 1976-1978 field study in Bandipur and his 1985 census of dholes using questionnaire surveys (Johnsingh 1981, 1985), which only covered as far east as Myanmar and is now out of date. In an attempt to map the dhole's range in 1993, Stewart (1993) conducted interview surveys across Southeast Asia, but was unable to locate dholes in Thailand. The most up-to-date distribution map of this species was compiled from status reports for the 2004 Canid Action Plan, but this map contains huge tracts of localities with unconfirmed or unknown dhole status (Durbin et al. 2004). No recent attempt has been made to survey dhole distribution, or to estimate remaining population numbers.

Our study intends to use established distribution modeling tools to develop and test the first ever distribution map for dhole, an endangered canid species, in Thailand. The results from our research are meant to assist conservation decision makers for prioritizing geographic areas for future dhole surveys, research, management, and conservation. To achieve this we developed a new and unique approach that incorporates distribution models of prey and competitor species to significantly increase the predictive power of our distribution models (Anderson et al. 2002, Singh et al. 2009). As Thailand has one of the most extensive protected area systems in the region (Pattanavibool & Dearden 2002), understanding the dholes' distribution in Thailand should have significant conservation benefits. Our modeling efforts will also advance current understanding of the ecology of dholes and the factors that control this species geographic distribution in Thailand. Finally, we believe that our approach could be translated to better explore the status and distribution of dhole throughout its geographic range.

Several factors may influence patterns of dhole distribution including vegetation and landscape structure, food availability, competition with other carnivores, and human population levels (e.g., Morris 1925, Prater 1965, Barnett et al. 1980, Johnsingh 1983). However, a lack of understanding of specific influences on dholes of different environmental and human factors is an impediment to managing their populations in Asian protected areas.

Vegetation type does not seem to constrain dhole distribution as they occur across a wide range of land cover types, including tropical dry and moist deciduous forest, evergreen and semi-evergreen forests, low scrub interspersed with bamboo, grasslands, and alpine steppe (e.g. Peploe 1947, Barnett et al. 1980, Johnsingh 1981, 1983); dholes even inhabit open country in Ladak and Tibet (Prater 1965). Johnsingh (1981) suggested that dholes may prefer open forest to dense forest and the moist deciduous forests of India may represent optimal habitats (Phythian-Adams 1949). In an Indian study that applied occupancy models to data from country-wide experts, the best model for predicting dhole occupancy included covariates for evergreen, temperate, and deciduous land-cover with low and mid elevations (Karanth et al. 2009). However, it is possible that dholes' apparent vegetation preferences are actually the result of prey distributions and avoidance of competing predators (Johnsingh 1981).

Dhole prey selection varies throughout the range but they often tend to focus on medium to large ungulates. Sambar (*Rusa unicolor*), wild boar (*Sus scrofa*), tahrs (*Hemitragus jemlahicus*), muntjac (*Muntiacus* spp.*)*, chital (*Axis axis*), markhors (*Capra falconeri*), musk deer (*Moschus* spp.*)*, and goral (*Naemorhedus* spp.*)* have all been recorded among dhole prey items (e.g., Morris 1925, Prater 1965, Barnett et al. 1980, Johnsingh 1983). Yet, in Mudumalai Wildlife Sanctuary in India, hares and rodents comprised 46% of the dholes' diet (Barnett et al. 1980), while in Taman Negara National Park in Malaysia, 78% of dhole scats contained mouse deer

(*Tragulus napu* and *T. javanicus*; Kawanishi & Sunquist 2008). This indicates that dholes may be able to rely on smaller prey items in areas where ungulate populations have declined.

Dholes are sympatric with tigers (*Panthera tigris*), leopards (*Panthera pardus*), and jackals (*Canis aureus*) throughout Southeast Asia (Johnsingh 1992) and with wolves (*Canis lupus*) in China and India (Johnsingh & Yoganand 1999, Harris 2006), begging the question of whether dholes compete with other carnivores for shared prey. Johnsingh (1992) identified 13 parameters which enabled tiger and dholes to coexist, and partitioning of prey selection was identified as the top factor (Karanth & Sunquist 2000). Although prey partitioning may enable coexistence of tigers and dholes, interguild predation, i.e. direct predation of the smaller by the larger carnivore, may lead to greater separation. In our case this would mean the distribution and abundance of larger, potentially competing carnivore species, may restrict dhole habitat selection (Woodroffe & Ginsberg 2005). Examples of this include cases where dholes have been killed by tigers and attacked by leopards (e.g. Johnsingh 1983, Lynam et al. 2001, Karanth & Sunquist 2000), indicating both larger carnivores may be behaviorally dominant over dholes. And Venkataraman (1995) argues that dholes need to be aggressive towards leopards as a defense against leopard attacks on dholes.

Other dhole habitat considerations include suitable denning sites and proximity to water (Inverarity 1901, Prater 1965), although no study has suggested that den sites are a limiting resource. Dholes are known to hunt sambar by driving them into water bodies (Johnsingh 1983). Dhole distribution may be inversely related to human distribution because the species is sometimes persecuted as livestock predators, prey populations are often reduced by humans, and domestic dogs may transmit diseases (Durbin et al. 2004).

Dholes overlap with other large carnivores throughout their range, but they probably play a unique ecological role that is not functionally redundant with the roles of other carnivores

(Woodroffe & Ginsberg 2005). This implies that dholes have their own unique impacts on prey species and ecosystem processes, and that their conservation is important for maintaining ecological function and community integrity. In order to explore this influence and better elucidate the ecological role of dholes, managers first need to understand where the species occurs and why. We used data collected from 1996 through 2010 from 15 protected areas to assess potential factors affecting the distribution of dholes in Thailand. Our goals were to 1) confirm the presence of dholes in protected areas in Thailand, 2) identify environmental factors associated with dhole occupancy, 3) predict which areas within the country are within the species' potential distribution, 4) evaluate the efficacy of protected areas in Thailand in providing sufficient area for viable dhole populations, and 5) identify areas for future research efforts on this endangered species.

Materials and Methods

Input Data

From 1996 through 2010, camera traps were deployed at 15 protected areas within Thailand: Bang Lang National Park (BL), Hala-Bala Wildlife Sanctuary (HB), Huai Kha Kaeng Wildlife Sanctuary (HKK), Kaeng Krachan National Park (KK), Khao Ang Rue Nai Wildlife Sanctuary (KARN), Khao Sam Roi Yod National Park (KSRY), Khao Sok National Park (KOS), Khao Yai National Park (KY), Klongsaeng Wildlife Sanctuary (KLS), Kuiburi National Park (KB), Maenam Pachi Wildlife Sanctuary (MP), Phu Khieo Wildlife Sanctuary (PK), Ta Phraya National Park (TAP), Thap Lan National Park (THP), and ThungYai Naresuan Wildlife Sanctuary-West (TYW; Fig. 4.1). In total, individual cameras were set at 1,174 sites, and accumulated 48,130 trap nights with a mean of 41 trap nights per camera. Camera trap sites were not baited and placed a minimum of

0.5 km apart at elevations ranging from 0 – 1,351 m (mean = 428 m). All cameras were operational 24 hrs per day and recorded time and date for each exposure. Cameras were placed ~50 cm from the ground and close to trails, stream beds, and ridges where wildlife signs (i.e. footprints and scats) were present to maximize the chances of capturing an animal.

Habitat Variables

We used six environmental variables across Thailand, together with the predicted occurrence of three prey species, and the predicted occurrence of potential competitors (tigers and leopards), to model dhole distribution. For assessing the potential distribution of prey and competitor species, independent probability of occurrence models were developed using Maxent. Following the modeling procedure for dholes described below, we first produced predicted occurrence layers for three prey species (*Sambar, Red Muntjac*, and *Wild boar*) based on locations where the species were photo-trapped. The predicted occurrence layers are a surrogate for prey availability or abundance. The resulting layers were included as predictor variables in the tiger, leopard, and dhole models. Additionally, the output layer for *Tiger* and *Leopard* was included as a variable for the dhole model. Presence records used for training included sambar (n=124), red muntjac (n=271), wild boar (n=184), tiger (n=80), and leopard (n=100). We are assuming that the inclusion of prey and competitors linked with environmental variables (Anderson et al. 2002, Singh et al. 2009) will result in a better spatial representation of the distribution of dholes, which cannot be substituted by only using environmental variables. Because Maxent does not use a statistical regression, but an optimization, co-linearity and correlation of variables are not used in the theoretical analysis of Maxent. It is therefore more stable regarding correlated variables (Elith et al. 2011) and unnecessary to create separate abiotic and biotic models.

Annual precipitation (1950-2000) and elevation was obtained from the WorldClim database (Version 1.4, http://www.worldclim.org). General country-wide land cover categories and distances to nearest protected area edge, village, and stream were obtained using ArcMap 9.3 from shape files provided by the Thailand Department of National Parks, Wildlife, and Plant Conservation (DNP). Distance to nearest edge was measured from all grid points within a protected area to the boundary, with areas outside of protected areas being assigned a zero value. We consolidated land cover categories from 25 to 14; they were entered as a categorical variable in the model and included: agriculture, bamboo, beach forest, dry dipterocarp forest, dry evergreen forest, eucalyptus plantation, grassland, hill evergreen, mixed-deciduous forest, moist evergreen forest, pine forest, secondary growth forest, teak plantation, and other.

Distribution Modeling

Locations at which dholes were photo-trapped (n=96) were the source of data for Maximum Entropy (Maxent, Phillips et al. 2006). Maxent estimates a frequency distribution by finding the distribution that is closest to uniform, constrained by the average values for a set of variables taken from the target distribution (Phillips et al. 2006). We used Maxent because it performs better than other presence-only modeling techniques (Elith et al. 2006), especially with low numbers of occurrence locations (Papes & Gaubert 2007). This method has been used to develop habitat suitability models for a range of mammals (e.g. DeMatteo & Loiselle 2008, Monterroso et al. 2009, Wilting et al. 2010, Jennings & Veron 2011).

All environmental layers were projected to the Indian 1975 UTM zone 47N to match their coordinates, clipped to the extent of the boundary of Thailand, resampled to the same cell size of 30 arc-seconds (~ 1 km^2), and entered with the occurrence data into Maxent version 3.3.3 (www.cs.princeton.edu/~schapire/maxent). We set the program to run 500 iterations with a

convergence threshold of 0.00001, a regularization multiplier of one, a maximum of 10,000 background points, the output grid format as 'logistic', algorithm parameters set to 'auto features,' and all other parameters at their default settings (Phillips & Dudik 2008). The model was trained using a subset that included only the protected areas surveyed. The final distribution map resulted from the model projecting into all of Thailand, including protected areas where we collected no data and outside of protected areas. The model was trained using a mask to include surveyed protected areas because we only sampled camera-trap locations for prey, competitors, and dholes within protected areas. In this way our background sample excluded areas that have not been searched (Elith et al. 2011). While extrapolation beyond the area where the data was collected often is an issue in distribution modeling, Maxent has consistently preformed very well in such applications. We experimented with different threshold values but this tends to lead to significant over prediction. Based on our experience and published literature, we feel justified in our approach. The outputs also are parsimonious and can serve as a first hypothesis for areas where we may find additional dhole populations or may want to consider potential sites for dhole restoration and recovery. We had the program randomly withhold 25% of the presence locations in order to test the performance of each model.

Model performance was assessed by the area under the curve (AUC) of the receiver-operating characteristic (ROC) plot (Liu et al. 2005). We calculated standard errors and confidence intervals for each of the models using ROCR (Singh et al. 2009), vcd (Meyer et al. 2010), and boot (Canty & Ripley 2010) packages in R v2.11.1 (R Development Core Team 2010). The data were jackknifed to evaluate each variable's importance in explaining the observed distribution. The percent contribution of each variable was calculated based on how much the variable contributed to an increase in the regularized model gain as averaged over each model

run. To calculate variable permutation, for each variable in turn, the values of that variable on training presence and background data were randomly varied and the resulting change in training AUC is shown normalized to percentages (Maxent Tutorial; http://www.cs.princeton.edu/~schapire/maxent/). To delineate areas with better than random prediction of dhole presence, we used *a-priori* prevalence values (96 dhole detection locations out of 1,174 total sampling locations) as the "presence" threshold (0.08 detection). In a review of twelve approaches for choosing a threshold of occurrence, Liu et al. (2005) ranked this prevalence approach as one of the most robust.

Results

Distribution models for sambar, red muntjac, wild boar, tiger, leopard, and dhole performed well based on the moderately high (>0.80) AUC values (Swets 1988; Table 4.1). Distance to protected area edge (*Edge*) and annual rainfall (*Rain*) had the highest predictive power for all prey species (Table 4.2). The probability of presence for prey was higher at lower rainfall locations and at distances closer to the interior of protected areas (graphs not shown).

The variables with the highest percent contribution and permutation importance for the dhole model were *Leopard* and *Sambar* (Table 4.2). The jackknife test of variable importance shows the highest gain when the variable *Sambar* is used in isolation, which therefore appears to have the most useful information by itself (Fig. 4.2). However, the variable that decreases the gain the most when it is omitted is *Leopard*, which indicates that this variable has the most information that is not present in the other variables (Fig. 4.2). The variables *Leopard, Sambar, Stream,* and *Red Muntjac* make up almost 90% of the contribution for the dhole model and all of the variables are positively correlated with predicted dhole presence (Table 4.2, Fig. 4.3).

We generated a map (predicted probability of occurrence; Fig. 4.4) of potential dhole distribution in Thailand. The highest dhole probability of presence was projected to be below 500 m elevation (graph not shown). The land cover categories with the highest predicted probability of dholes as calculated in Maxent included grasslands (predicted dhole presence of 60%), mixed deciduous forest (57%), dry dipterocarp forest (49%), dry evergreen forest (47%), and hill evergreen forest (29%; Fig. 4.5). The model predicted < 10% probability of occurrence of dholes in all other land cover types. The total area predicted to be potential habitat for dholes was 34,404 km^2 which is roughly 7% of the total area in Thailand (Fig. 4.6).

Thirty percent of this potential habitat for dholes falls within current protected areas. If we exclude all land outside of protected areas, the total potential habitat for dholes is 10,461 km^2 or 2% of Thailand (Fig. 4.6). To further refine the potential habitat, we excluded patches that are too small to support a dhole pack. Grassman et al. (2005a) found dholes in PK to have ranges of 12.0km^2 and 49.5km^2. Therefore, we counted only contiguous patches of predicted habitat greater than 50 km^2. The remaining 31 patches have the potential to support 161 dhole home ranges of 50 km^2 based on our rough assumptions. However, 58% of those patches might sustain fewer than three packs (Fig. 4.7). From the model, we identified four protected areas [Khlong Wangchaow National Park (KW), Salakpra Wildlife Sanctuary (SP), Khao Ang Rue Nai Wildlife Sanctuary (KARN), and Pang Sida National Park (PS)] where dholes may range across almost the entire protected area and that include patches greater than 50 km^2 (Fig. 4.8).

Discussion

Identifying areas of high habitat suitability for dholes lays the foundation for planning future research and conservation initiatives. Our Maxent results are a step towards highlighting areas of suitable habitat for dholes. We extrapolated our predictions to the whole of Thailand

to identify areas that may be suitable for dholes, but were previously disregarded. We incorporated competitors because interactions may skew dhole distribution despite environmental suitability and prey availability. While we recognize the potential circularity of the model because we used the same environmental variables to develop distribution models that were surrogates for prey availability and competitor presence, we elected to proceed because so little is known about dholes and we thought it was important to include these covariates, limited as the data may be. Not surprisingly, prey availability (*Sambar* and *Red Muntjac* combined) explained 44% of the species' predicted occurrence.

The probability of presence for prey was higher at lower rainfall locations and at distances closer to the interior of protected areas. These findings are dissimilar to Ngoprasert et al. (in press) who found sambar and wild boar associated with higher rainfall. However, they found red muntjac associated with areas far from forest edges.

Our results indicate that the strongest correlate with the distribution of dholes, which led to the highest model gain when used in isolation, is the presence of *Sambar*. A strong association with this single prey species was expected considering sambar comprise 30% of the frequency of occurrence of prey items in dhole feces in Thailand (Grassman et al. 2005a, Salangsingha & DoungKae 2009) and up to 90% occurrence in feces of dhole in India (Rice 1986).

Besides prey, the other variable shaping dhole distribution is the presence of leopards. Although there are accounts of interspecific competition between leopards and dholes (Johnsingh 1983, Wood 1929, Venkataraman 1995), our modeling indicates that dhole presence increased as leopard presence increased. This probably arises because these two species share habitats because of similar prey preference (e.g. Johnsingh et al. 1999, Karanth & Sunquist 2000). *Sambar* (a large prey, on average > 180 kg) contributed most in the Maxent model for leopards and second-most for dholes.

The other possibility is that the positive association of dholes with leopards is related to their predicted negative association with tigers, their potential intra-guild predator. However, our *Tiger* variable as modeled contributed very little (neither positively nor negatively) to predicted dhole distribution.

The potential range of dholes covered a wide spectrum of habitats, but our model predicted that dholes occur primarily in grasslands and mixed deciduous forest at generally 150 m elevation. This is consistent with a previous radio-telemetry study in PK where one dhole pack was found to base its home range around a grassland area (Grassman et al. 2005a). We caution, however, that this may be an artifact of the prey distribution in PK and may not represent the general population. Regardless, overall, the impact of land cover type alone only contributed 2.5% to predicting dhole occurrence; this emphasizes that prey base, not land cover type, is the main limiting factor for the species.

The range of predicted dhole habitat does not expand into the north and the model failed to predict dhole occurrence in Doi Chiang Wildlife Sanctuary and Lum-nam-pai Wildlife Sanctuary in the far north, despite field records of dhole sign from Kanchanasaka (2005). The protected areas this region may preclude large populations of sambar due to poaching pressure (Pattanavibool & Dearden 2002). However, the north does have contiguous forest cover; we could be missing key variables or there is the possibility that poor input (e.g. an out-of-date landcover layer) may have resulted in the model being inaccurate for this region.

This study provides a first indication of how much dhole habitat is not protected in Thailand. Our results show that currently only 30% of potential habitat falls within protected areas in Thailand. Additionally, protection measures inside protected areas may not be adequate because there are large areas of potential habitat inside protected areas where dholes are apparently absent. This might be related partly to prey availability, but the edge itself may

be a sink for dholes due to the proximity to human settlements and the greater likelihood of getting shot (K. Jenks, pers. obs.) or poisoned (S. Vitnitpornsawan, pers. obs.) there relative to the safer core area. The observation that wildlife abundance is higher in central parts of protected areas versus marginal areas has been specifically documented in Khao Yai National Park (Lynam et al. 2003, Jenks et al. 2011). Current protection efforts are most intense in areas close to a park or sanctuary headquarters, with remote areas getting less protection. We recommend that protected area edges be specially managed in order to support dholes and their prey.

Additionally, there is a low probability that the 70% of potential dhole habitat outside of protected areas actually supports dholes because there are no verifiable records of dholes living outside of protected areas in Thailand. Many areas predicted to have suitable ecological conditions for dholes may actually be devoid of dhole populations because virtually all forests outside of protected areas in Thailand have been converted to agriculture and intersected by roads for human settlement. If forests are still present, they are likely to be largely without prey. For example, even sambar is now listed as Vulnerable due to intense poaching pressure (IUCN 2008). Moreover, the lack of formalized protection measures outside of protected areas means that dhole survival chances are much reduced there.

If we exclude all area outside of protected areas, the total potential habitat for dholes is 10,461 km^2 or only 2% of Thailand. If we restrict these areas further to include only contiguous patches of predicted habitat greater than 50 km^2, the remaining patches very roughly support 161 dhole home ranges.

Another challenging issue facing individuals involved in dhole conservation is locating suitable sites for basic research of this elusive species. Our Maxent predictive map is a preliminary step which can guide field research to further clarify the breadth of the dholes'

distribution. The model can be tested by surveying for dhole presence in 1) areas predicted to have a high probability of dholes and 2) areas predicted to have no probability of dholes where the model may be wrong. We identified four protected areas (KW, SP, PS, and KARN) where dholes were predicted to range across almost the entire area. These are ideal starting locations for basic dhole ecological research. However, these areas also represent locations where large predators (i.e. potential competitors) are almost absent, especially tiger. To understand more about the fate of dholes in the presence of large predators, research also needs to be conducted in protected areas where dholes were predicted to be present along with tigers and leopards, such as KK, KB, HKK, and TYW. Additionally, we need to determine if dholes are using areas outside of protected areas. The focus for this should stem from areas of predicted presence from our modeling including the area north of MP and south of SP, and a region southwest of PK. Finally, we also support surveys in the north to test whether or not the model predictions are correct in this region.

We have now explored the question of *where* dholes are found, the next step is to shed light on the size and stabilities of their populations. It may be that 7% of the country is potential habitat for dholes, but this was inferred from a small number of records and may not support stable populations, but only small, isolated packs. Furthermore, we estimated that the majority of contiguous patches may support fewer than three packs. Maxent modeling has provided us with a helpful evaluation of the distribution of the dhole in Thailand, which can now be used for conservation planning.

Acknowledgements

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Table 4.1. Model performance measured by the area under the curve (AUC) of the receiver operating characteristic (ROC) plot, standard error (S.E.), and 95% confidence interval (CI).

Maxent Model	**AUC**	**S.E.**	**95% CI**
Sambar	0.883	0.025	0.827, 0.927
Red Muntjac	0.827	0.022	0.782, 0.880
Wild Boar	0.827	0.026	0.772, 0.874
Tiger	0.715	0.060	0.589, 0.843
Leopard	0.929	0.040	0.827, 0.981
Dhole	0.932	0.033	0.850, 0.993

Table 4.2. Estimates of relative percent contribution (RC) and permutation importance normalized to percentages (PI) for variables used in Maxent modeling of species distributions in Thailand.

	Maxent Model											
	Sambar		Red Muntjac		Wild Boar		Tiger		Leopard		Dhole	
Variables	RC	PI	RC	PI	RC	PI	RC	PI	RC	PI	RC	PI
Leopard											37.6	39.2
Sambar							35.0	2.9	29.7	3.7	36.8	25.3
Stream	2.1	0.7	2.4	3.2	10.2	4.9	5.2	0.5	0.7	0	8.5	5.0
Red Muntjac							7.5	2.1	7.0	0.4	6.9	10.5
Elev	10.7	10.8	11.2	6.1	10.1	9.7	2.3	1.8	2.5	3.5	4.0	3.8
Landcover	14.1	9.1	9.8	9.7	14.8	8.4	16.4	31.9	26.9	22.1	2.5	8.3
Village	10.7	24.9	6.6	13.7	4.1	12.8	13.9	18.1	5.0	4.1	1.3	2.4
Wild Boar							16.7	16.3	10.8	27.0	1.2	0
Tiger											0.7	0.5
Edge	35.1	26.4	29.2	33.6	19.2	33.7	0.5	1.5	1.5	1.0	0.4	4.1
Rain	27.4	28.1	40.7	33.7	41.6	30.6	2.6	25.0	15.8	38.2	0.2	0.9

Maxent, maximum entropy. *Edge*=distance of wildlife presence to protected area boundary (m), *Elev*=elevation (m), *Landcover*=categorical land cover type*, Rain*=annual rainfall (mm), *Stream*=distance of wildlife presence to nearest stream (m),*Village*=distance of wildlife presence to nearest village (m), *Sambar, Red Muntjac, Wild Boar, Leopard, Tiger*=predicted layer of occurrence from Maxent modeling for each species. Species italic when used as variables.

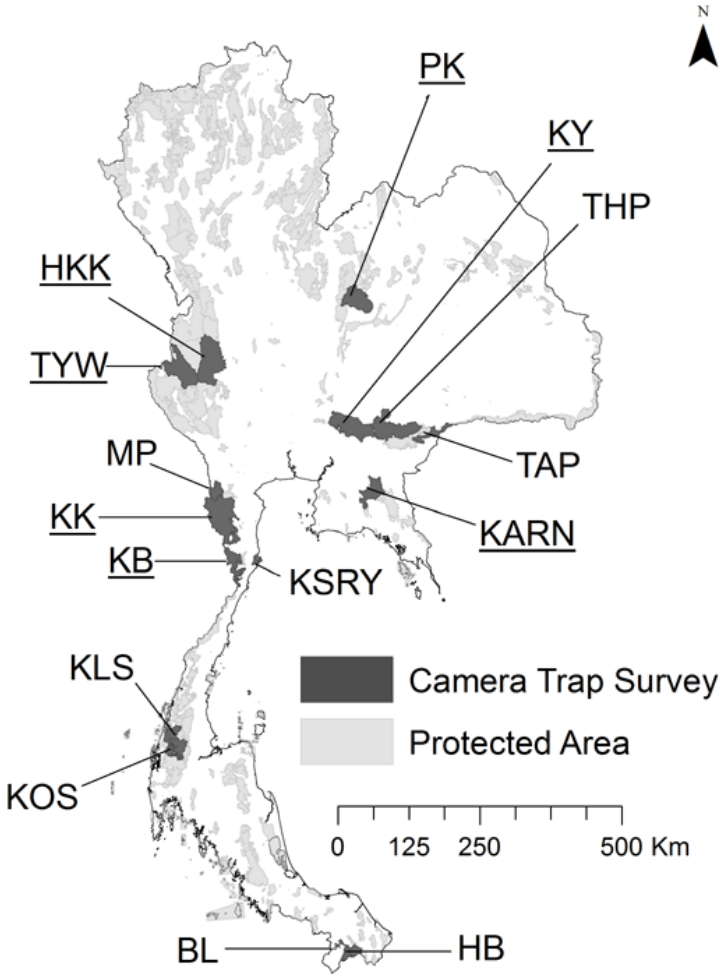


Figure 4.1. The study locations included 15 protected areas within Thailand: Bang Lang National Park (BL), Hala-Bala Wildlife Sanctuary (HB), Huai Kha Kaeng Wildlife Sanctuary (HKK), Kaeng Krachan National Park (KK), Khao Ang Rue Nai Wildlife Sanctuary (KARN), Khao Sam Roi Yod National Park (KSRY), Khao Sok National Park (KOS), Khao Yai National Park (KY), Klongsaeng Wildlife Sanctuary (KLS), Kuiburi National Park (KB), Maenam Pachi Wildlife Sanctuary (MP), Phu Khieo Wildlife Sanctuary (PK), Ta Phraya National Park (TAP), Thap Lan National Park (THP), and ThungYai Naresuan-West Wildlife Sanctuary (TYW). Dholes were detected at underlined sites.

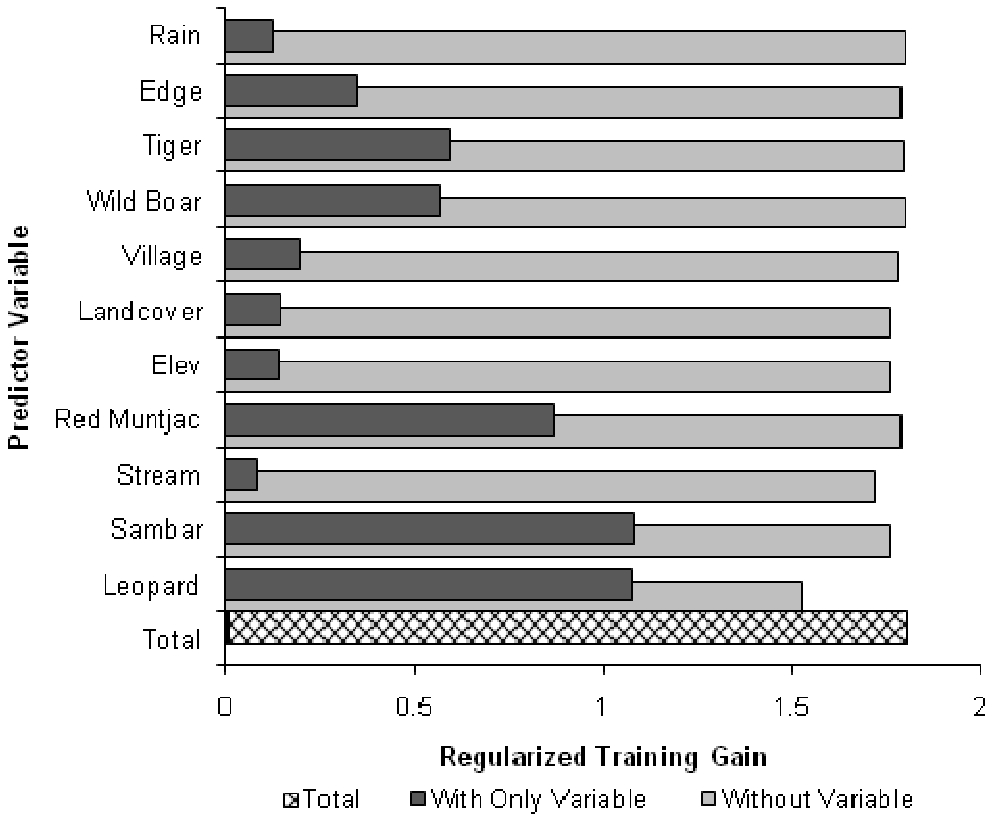
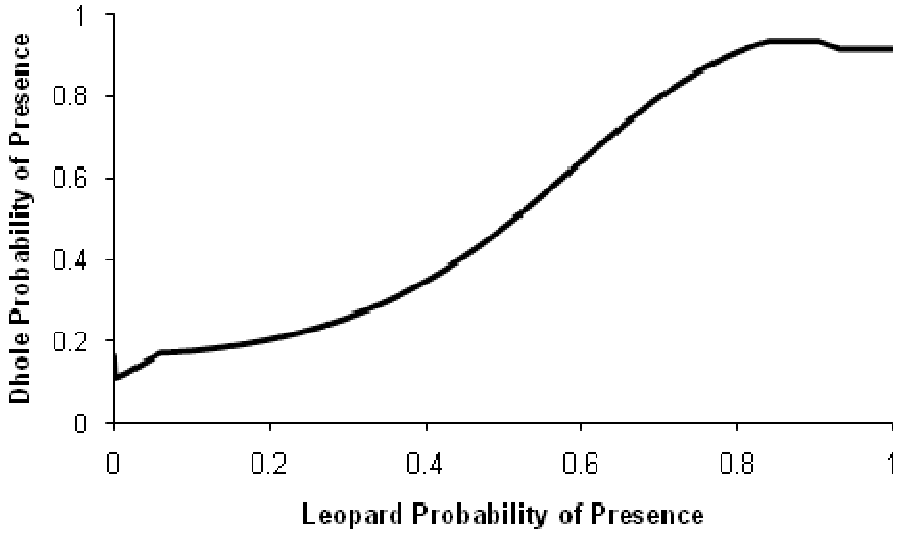


Figure 4.2. Jackknife analyses of individual predictor variables importance in the development of the full model for Dholes in relation to the overall model quality or the "regularized training gain." Black bars indicate the gain achieved when including only that variable and excluding the remaining variables; grey bars show how much the gain is diminished without the given predictor variable. Edge=distance to protected area boundary (m), Elev=elevation (m), Landcover=categorical land cover type, Rain=annual rainfall (mm), Stream=distance to nearest stream (m),Village=distance to nearest village (m), Sambar, Red Muntjac, Wild Boar, Leopard, Tiger=predicted layer of occurrence from Maxent modeling for each species.

A.


Dhole Probability of Presence
1
0.8
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
1
Leopard Probability of Presence

B.

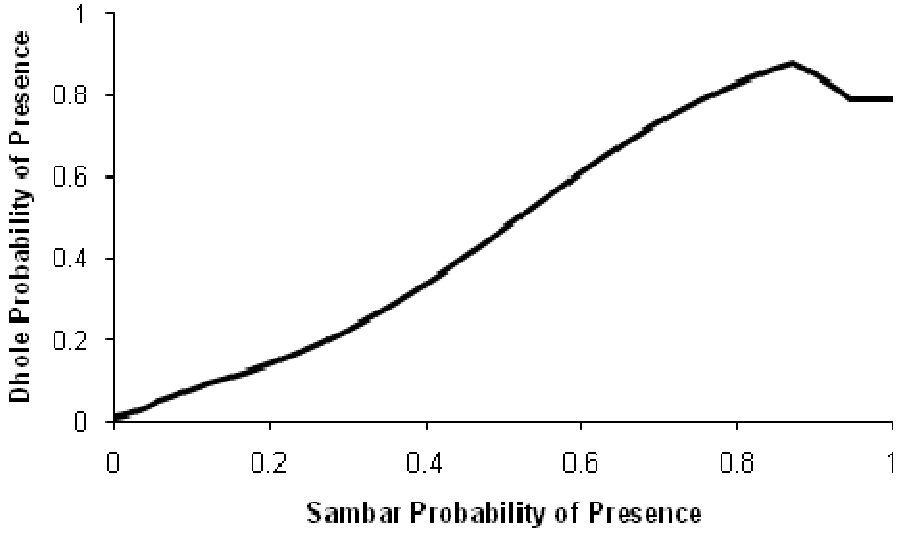
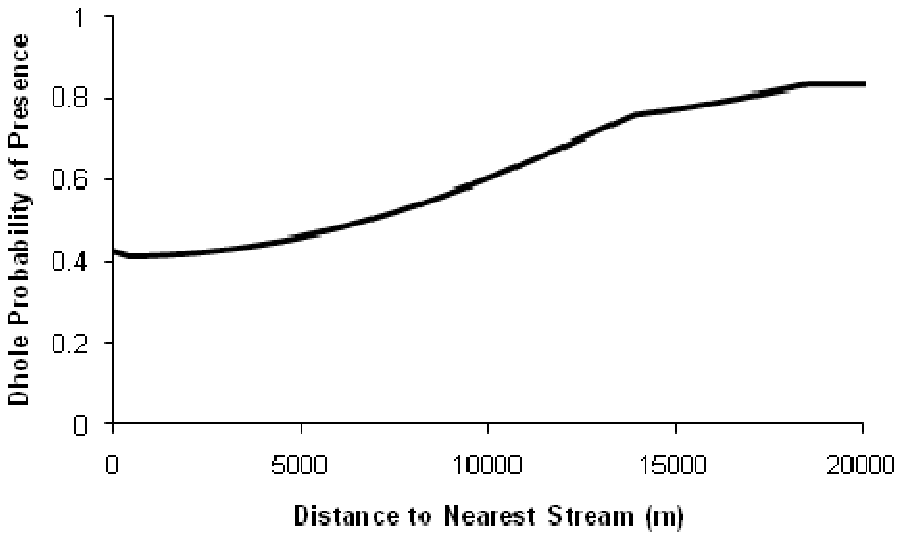

Dhole Probability of Presence
1
0.8
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
1
Sambar Probability of Presence

Figure 4.3.

C.



D.

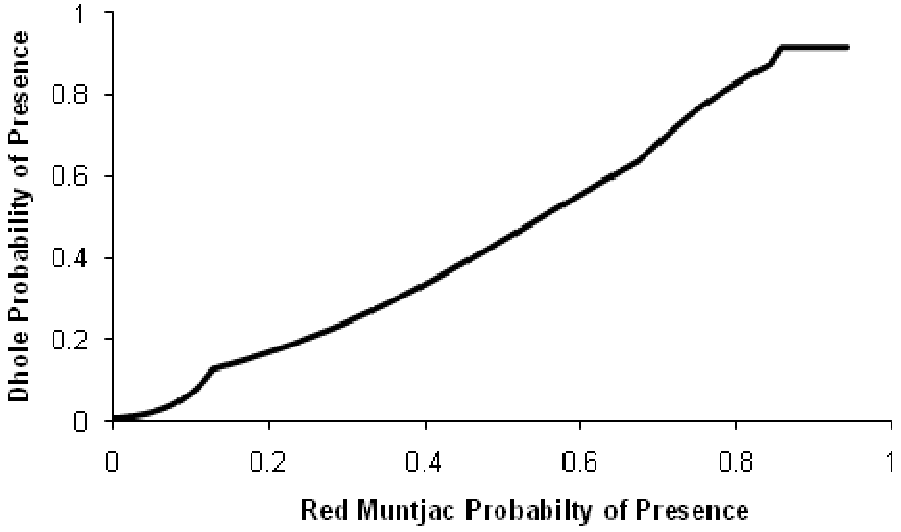


Figure 4.3. Graphical representation of the relationship between predictor variables Leopard (A), Sambar (B), Stream (C), Red Muntjac (D) and Dhole probability of presence. Each of the curves represents a different Maxent model created using only the corresponding variable.

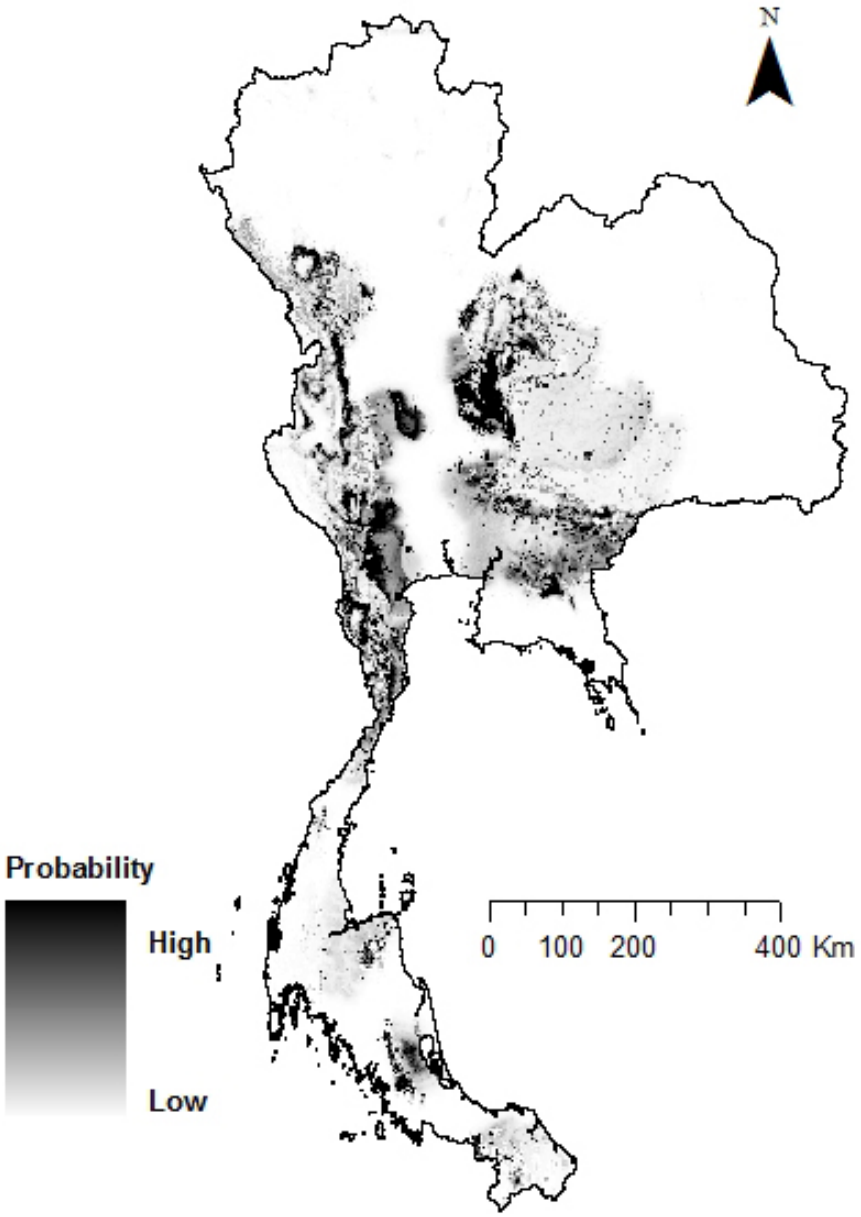


Figure 4.4. Predicted distribution for Dholes within Thailand estimated by Maxent modelling. Potential areas are shown in gray shading, with the darker color indicating higher probabilties of occurrence.

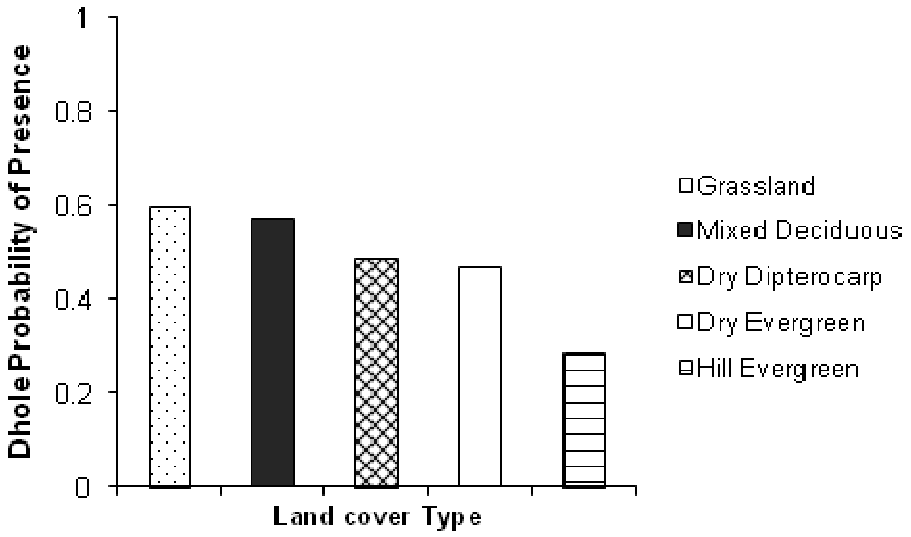


Figure 4.5. Land cover categories with the highest probability of predicted Dhole presence in Thailand.

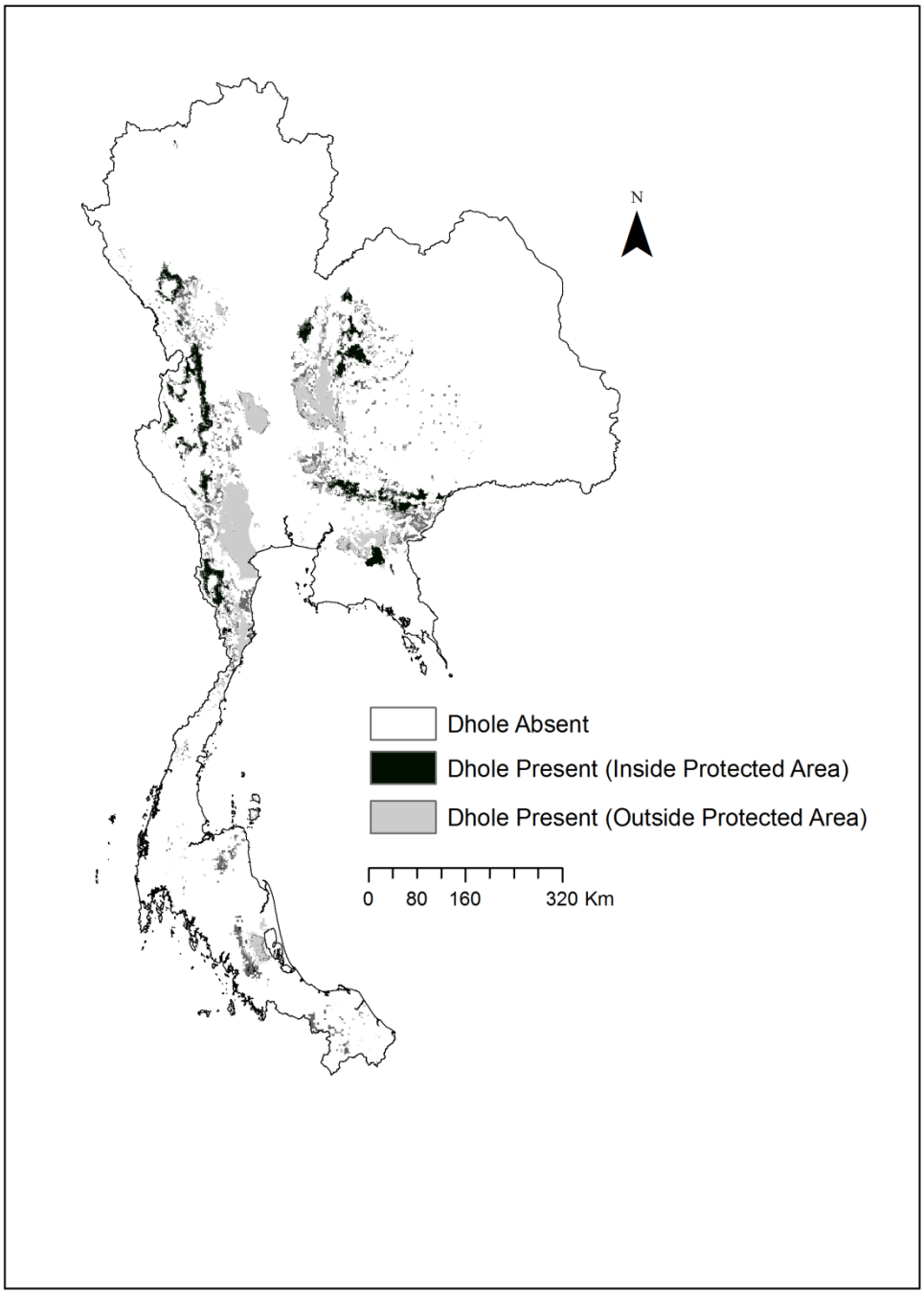


Figure 4.6. Predicted occurrence of Dholes in Thailand based on an 0.08 threshold of prevalence (96 Dhole detection locations out of 1,174 total sampling locations). Areas in black represent predicted Dhole occurrence inside protected areas. Areas in grey represent predicted Dhole occurrence outside of protected areas.

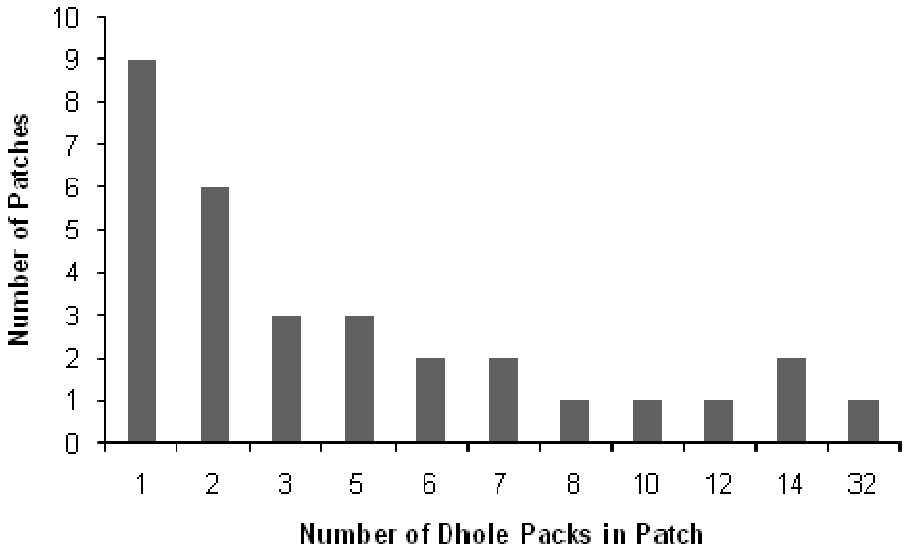


Figure 4.7. Approximate number of Dhole packs in a given patch versus the number of patches.

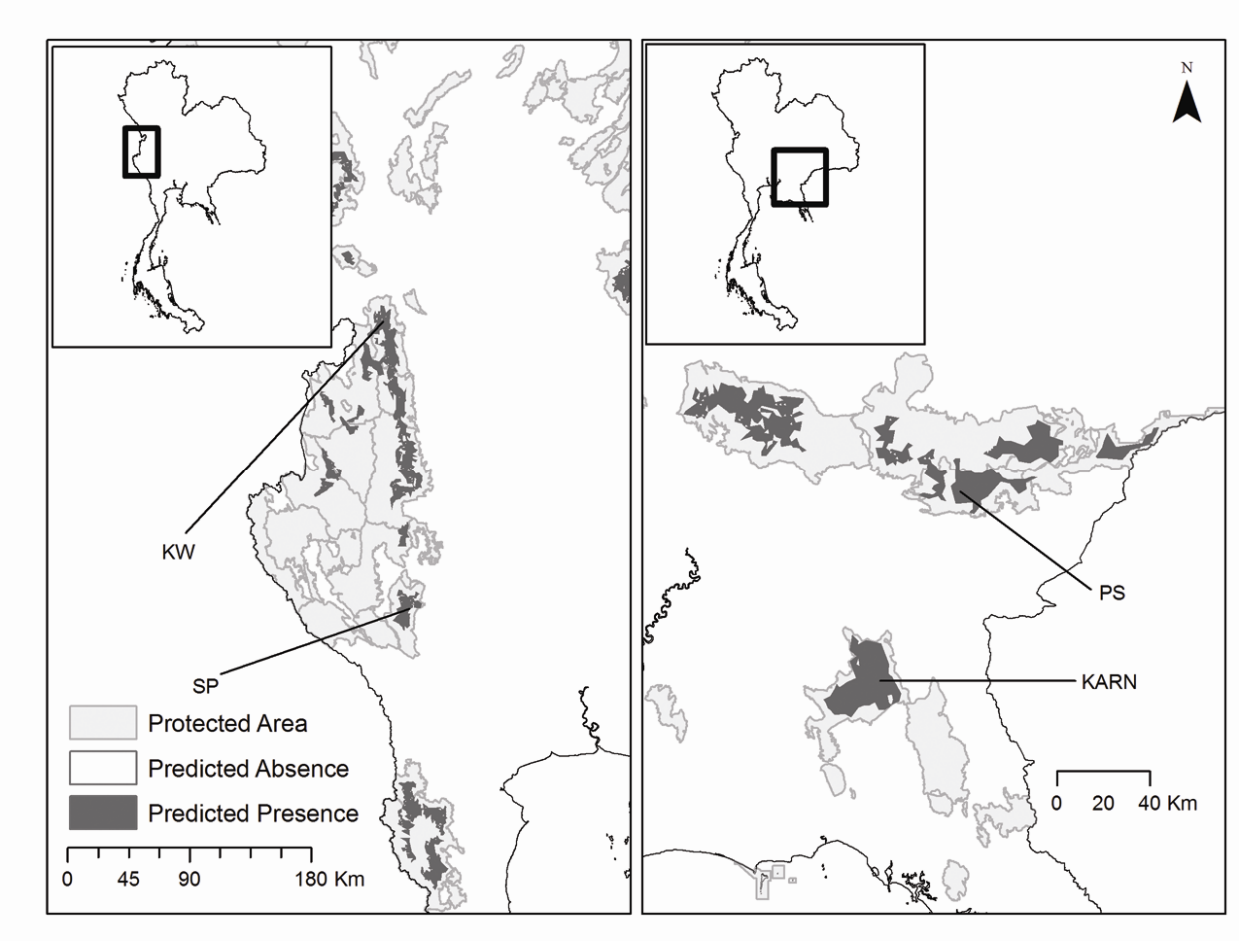


Figure 4.8. Individual protected areas in Thailand that are recommended for future field studies based on the large area of Dhole presence: Khlong Wangchaow National Park (KW), Salakpra Wildlife Sanctuary (SP), Pang Sida National Park (PS), and Khao Ang Rue Nai Wildlife Sanctuary (KARN). Predicted presence of Dholes based on a 0.08 threshold and only includes patches that are greater than 50 km^2.

CHAPTER V.

DHOLES IN THAILAND: COMMUNITY-BASED KNOWLEDGE AND ATTITUDES

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Abstract

The dhole (*Cuon alpinus*), or Asiatic wild dog, is an example of a Southeast Asian carnivore that is threatened with extinction, but overlooked with regards to conservation initiatives. To understand local people's beliefs before managers make efforts to improve local conservation awareness, we conducted 791 villager interview surveys in east-central Thailand adjacent to five protected areas. Respondents reported seeing dholes within the last year near all of the protected areas surveyed. While a photograph of an Asiatic jackal (*Canis aureus*) was correctly identified by 41% of the interviewees, a dhole photograph was only correctly identified by 20%. However, overall attitudes towards dholes among villagers were positive; 77% of participants agreed that dholes should be protected in the wild. There were no reports of human attacks by dholes and relatively few instances of livestock depredation. Forty-six percent of the people who reported hearing or seeing a conservation message in the past month agreed that dholes should be protected whereas only 30% of the people who did not come in contact with such a message agreed with dhole protection. We recommend wildlife sanctuaries

increase basic educational materials at their entrances or headquarters to help local people name and appreciate local species. To increase attitudes towards conservation in general, we support programs that encourage students to take field trips and learn about the forest. Our results indicate an encouraging conservation environment for dholes in east-central Thailand and suggest ways that dholes and wildlife can benefit from current positive attitudes.

Introduction

An important component of conservation management is defining the problem, outlining *why* it is a problem, and defining *for whom* it is a problem (Clark et al. 1996, Riley et al. 2002). To clarify the problem and who is affected by the problem, considering the perceptions of stakeholders is imperative for conservation managers. A stakeholder is any person who may be affected by, or may affect, wildlife or conservation management actions (Decker et al. 1996). Consideration of stakeholders and involving them actively in conservation plans can improve decisions by bringing in information, educate citizens about species or natural systems, and build support for conservation actions; outcomes all enhanced when the community has a stake in their success (Lafon et al. 2004, Clark et al. 1996).

However, public support for conservation diminishes when human-wildlife conflict or historical attitudes reinforce negative opinions (Sillero-Zubiri & Laurenson 2001). This is of paramount importance in the conservation of predators, species which tend to carry strong negative connotations (e.g. Musiani & Paquet 2004; Baker et al. 2008). In these cases, understanding stakeholders' understanding of wildlife and tolerance of wildlife problems is at the core of working toward relief of that conflict (Riley et al. 2002). Therefore, it is essential to

understand local people's beliefs, values, and knowledge before managers can make efforts to improve support for predator conservation actions.

The dhole (*Cuon alpinus*) is a Southeast Asian predator associated with negative connotations focused on the occasional killing of livestock by dhole. For example, in the Yamphudin sector of Nepal, Snow Leopard Conservation Sub-Committee records show that relief funds were paid to cover 14 livestock deaths attributed to dholes in 2010 (Khatiwada 2011). Additionally, 74% of the respondents in an interview survey reported that dholes killed livestock in the Nepal rangelands (Khatiwada 2011).

Historically such conflicts with humans were a leading cause of population decimation. Dholes were regarded as "a pest of the jungles," and consequently were trapped, shot, or poisoned (Phythian-Adams 1949). Natural history reports from the early 1900's spread negative accounts of the wild dogs, noting effective strychnine dosages to use for their extermination (Brander 1908). As late as 1972, bounties were paid for dhole pelts in India (Durbin et al. 2004) and poisoning by the government and farmers extirpated the population of dholes in Bhutan in the 1980's (Wang & MacDonald 2006). Despite negative attitudes about dholes in other range countries, however, it is unclear if these attitudes are also persistent in Thailand.

Little ecological information on dholes living in Thailand exists (but see Austin 2002; Grassman et al. 2005a), and although dhole presence has been confirmed in some protected areas (Jenks et al. 2012 in press) actual population numbers are unknown. Yet, with the near extirpation of large felids, including tigers (*Panthera tigris*) and leopards (*Panthera pardus*) in many protected areas in Thailand, the predator that is most often seen by park rangers and tourists is the dhole. The impression of increased dhole sightings, along with the observation

that dholes are usually sighted in multitude because they live in packs, led managers in Khao Yai National Park (KYNP) to conclude that dholes were increasing rapidly tied with concerns that they might attack tourists and have a negative effect on sambar deer (pers. comm. P. Wohandee, prior Superintendent at KYNP). Senior rangers were debating culling as an option to curtail dhole populations to maintain a high density of prey species, to support other predators such as tigers, and to protect tourists. There was no scientific evidence about prey populations or dhole attacks that would have supported such management decisions, further highlighting negative attitudes that support an ad-hoc approach to management of this endangered canid.

In addition to providing ecological data that complements field studies, questionnaires in ecology are also useful for understanding stakeholders' attitudes and getting people actively involved in the conservation process (White et al. 2005). We conducted villager interview surveys to: 1) identify local attitudes towards dholes, and 2) document the status of dholes in wildlife sanctuaries adjacent to Cambodia. By doing so we hoped to identify useful approaches to improve local support for dhole conservation before proceeding with additional field studies of the species in Thailand.

Methods

Surveys were conducted in east-central Thailand (latitude 13°-14°N, 101-105°E) adjacent to five protected areas where dholes were thought to be present (Haui Sala Wildlife Sanctuary [HS], Haui Samran Wildlife Sanctuary [HSM], Haui Tabtan Wildlife Sanctuary [HT], Dong Yai Wildlife Sanctuary [DY], and Panhomdongrak Wildlife Sanctuary [PD]; Jenks et al. 2012) and two areas where dhole presence has been confirmed (Khao Ang Rue Nai Wildlife Sanctuary [KARN], and Khao Yai National Park [KYNP]; Fig. 5.1).

The villages around these protected areas vary in size, all are rural (population statistics are not available), and the majority of livelihoods focus on agriculture and cattle herding. The region receives on average < 1000 mm precipitation per year (Thai Meteorological Department 2011). Dry evergreen forests cover most of the protected areas which are surrounded by villages and roads, cassava fields, and eucalyptus plantations. To the east, the protected areas follow the Phatam-Khao Phanom Dongrak hills running along the border with Cambodia and contain areas of sandstone rock shelves. Some of these wildlife sanctuaries lack any wildlife surveys and may have lower poaching due to the presence of land mines making areas inaccessible (ICEM 2003). There is extensive human-wildlife conflict along the borders, usually caused by crop-raiding elephants (S. Wanghongsa pers. comm.).

Sampling

From May 2007 through August 2009 we surveyed an opportunistic sample of respondents (≥ 18 years of age) in 34 villages that were within 10 km of targeted protected areas (Table 5.1). We made an effort to reach a representative sample of villagers by including at least three villages bordering each protected area and by asking village headsmen to congregate members in the morning before work. To sample older adults and non-workers we randomly interviewed people that were at home and easily accessible in the afternoons. An effort was made to interview as many men as women. Each respondent was questioned separately and only one person from each household was questioned to ensure independence of data collected.

The Survey Instrument

Structured interviews were conducted in Thai, the national language, by students from Kasetsart University and research assistants from KARN. Assistants were trained by the principal investigator prior to the interviews to maximize the accuracy of the data collected. We introduced the survey by describing that the purpose of the interview was to understand the public's knowledge and opinions about wildlife in general and did not note that our primary interest was information about dholes. We assured confidentiality of the information by clearly stating that these raw data or any individually identifiable responses would not be shared with any law enforcement, government, or park officers; we assured anonymity by not asking for people's names. Surveys were approved and certified through the University of Massachusetts Institutional Review Board (IRB #06239).

The interview protocol was piloted with 30 villagers around KYNP in May 2007 and the questions were revised and modified as necessary for clarification. The final protocol consisted of a combination of multiple choice response (nominal data, yes/no data, socioeconomic background questions), ranking, and open-ended questions. The survey instrument comprised of the following sections used in this study: 1) 12 demographic questions; 2) 11 questions about wildlife identification using photographs; 3) 6 questions about attitudes towards dholes; 4) 1 question about villagers' frequency of visits to the forest; 5) 1 question of villagers' contact with rangers in the past year; and 6) 1 opened-ended question regarding views about conservation.

To evaluate general wildlife knowledge, respondents were shown photographs of mammal species. For each picture, interviewees were asked if they knew the name of the animal, whether they had ever seen this animal, and whether they thought the animal was

currently found in the adjacent protected area. They had the option to respond "do not know" or "not sure." The species identification questions were administered prior to opinion-based questions. To ensure correct identification of species during opinion questions, photographs were used in tandem with sections of the survey related to each species. The use of photographs also helped target information about dholes which could potentially be confused with sympatric wild canids (golden jackal [*Canis aureus*] and feral dogs [*C. familiaris*]). A photograph of a maned wolf (*Chrysocyon brachyurus*) was included to test whether or not respondents could correctly pick out a non-native species. Species names provided by respondents for each photograph were classified as correct or incorrect. We considered names correct if they referred to the intended species or, in the case of maned wolf, indicated that the species was alien and not found in Thailand (Table 5.2).

Ranking response questions were used as a measure of attitudes. The ranking response questions used a 5-point Likert-type scale as a response format (Likert 1932). In reply to a statement such as "dholes are a pest species," respondents were asked to specify their level of agreement to a statement by choosing one of a given response category. The responses ran from "strongly disagree" to "strongly agree" and the response categories (1-5) were written in Thai on a diagram for the respondents' reference and clarification.

Data Analysis

Responses were translated into English prior to data analysis. Statements given in response to the final open-ended question, "Is there anything you would like to tell us about wildlife conservation?" were subjectively classified into positive or negative responses for analysis presented in this paper. Examples of positive statements included, "I believe in

conservation for the next generation" and "the park rangers are doing a good job" or wording indicating an interest in wildlife or environmental protection. Examples of negative statements included people who complained about wildlife conflict, concerns over being banned from hunting or the use of forest products, and wording that indicated being dissatisfied with the work conducted by park rangers.

In the first stage of data analysis we computed descriptive summaries and basic data tabulations to understand the number of responses, means, variance, and percentiles. We summarized the frequency of respondents giving a particular response and frequencies of responses of an issue, and tested the equality of frequencies using chi-square goodness of fit. To establish if certain responses varied among groups within differing socio-demographic backgrounds and experience we used chi-square cross tabulation analysis. To adjust for multiple tests ad-hoc, differences were considered significant when p-values were < 0.01. Data were analyzed in R (version 2.11.1). Distance from villages to nearest protected area was calculated in ArcGIS version 9.3 (ESRI Inc. Redlands, USA).

Results

Respondent Socio-Demographics

We conducted 791 interview surveys near seven protected areas (Table 5.1). The average distance of respondents living from the nearest protected area boundary was 1.4 km. Respondent populations were fairly homogeneous between protected areas with respect to average age (46 yr.) and males and females (51% males) interviewed. The majority (81%) of respondents finished schooling through level six with 58% reporting an income of <60,000 baht (ca. $USD 2,000) per year. A higher percentage (79%) of KARN respondents indicated that they

grew crops, compared to 47% of HS, 34% of HSM, 50% of HT, 58% of PD, 30% of KYNP, and 58% of DY. Overall, 37% of respondents reported visits to the forest or indicated that they collected wildlife or other forest products (HS = 46%, HSM = 41%, HT = 42%, KARN = 30%, PD = 34%, KYNP = 33%, DY = 35%).

Knowledge of Species Identification

Over 70% of respondents provided a correct species name for tiger (98%), leopard (*Panthera pardus*; 80%), sambar deer (80%), and barking deer (*Muntiacus muntjak*; 70%; Tables 5.2 and 5.3). Fewer than 10% of respondents were able to correctly label smaller cat species (Table 5.3). The photograph of an Asiatic jackal was correctly identified by 41% of the people, while the dhole was only correctly identified by 20% of people. Thirty-five percent of the respondents did not attach a label to the photograph of a maned wolf and only one percent correctly identified the species as non-native to Thailand (Table 5.3).

Participants more frequently labeled the dhole photograph as an Asiatic jackal (32%) or forest dog (27%) than correctly as a dhole (20%; Fig. 5.2). However, only 6% of respondents mistook the dhole and Asiatic jackal photographs for that of a domestic dog (Fig. 5.2). The majority (58%) of respondents offered a Thai species name for the maned wolf despite the fact that it is a non-native canid (Fig. 5.2). Of the 157 people who correctly identified the photograph of a dhole, 96 reported actually seeing a dhole, 55 reported never seeing a dhole, and the others were not sure.

The number of photographs that respondents correctly identified was dependent on sex, education level, nearest protected area, distance to protected area, exposure to messages about wildlife, and whether or not they visited the forest (Table 5.4). Males had higher average

scores (5.25) than females (4.44) in correctly identifying wildlife photographs. Correct identification of species improved with increasing education, and participants near KYNP had the highest average photo scores (Fig. 5.3). Respondents living closer to the park had better scores than those farther away (an average of six correct for people living at the boundary of the protected area versus four correct at 7.6 km). When people reported hearing or seeing a message about wildlife in the last month they had better scores identifying photographs; everyone in this category correctly identified at least one species correctly. People who visited the forest also had a slightly better photo score.

Attitudes toward Dholes

The majority (77% of 157) of respondents who correctly identified the dhole photograph believed that dholes were present in the surrounding forest and 61% reported actually seeing a dhole in the past year (Table 5.5). Villagers reported seeing dholes in all protected areas surveyed. Most of the people who expressed an opinion on the matter believed that the dhole population over the last ten years was stable (Table 5.5).

Half (50%) of all participants believed that dholes will not attack a person, but the majority (61%) did agree that dholes will attack livestock (Table 5.5). Villagers near every protected area reported dhole attacks on livestock; however, the overall percentage of people who reported an attack was 4.5%. The majority of animals reported stolen were chicken (17 instances), followed by ducks (3), calves (3), rabbits (1), pigs (1), and fish (1). There was one report of a dhole fighting with a domestic dog and one puppy that was reportedly killed by a dhole.

There were slightly more people (51%) who moderately or strongly agreed with the statement that "dholes are dangerous" (Table 5.5). To evaluate whether or not this extended into an anti-conservation climate for dholes, we asked respondents to rank two statements: "I agree that dholes should be *eliminated* from the surrounding forest "(12% moderately or strongly agreed), and "I agree that dholes should be *protected* in the surrounding forest" (77% agreed; Table 5. 4). Additionally, only 38% of respondents expressed the opinion that dholes are over-populated.

Whether or not respondents agreed with the statement, "dholes are dangerous," depended on their gender, nearest protected area, and distance to protected area (Table 5.4). Fifty-six percent of the women agreed that dholes are dangerous, whereas 47% of the men agreed. More respondents living closer to protected areas were of the opinion that dholes are dangerous (Fig. 5.4). Direct experience of dhole depredation on personal livestock affected attitudes towards dholes. Of the 36 people who reported dhole depredation, 67% agreed with the statement that "dholes are dangerous." Of the remaining 755 people, 51% agreed that "dholes are dangerous."

People's attitudes towards supporting or eliminating dholes did not necessarily correlate with them thinking that dholes are dangerous; e.g., communities near HSAM had the second lowest percent of people agreeing with the statement that "dholes are dangerous," but was the second highest group to agree that "dholes should be eliminated" (Fig. 5.5). Males (42%) were more likely than females (35%) to agree that dholes should be protected. Forty-six percent of the people who reported hearing or seeing a conservation message in the past month agreed that dholes should be protected whereas only 30% of the people who did not come in contact with such a message agreed with dhole protection.

Attitudes toward Conservation

Positive or negative comments about conservation depended on respondents' education level, nearest protected area, and distance to protected area (Table 5.4); 61% of people who were not educated past primary school (level six or below) gave positive conservation comments versus only 46% of those who continued their education past level six. The KYNP group of interviewees had the lowest percentage of respondents who offered positive conservation comments (Fig. 5.6). Participants who lived closer to a protected area gave more positive comments about conservation than those who lived farther away. The percentage of people who reported contact with a park ranger or a sanctuary ranger in the past year did not significantly influence their comments toward conservation (Table 5. 4); neither did exposure to messages about wildlife (Table 5.4).

Discussion

Our results indicate an encouraging status of dholes in east-central Thailand. Respondents reported seeing dholes near all of the protected areas surveyed, which for areas other than KARN and KYNP represent the first academic documentation of dhole presence there. This is an initial step towards field surveys to fill in status gaps for dholes (Jenks et al. 2012 in press). It is also promising that villagers reported dhole populations have been stable over the past ten years. Although we must highly caution that we do not know the degree that they are good judges of population estimates.

Any future efforts related to dhole conservation must involve working with human attitudes toward dholes to clarify human-wildlife problems and bolster support for actions; from our study, attitudes toward their protection are positive. There were no reports of human

attacks by dholes and relatively few instances of livestock depredation attributed to dholes; we do not have data on how much of the reported depredation is actually caused by feral or domestic dogs. Furthermore, 77% of respondents agreed that dholes should be protected in the park and surrounding forests. While it is difficult to evaluate the quality of the statement that a species should be protected or conserved, and to avoid a default response of "yes, I agree" to any statement, we asked this statement phrased both in the positive and negative.

It is promising that only a slight majority (52%) of respondents think that dholes are dangerous. The closer to a protected area respondents lived, the more agreed with the statement that "dholes are dangerous." This was not necessarily explained by direct contact, since having simply seen a dhole did not increase the likelihood that a person would agree with the statement. Yet, direct experience of dhole depredation on personal livestock did increase the likelihood that a person would agree with the statement. This was expected as people's attitudes towards wolves are affected by direct experience of wolf depredation (e.g. Petty et al. 1997). Additionally, Karlsson and Sjostrom (2007) suggested that attitudes towards wolves in Sweden were more likely a result of indirect experience because villagers who experience livestock depredation may spread negative information about wolves and those living closer to wolves may be more exposed to this negative information. We suspect that a similar "cloud of negative information exposure" could be influencing attitudes towards dholes.

Villagers' failure to distinguish between wild canid species may increase pervasiveness of negativive perceptions of dholes. Although only 6% of respondents mistook the dhole and Asiatic jackal photographs for that of a domestic dog, there was consistent confusion between the dhole and Asiatic jackal. Very few identified a maned wolf as a non-native species. This tendency to lump the dhole, Asiatic jackal, and any other unknown canid into a general "forest

dog" category could result in all negative interactions with wild canids also being lumped together and attributed to whatever canid species is the topic of discussion. Therefore, conservation managers should consider education materials that pictorially differentiate between dholes and Asiatic jackals, but that encourage conservation of *both* species.

Not only misidentification of a target species, but inferior knowledge of all species present in habitat adjacent to villages is a concern for conservation measures. People who have little understanding of something are less likely to fight to protect it (Mosquin & Rowe 2004). While interviewees could identify large charismatic species such as tiger and leopard, > 90% failed to correctly name photographs of a clouded leopard (*Neofelis nebulosa*) and leopard cat (*Prionailurus bengalensis*). Correct identification of photographs increased with higher levels of schooling. We do not believe that this is an artifact of the groups' potentially increased familiarity with tests because we presented the questions in a verbal conversation context that is familiar to people regardless of their education. When participants in our study reported hearing or seeing a message about wildlife in the last month they also had better scores identifying species photographs. Respondents from the only national park that we surveyed, KYNP, had the highest average scores on the photo identification section of our questionnaire. The increased knowledge of this group could be contributed to the popular and carefully planned Visitor's Center at the park headquarters. National parks in general in Thailand have a greater focus on visitor education and tourism programs than wildlife sanctuaries. KARN had the second-highest average photo identification score and this wildlife sanctuary is one of the few in the country with an active research station and small educational display area. Because level of education was correlated with a higher photo score, we recommend wildlife sanctuaries

increase basic educational materials at their entrances or headquarters to help local people name and appreciate local species.

Exposure to education influenced people's ability to recognize local species; however, it did not significantly impact their attitude towards conservation. A strong conservation ethic stems from those with the most ties to the land (Mosquin & Rowe 2004). Respondents with lower levels of education were more likely to offer positive comments about conserving wildlife for the next generation. This may be because those with less education were more likely to have agricultural-based jobs that kept them connected to the environment. This group tended to support the presence of wildlife even in instances where they were desperately asking for more protection from problem species such as elephants.

It was interesting to note that KYNP had the lowest percentage of respondents who gave positive comments regarding wildlife conservation. In comparison, comments from villagers around wildlife sanctuaries reflected a greater understanding of what was happening in their natural environment. Villagers around the national park expressed frustration that the park managers were not taking care of villagers' needs by refusing to allow them to collect wood, bamboo, and mushrooms inside the park. Other people commented on the expensive entry fees and boundary disputes. These comments were different from negative statements from villagers around wildlife sanctuaries who tended to comment about problems with crop-raiding elephants and not enough sanctuary rangers or that the rangers were not doing their job properly. In their opinion the rangers needed to work harder because wildlife and forest areas are decreasing and hunting is rampant. However, the tone of comments or complaints was not related to frequency of contact with rangers.

Education about wildlife can increase people's knowledge of what is found in their environment, but it may not extend to increasing their general conservation attitude. To increase the number of people viewing conservation in a positive light, they need to be reminded of their connection to the environment. To improve villagers' connection to the environment, we recommend increased support and funding for programs that bring student groups from the cities into the forested protected areas for education opportunities. We are aware of programs focusing on students already in place at KYNP and KARN.

Conclusion

The dhole has a wide geographic range and has historically been heavily persecuted because of conflicts with livestock and general negative attitudes towards the species. Our study found that dholes are not heavily despised or persecuted in east-central Thailand. Instead, we found a large contingency of villagers who agree that dholes should be protected. Furthermore, there were no reports of human attacks by dholes and relatively few instances of livestock depredation by dholes. This is a positive background to boost efforts to disseminate positive information about the role of dholes in the ecosystem and to establish collaborative conservation plans with villagers.

We recommend wildlife managers and researchers encourage national parks and wildlife sanctuaries to highlight basic information about local species. It is not necessary to spend extensive resources on complicated posters, videos, or displays. What are first needed are basic opportunities for villagers to learn the species names of wildlife that is present "in their own backyard."

The next step is to translate the positive attitudes that we already found into future conservation actions. It may be opportune timing for protected area staff to initiate joint wildlife monitoring and anti-poaching patrolling, and to establish collaborative plans for prey recovery that would benefit the dhole (Steinmetz et al. 2006).

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of the National Zoo, secured over 500 free Smithsonian logo pencils to hand out as gifts after interview surveys.

Table 5.1. Details of villager interview surveys conducted from November 2007 through August 2009 in east-central Thailand.

Protected Area	Date[1]	Villages	Distance[2]	Total Surveyed	Males	Females	School[3]	Income[4]	Crops[5]	Forest[6]
Dong Yai	July-August 2009	4	1.0	100	36	64	68	54	58	35
Haui Sala	July-August 2009	4	1.0	102	45	57	90	78	48	47
Haui Samran	July-August 2009	3	2.4	82	42	40	70	52	28	34
Haui Tabtan	July-August 2009	4	2.3	121	55	66	92	80	60	51
Khao Ang Rue Nai	March 2008, Nov. 2007	7	0	200	144	56	183	97	157	59
Khao Yai	May 2007	8	1.0	87	36	51	53	37	26	29
Panhomdongrak	July-August 2009	4	3.8	99	49	50	87	60	57	34
TOTALS		34	1.6	791	407	384	643	458	434	289

[1]Date surveys were conducted; [2]Average distance (km) of villages to nearest protected area; [3]Number of respondents who finished schooling through level 6; [4]Number who reported income of < 60,000 baht; [5]Number who reported they grew crops; [6]Number who reported they visited the forest at least once in the past year.

Table 5.2. Names accepted for each species during a November 2007 through August 2009 survey regarding the opinions and knowledge about wildlife in communities surrounding Thailand protected areas.

English (Scientific Names) for Species	**Thai Phonetic Names Accepted as Correct for Species**	**Translated Thai Names Accepted as Correct**
Tiger (*Panthera tigris*)	seuua, seuua khrohng	tiger, huge tiger
Leopard (*Panthera pardus)*	seuua dtao	leopard, spotted tiger
Clouded Leopard (*Neofelis nebulosa*)	seuua lai maaek	clouded leopard
Leopard Cat (*Prionailurus bengalensis*)	maaew dtao	leopard cat, small spotted cat
Large Indian Civet (*Viverra zibetha)*	chaa mot, cha mot chiang, ehen lain nok, ehen tham ma da	civet, segmented civet, striped-tailed civet, palm civet
Dhole (*Cuon alpinus*)	maa nai	dhole
Asiatic Jackal (*Canis aureus*)	maa jing jaawk, jing jaawk	jackal, fox
Maned Wolf (*Chrysocyon brachyurus)*	chaniit dang bratet	non-native species
Sambar Deer (*Rusa unicolor*)	gwaang, gwaang baa	deer, sambar deer, forest deer
Barking Deer (*Muntiacus muntjak*)	geng	barking deer
Banteng (*Bos javanicus)*	wua daeng	banteng

Table 5.3. Numbers and percentage of participants responding correctly and not responding to wildlife naming questions during a November 2007 through August 2009 survey in communities surrounding Thailand protected areas. (All percentages reported are based on the total number of participants n=791).

Species	**Number of Correct Responses**	**Percentage of Correct Responses**	**Number of Non-Responses**	**Percentage of Non-Responses**
Tiger	772	98	3	0
Leopard	633	80	52	7
Clouded Leopard	70	9	248	31
Leopard Cat	62	8	132	17
Large Indian Civet	394	50	339	43
Dhole	157	20	77	10
Asiatic Jackal	327	41	143	18
Maned Wolf	5	1	280	35
Sambar Deer	630	80	71	9
Barking Deer	557	70	61	8
Banteng	235	30	22	3

Table 5.4. Relationship Between Opinions on Dholes and Ability to Identify Wildlife, and Interviewee Attributes.

Interviewee Attributes	Photo Score	General Attitude towards Conservation	Opinion on Dholes being Dangerous	Opinion on Eliminating Dholes	Opinion on Protecting Dholes
Sex	**χ^2 = 62.624, df = 10, p < 0.001**	χ^2 = 2.333, df = 1, p = 0.127	χ^2 = 9.456, df = 4, p = 0.051	χ^2 = 12.596, df = 4, p = 0.013	**χ^2 = 17.748, df = 4, p = 0.001**
Age	χ^2 = 56.738, df = 50, p = 0.238	χ^2 = 6.469, df = 5, p = 0.263	χ^2 = 30.527, df = 20, p = 0.062	χ^2 = 24.836, df = 20, p = 0.208	χ^2 = 16.015, df = 20, p = 0.716
Education Level	**χ^2 = 244.302, df = 140, p < 0.001**	χ^2 = 25.537, df = 14, p = 0.030	χ^2 = 62.636, df = 56, p = 0.253	χ^2 = 58.508, df = 56, p = 0.384	χ^2 = 42.374, df = 56, p = 0.911
Protected Area	**χ^2 = 269.460, df = 70, p < 0.001**	**χ^2 = 81.634, df = 7, p < 0.001**	**χ^2 = 110.057, df = 28, p < 0.001**	**χ^2 = 134.025, df = 28, p < 0.001**	**χ^2 = 194.812, df = 28 p < 0.001**
Distance to Protected Area	**χ^2 = 112.108, df = 50, p < 0.001**	**χ^2 = 17.044, df = 5, p = 0.004**	**χ^2 = 92.482, df = 20, p < 0.001**	**χ^2 = 113.679, df = 20, p < 0.001**	**χ^2 = 120.296, df = 20, p < 0.001**
Ranger Visits	χ^2 = 16.413, df = 10, p = 0.088	χ^2 = 3.810, df = 1, p = 0.051	χ^2 = 10.218, df = 4, p = 0.037	χ^2 = 3.191, df = 4, p = 0.526	χ^2 = 2.384, df = 4, p = 0.666
Exposure to Messages about Wildlife	χ^2 = 21.930, df = 10, p = 0.015	χ^2 = 0.100, df = 1, p = 0.752	χ^2 = 0.539, df = 4, p = 0.970	χ^2 = 5.128, df = 4, p = 0.274	χ^2 = 12.536, df = 4, p = 0.014
Visited Forest	χ^2 = 19.920, df = 10, p = 0.030	χ^2 = 3.097, df = 1, p = 0.079	χ^2 = 2.396, df = 4, p = 0.663	χ^2 = 8.605, df = 4, p = 0.072	**χ^2 = 13.570, df = 4, p = 0.009**

1 All chi-square values with a p-value less than or equal to 0.01 are significant. So the null hypothesis should be rejected, and should show that the responses are dependent on the attributes.

2 All chi-square values with a p-value greater than 0.01 are not significant. So we fail to reject the null hypothesis, and should show that the responses are independent of the attributes.

Table 5.5. Characteristics of Respondents' Opinions in Regard to Dholes (n=791).

Information Sought	Responses from People	Number of Respondents and Percentages	Chi Square Goodness of fit; df; p Value
Have you ever seen a dhole in the protected area or surrounding forest?*	Yes	96 (61%)	$\chi^2 = 77.592$, df = 2, $p < 0.001$
	No	55 (35%)	
	I Don't Know	6 (4%)	
Do you believe dholes are present in the protected area or surrounding forest?*	Yes	121 (77%)	$\chi^2 = 141.605$, df = 2, $p < 0.001$
	No	31 (20%)	
	I Don't Know	5 (3%)	
Over the last 10 years, how has the number of dholes you have seen in this area changed?*	Stable (No Change)	58 (37%)	$\chi^2 = 93.541$, df = 4, $p < 0.001$
	Increasing	7 (4%)	
	Decreasing	33 (21%)	
	There Are None	1 (1%)	
	Not Sure / Don't Know	58 (37%)	
If given a chance, dholes will attack a person	Strongly Disagree	153 (19%)	$\chi^2 = 153.874$, df = 4, $p < 0.001$
	Moderately Disagree	242 (31%)	
	No Opinion	124 (16%)	
	Moderately Agree	223 (28%)	
	Strongly Agree	49 (6%)	
If given a chance, dholes will attack livestock	Strongly Disagree	79 (10%)	$\chi^2 = 354.430$, df = 4, $p < 0.001$
	Moderately Disagree	145 (18%)	
	No Opinion	81 (10%)	
	Moderately Agree	364 (46%)	
	Strongly Agree	122 (15%)	
Dholes are dangerous	Strongly Disagree	63 (8%)	$\chi^2 = 296.478$, df = 4, $p < 0.001$
	Moderately Disagree	199 (25%)	
	No Opinion	119 (15%)	
	Moderately Agree	328 (41%)	
	Strongly Agree	82 (10%)	
Dholes are over-populated	Strongly Disagree	87 (11%)	$\chi^2 = 239.651$, df = 4, $p < 0.001$
	Moderately Disagree	216 (27%)	
	No Opinion	268 (34%)	
	Moderately Agree	190 (24%)	
	Strongly Agree	30 (4%)	
Dholes should be eliminated from the park and surrounding forest	Strongly Disagree	168 (21%)	$\chi^2 = 392.458$, df = 4, $p < 0.001$
	Moderately Disagree	349 (44%)	
	No Opinion	174 (22%)	
	Moderately Agree	81 (10%)	
	Strongly Agree	19 (2%)	
Dholes should be protected in the park and surrounding forest	Strongly Disagree	37 (5%)	$\chi^2 = 505.125$, df = 4, $p < 0.001$
	Moderately Disagree	41 (5%)	
	No Opinion	108 (14%)	
	Moderately Agree	363 (46%)	
	Strongly Agree	242 (31%)	

*Only Interviewees who correctly identified the picture of a dhole are included (n=157). The remaining information was sought only after the respondents were again shown the photograph of a dhole and told the correct name.

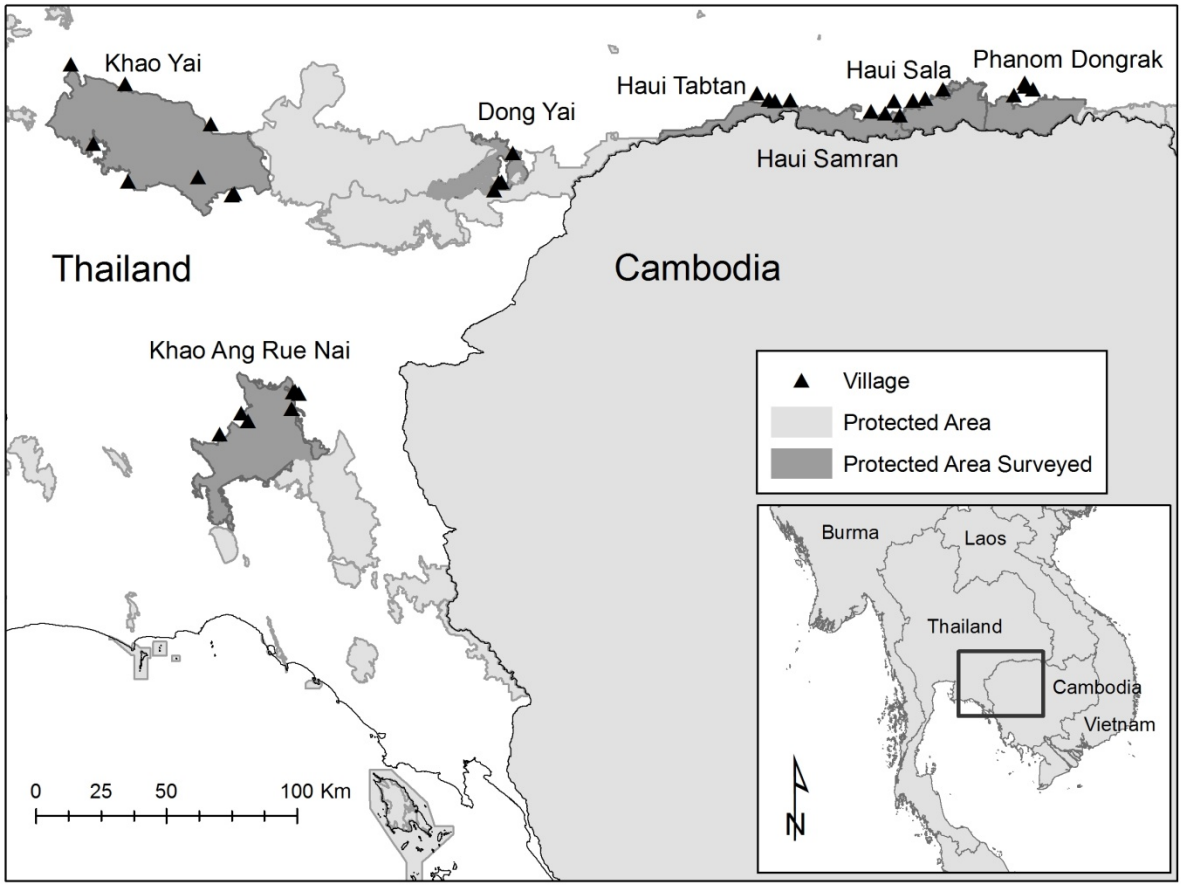
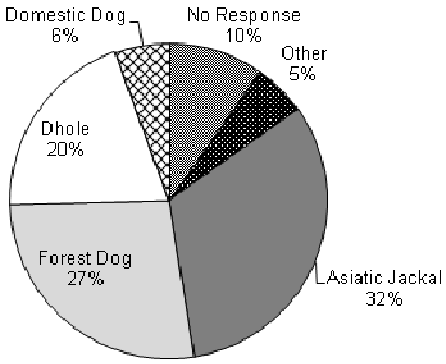
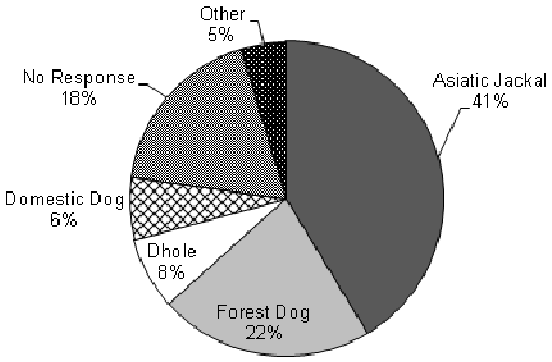


Figure 5.1. The communities around Thailand protected areas where surveys of villagers were conducted during a November 2007 through August 2009 survey.

A. DHOLE



B. JACKAL



C. MANED WOLF

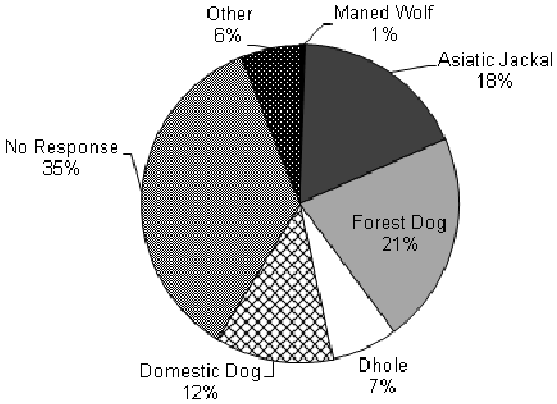


Figure 5.2. Percentage of participants with each answer when asked to name a photograph of a dhole (A), Asiatic jackal (B), and maned wolf (C).

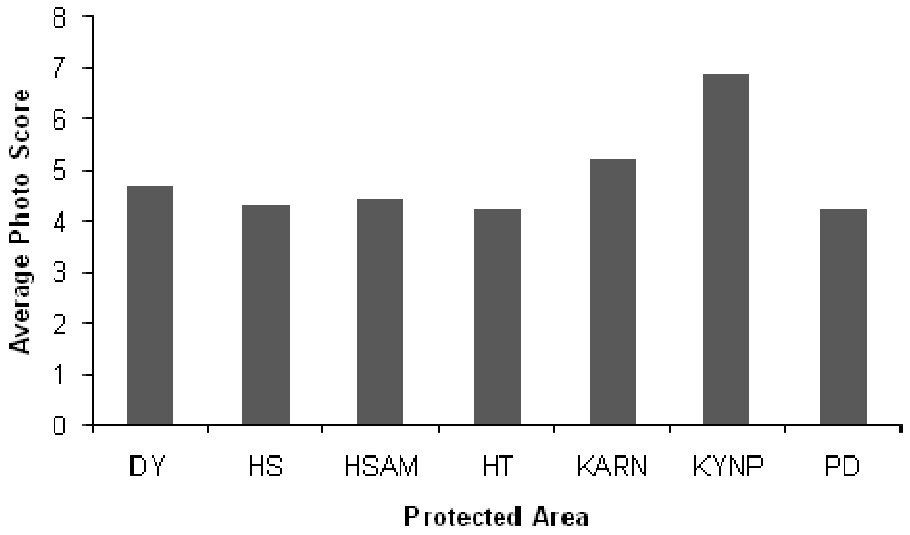


Figure 5.3. Average Photo Score by Protected Area. Dong Yai Wildlife Sanctuary (DY), Haui Sala Wildlife Sanctuary (HS), Haui Samran Wildlife Sanctuary (HSM), Haui Tabtan Wildlife Sanctuary (HT), Khao Ang Rue Nai Wildlife Sanctuary (KARN), Khao Yai National Park (KYNP), and Panhomdongrak Wildlife Sanctuary (PD).

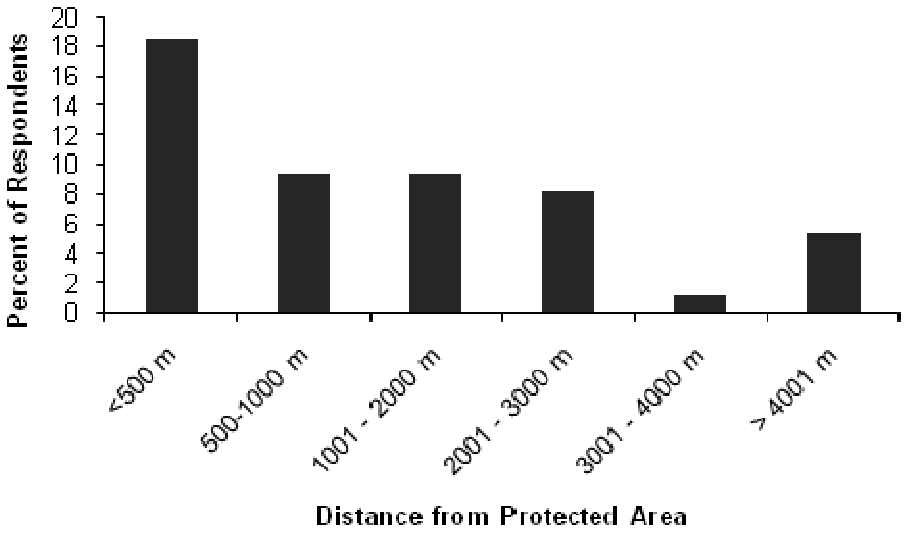


Figure 5.4. Percentage of respondents who moderately or strongly agree dholes are dangerous and the distance of their village from the nearest protected area.

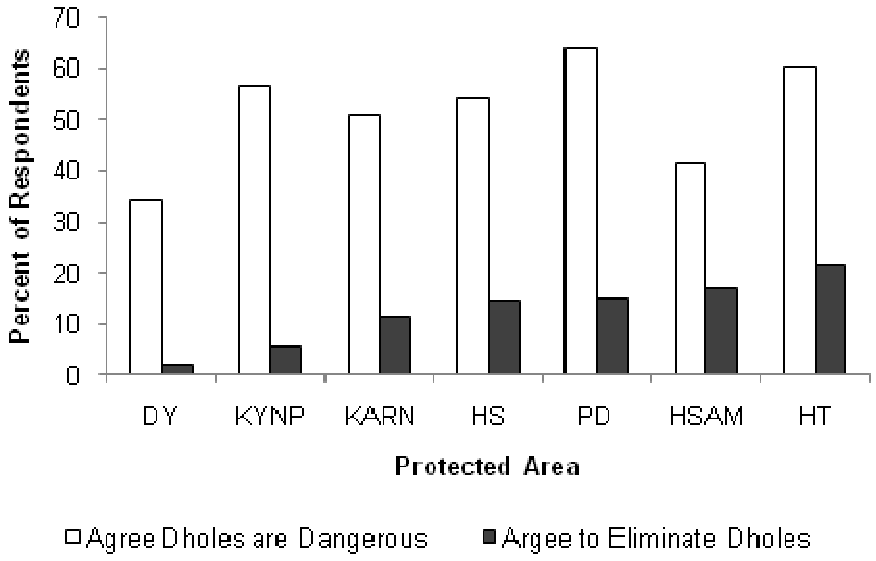


Figure 5.5. Percentage of respondents from each protected area who moderately or strongly agree dholes are dangerous and should be eliminated from the surrounding forest area. Dong Yai Wildlife Sanctuary (DY), Haui Sala Wildlife Sanctuary (HS), Haui Samran Wildlife Sanctuary (HSM), Haui Tabtan Wildlife Sanctuary (HT), Khao Ang Rue Nai Wildlife Sanctuary (KARN), Khao Yai National Park (KYNP), and Panhomdongrak Wildlife Sanctuary (PD).

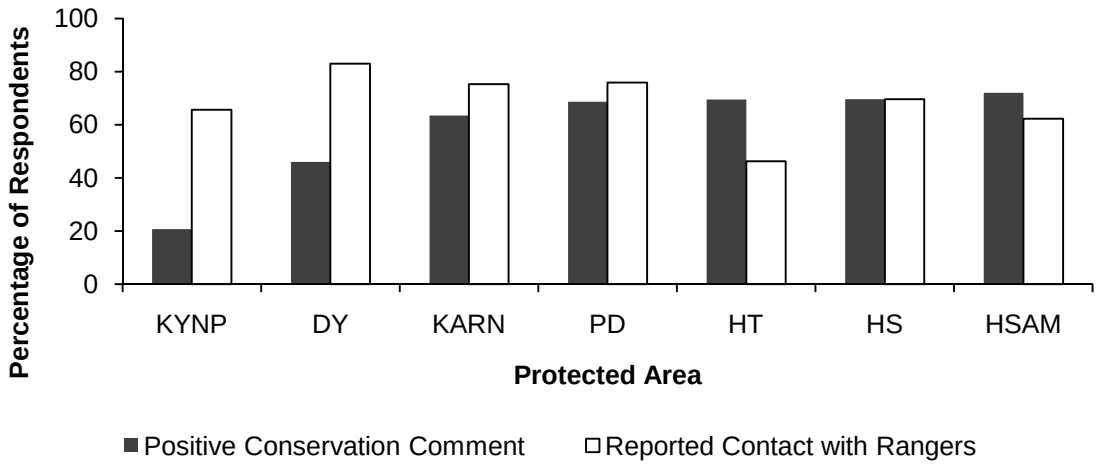


Figure 5.6. Percentage of respondents from each protected area who gave a positive comment regarding wildlife conservation and reported park/sanctuary rangers visited their village in the last year. Dong Yai Wildlife Sanctuary (DY), Haui Sala Wildlife Sanctuary (HS), Haui Samran Wildlife Sanctuary (HSM), Haui Tabtan Wildlife Sanctuary (HT), Khao Ang Rue Nai Wildlife Sanctuary (KARN), Khao Yai National Park (KYNP), and Panhomdongrak Wildlife Sanctuary (PD).

CHAPTER VI.

DHOLE CONSERVATION IN THAILAND

Thailand harbors some of Southeast Asia's most charismatic and endangered wildlife, including tigers (*Panthera tigris*), leopards (*Panthera pardus*), clouded leopards (*Neofelis nebulosa*), elephants (*Elephas maximus*), Asian bears (*Ursus thibetanus*), and dholes (*Cuon alpinus*). The country also has the most extensive protected area system in the region, which was inaugurated in the 1960's.

Unfortunately, many of these protected areas are fragmented and continually threatened by human encroachment. Local villagers continue to collect forest products, domestic dogs carrying disease range into protected areas, and domestic cattle herds forage inside parks, bringing disease and breeding with native ungulates. Poaching for the black market continues to threaten wildlife and decimate certain tree species. There is also moderate human-wildlife conflict along the borders, usually focused on crop-raiding elephants.

All national parks and wildlife sanctuaries were required to draft five-year management plans to deal with these challenges. However, these plans only have around a 50% implementation rate (ICEM 2003). Parks often lack staff, equipment, knowledge, or funding. Park chiefs frequently do not stay in office long enough to follow-through with large projects. For example, the Department of National Parks, Wildlife, and Plant Conservation (DNP) usually undergoes a staff shuffle whenever there is a new department Director-General (approximately every two years). New park chiefs are assigned especially to top-grossing parks such as Khao Yai

National Park (KYNP). With an emphasis on profits and tourism, the park system heavily relies on outside support to do its conservation work. International conservation organizations have stepped up to help protect Thailand's biodiversity.

In 2002, Smithsonian National Zoological Park Theriogenologist, Jo Gayle Howard, and Nashville Zoo President, Rick Schawartz, founded the Thailand Clouded Leopard Consortium at Khao Khieo Open Zoon in Thailand. This is an international effort that supports wild clouded leopard conservation and works to improve breeding success both in Thai and North American zoos. While the zoo scientists hoped to learn more about clouded leopard behavior and breeding, zoo ecologists lead by Peter Leimgruber devised field surveys to learn more about clouded leopards and other carnivores at KYNP. I initially got involved in the KYNP survey to map clouded leopard distributions. However, clouded leopards share their forest habitats with a variety of carnivores and other wildlife. As a result, we were able to use simple tools such as camera traps that allowed us to study the distribution of all wildlife (and human intruders) while also increasing the capacity of the rangers to monitor their wildlife.

To better protect wildlife, managers need detailed information on their presence, absence, and status. While it is rarely possible to accurately count individuals to assess species' status and answer the question "how many are there?", it *is* feasible to estimate changes in a species' distribution over time. Information on a species' geographical distribution is also invaluable when selecting an area for protection. My research built upon a project developed by Peter Leimgruber and Pete Cutter to bulid capacity among park rangers while providing KYNP managers a way to monitor large mammal distribution to identify conservation hotspots, continually monitor wildlife, and support anti-poaching efforts. I also undertook research to

gather information on and increase conservation awareness of a little-known endangered canid, the dhole.

Khao Yai National Park: A Case Study of Camera-Trapping as a Tool for Park Management

KYNP was the first national park established in Thailand in 1962, and has the potential to represent a regional model for wildlife conservation because of its status as the most visited park and its symbol of nature conservation to the Thai people (Chape 2005). We initiated a wildlife monitoring project to use KYNP as an example to demonstrate how basic and continued wildlife monitoring using standard camera-trapping could be used as an integral tool for park management and anti-poaching efforts in protected areas of the region. Beginning in October 2003, KYNP established a Carnivore Conservation Project (CCP), with support from the Smithsonian Institution and WildAid Foundation (now FREELAND) with a monitoring team of KYNP park rangers. Results (reported in Chapters 1 and 2) include the following:

Basic Photo Detections

- A high number of camera trap photographs was obtained for viverrids (4 species, 51 photos), and ursids (2 species, 38 photos).
- A low number (range, one to 10) of camera trap photographs was obtained for each of the four felid species and two canid species detected by camera traps.
- We detected previously unrecorded species (Large-Spotted Civet [*Viverra megaspila*]) and elusive species (Golden Jackal [*Canis aureus*], Marbled Cat [*Pardofelis marmorata*], and Clodued Leopard [*Neofelis nebulosa*]).

- We found significantly lower relative abundance indices (RAIs) for mammals compared to data obtained in 1999-2000.
- Tigers (*Panthera tigris*) were not recorded by camera-trapping, adding evidence to the notion that the species has disappeared from the park other than perhaps transient individuals.
- Wildlife relative abundance in KYNP is significantly higher in central parts of the park than in marginal areas near park boundaries.
- Carnivores are neutral in response to distance to ranger stations, but may benefit from the park headquarters because they rely on prey species that congregate there.
- There is a high probability of presence of ungulates close to ranger stations and these species easily habituate to humans and forage on human trash.
- Camera-trapping needs to be augmented by other methods such as spotlight surveys to detect arboreal and rare species.

Detection of Poaching Activity

- Camera traps recorded direct evidence of poaching.
- Poaching activity was concentrated along the eastern border of the park.
- Human traffic has a major impact because it is widely distributed, with photo-captures at 43 (20%) of the 217 camera-trapping locations, and domestic dogs roaming as far as 7km from the park boundary.

- Protection efforts in KYNP may be ineffective because there appears to be a high probability of poachers even in the closest vicinity of the headquarters and ranger stations.

- Ranger stations have not been able to sufficiently reduce poacher presence.

Results to Inform Future Monitoring Program Designs

- There was a lack of significant difference in relative abundance indices for wildlife among seasons, so we recommend that future studies concentrate surveys during the dry season to reduce weather related camera malfunction in the tropical environment.

- Our data demonstrated that most of the mammal species at KYNP could likely be documented by sampling fewer than 75 locations over an area of approximately 2,000 km^2.

- 80% of detections of mammals using camera-traps were within 14 days, so a two week time period should be adequate for documenting the presence of mammals.

- Despite continued threats and a decrease or near extirpation of tigers, KYNP supports a diversity of carnivore species of conservation concern, including clouded leopards, dholes, and small felids. Our long-term camera trap monitoring, however, highlighted a continuing poaching problem in the park which was not sufficiently reduced by the presence of ranger stations; especially along the eastern boundary.

We designed the CCP project to emphasize capacity building and to intellectually stretch the park rangers beyond their normal duties. It seemed reasonable that they could increase the value of their anti-poaching patrols by also collecting scientific data. Collecting precise and reliable data, however, was deemed too time consuming for general ranger teams, even with the help of a trained and experienced leader. Instead, we now advocate the adoption of a system of regular monitoring using a range of methods by dedicated teams of rangers, separate from important anti-poaching patrol efforts. Additionally, our modeling of poacher and wildlife spatial distribution relative to ranger stations confirmed that using mobile range units may be more effective than establishing more ranger stations.

While expansion of anti-patrol units (especially targeting the eastern border of the park) and the inclusion of wildlife monitoring via camera traps are obvious goals for the park, there are broader and more fundamental issues of park management that need to be addressed to combat poaching. There are a number of issues that are within the scope of the Superintendent to improve. First, poaching near the park headquarters needs further investigation because it could involve the complicity of individual park staff if poachers are successfully able to use the major access roads without detection. It may be necessary to establish checkpoints along access routes to control illegal activities within KYNP. Second, there needs to be a commitment to support for sufficient resources for patrolling which will also help with staff morale.

Outside of the scope of park management, there is a lack of efficient capacity to enforce and implement the existing laws and regulations concerning illegal wildlife trade. Poaching consequences must be followed through by the local law enforcement to support park efforts.

Finally, approaches to wildlife conservation are often most successful when they involve the development of economic benefits for the local people so that protecting wildlife is in their best interest. Rural development projects such as alternative income projects involving organic mushroom cultivation (www.FREELAND.org) should receive high priority. Additionally, local communities in areas adjacent to protected areas should be enlisted to participate in efforts to protect wildlife.

Dholes-The Whistling Dog that No One Knows

In the case of rare species, estimating distribution (or area of occupancy) is sometimes difficult, and for little studied species such as the Asiatic wild dog, or dhole, it has yet to be done in any comprehensive manner. Any data on the current status of dholes is important to conservation planning for this endangered species (Durbin et al. 2004). Despite the fact that dholes overlap with other large carnivores throughout much of their range, the species is probably not functionally redundant with other carnivores (Woodroffe and Ginsberg 2005). This implies that dholes have their own unique impacts on prey species and ecosystem processes and are important in a conservation framework.

With the loss of tigers in most protected areas of Thailand, the dhole has assumed the role as the functionally top predator. Dholes are an endangered species that has historically not received appropriate conservation attention from park managers, but needs the same level of protection afforded to flagship species such as tigers, gibbons (*Hylobates spp.*), and hornbills (*Buceros spp.*).

In order to explore this influence and truly appreciate the importance of the dholes' role, I wanted to first understand where the species is naturally found and why. I approached

this question by intensively surveying one protected area known to harbor dholes, and then by combining camera trap data from 15 protected areas to build a country-wide distribution map (Chapters 3 and 4, respectively).

Status of Dholes at Khao Ang Rue Nai Wildlife Sanctuary

In response to the lack of data on dholes, we initiated an intensive field study of dholes in Khao Ang Rue Nai Wildlife Sanctuary (KARN) in eastern Thailand. We chose KARN as the focal study area because it supports a well-establish research station, is protected but does not allow high tourist numbers, and dholes are regularly seen inside the sanctuary. Results (reported in Chapter 3) include the following:

- We documented a minimum of six dholes from one pack whose movement was centered on the sanctuary headquarters.
- We confirmed dholes are breeding at KARN; two pups were first photographed in May 2008 when approximately six months old and young adults were recorded in June 2009.
- The KARN dhole pack was crepuscular and traveled a mean daily distance of 2.6 km.
- Photo detections of dholes were found to be negatively associated with the presence of Eurasian wild pigs (*Sus scrofa*), while baiting with roadkills had a significant positive relationship.
- Our camera trap photos confirmed dholes and domestic dogs use overlapping areas at KARN.

Camera traps seemed to be an efficient way to pinpoint the location of elusive dholes in KARN for further study. However, much of this camera-trapping was random with fewer than ten available cameras. My initial plan was to locate dholes to trap and place radio-collars on one individual from each pack. When this proved improbable for the time frame of my dissertation, I was still able to use the photos collected. However, I regret that I did not focus at the beginning on funding for a greater number of camera traps and then undertake a more systematic sampling approach (perhaps using patch-occupancy to assess detection probabilities for species presence/absence). Since the completion of my project, newly developed techniques have been developed combining camera-trapping data with occupancy analysis using a new biodiversity indicator, the Wildlife Picture Index (O'Brien et al. 2010). I believe these techniques may prove useful for future questions about wildlife distribution and conservation status.

Country-wide Distribution of Dholes in Thailand

By collaborating with colleagues using similar data collection techniques, we pooled camera trap data from 15 protected areas to build a country-wide distribution map. Our main findings (reported in Chapter 4) of this effort were:

- Dholes were predicted to occur most frequently in grassland areas and mixed deciduous forest at generally 150 m elevation.
- The predicted probability of presence of sambar (*Rusa unicolor*) and leopards (*Panthera pardus*) were the most important variables in predicting dhole presence.
- Prey availability explained 44% of dhole predicted occurrence.

- The presence of sambar as the variable with the highest percent contribution to the dhole model indicates that maintaining a sufficient prey base may be the most important factor determining the continued survival of dholes.
- We estimated that roughly 7% of the total land area in Thailand is potentially suitable for dholes.
- Currently only 30% of potential dhole habitat falls within protected areas in Thailand; however, there is a low probability that dhole habitat outside of protected areas actually supports viable populations.
- We identified the protected areas Khong Wangchaow National Park, Salakpra Wildlife Sanctuary, Pang Sida National Park, and Khao Ang Rue Nai Wildlife Sanctuary as ideal starting locations for future dhole ecological research in Thailand.

We have just scratched the surface regarding the status of dholes in Thailand. I believe the next step should be intensive field surveys at Khong Wangchaow National Park, Salakpra Wildlife Sanctuary, Pang Sida National Park, and Khao Ang Rue Nai Wildlife Sanctuary (identified from our predicted probability map). It is imperative to assess the current threats faced by dholes and recognize that they may not be uniform across the species' range. The documentation of dholes and domestic dogs using overlapping areas is of particular concern. In fact, initial blood testing of domestic dogs revealed village dogs on the outlying edges of KARN tested positive for distemper and parvovirus (K. Jenks unpublished data). I think this line of research is an essential future direction to protect dholes in Thailand from potential disease spillover.

Attitudes towards Dholes in Thailand

Intensive field studies are essential, but the associated data collection and progress is slow, especially for rare species such as dholes. A more rapid and cost-effective technique for revealing information on trends is indirect data collection including the use of questionnaires (White et al. 2005). This technique is especially valuable if local knowledge is incorporated from people with a long history in an area and locally developed perspectives (Berkes et al. 2000). For example, workshops in Thailand with village woodsmen have been shown to provide a useful technique for determining abundance of mammal species in Thung Yai Naresuan Wildlife Sanctuary (Steinmetz et al. 2006). Local knowledge has also shown to be useful to gain information about wildlife encounters, animal distribution, attitudes towards conservation, and local management practices (Newmark et al. 1993, Marks 1994, Alexander 2000, Nyhus et al. 2003, FitzGibbon & Jones 2006). Thus, we conducted 791 interview surveys of villagers from 34 villages in Buriram, Chachoengsao, Nakhon Nayok, Nakhon Ratchasima, Prachin Buri, Sa Kaeo, Sara Buri, Sisaket, and Surin, provinces. Our findings (reported in Chapter 5) include the following:

- While a photograph of an Asiatic jackal (*Canis aureus*) was correctly identified by 41% of the people, a dhole photograph was only correctly identified by 20% of people surveyed.

- Respondents reported seeing dholes near all of the protected areas surveyed; which for areas other than KARN and KYNP represent the first academic documentation of dhole presence there.

- Villagers near every protected area reported dhole attacks on livestock. The majority of animals reported stolen were chicken (17 instances), followed by ducks (3), calves (3), rabbits (1), pigs (1), and fish (1).

- Attitudes towards dholes among villagers were positive with 77% of respondents agreeing that dholes should be protected in the park and surrounding forests.

- Distance to the nearest protected area had an effect on attitudes towards dholes. The closer to a protected area respondents lived, the more agreed with the statement that "dholes are dangerous."

The basic message I inferred from the interview surveys was that villagers have a general lack of understanding of what is in "their own backyard." Not only misidentification of a target species, but inferior knowledge of all species present in habitat adjacent to villages is a concern for conservation measures. I recommend wildlife sanctuaries increase educational materials at their entrances or headquarters to help local people name and appreciate local species. It would also be useful to develop wild canid conservation campaigns aimed at local students and youth, for example, leading a field trip to a protected area to stimulate the appreciation of wildlife and nature.

We found an encouraging conservation environment for dholes in east-central Thailand because the majority of respondents had positive attitudes toward dholes; however, it will take time for the stigma of "the big bad wolf" to be lessened for the species. Even among trained forestry officers and university professors there is poor understanding of dholes' importance.

Funding for the region from both internal and external sources remains consistently focused on tigers.

To improve the "visibility" of the plight of the dhole we need to encourage more local graduate students to focus ecology projects on the species. Researchers at Kasetsart University and the Smithsonian Conservation Biology Institute initiated yearly workshops to bring together all partners, researchers, and field personnel knowledgeable about or interested in dholes to develop canid research programs in Thailand. However, one of the most difficult barriers the group faces is a lack of interested Thai students in field research.

Filling in the Gaps for Dholes

The dhole is a little known member of the canid family that is threatened with extinction but has pressing knowledge gaps that need to be filled to address basic conservation measures. It is known that dholes are at high risk of extirpation in many parts of their range due human persecution, depletion of prey base, competition with other species, and diseases transmitted by feral and domestic dogs (Durbin et al. 2004). In addition to the paucity of information surrounding dhole ecology, managers must deal with the negative public image of dholes. Wild dogs were once depicted as "red demons" (Littledale 1892) with the description: "Except for his handsome appearance, the wild dog has not a single redeeming feature, and no effort, fair or foul, should be spared to destroy these pests of the jungle" (Phythian-Adams 1949). Whether causes of mortality are natural or human-related, there is no data on survival rate for dholes based on age or sex classes. Such information is imperative for choosing targets of conservation efforts.

Before managers can begin to examine the potential to conserve dhole numbers, a basic understanding of their current status and basic ecology is necessary. To bridge some of the gaps in knowledge, dhole research needs an occupancy estimate by country and essential overall population status report on population trends, information collected on whether or not dholes can survive on small prey items, an estimate of a packs' spatial requirements and the consequences of overlap with competitors, data collected on the survival rates of age and sex classes, and research on disease threats. If current or planned research projects (preferably initiated by Thai students) can address some of these questions, we will form a clearer picture of the conservation needs of this endangered species.

APPENDIX A (1-4).

VILLAGE INTERVIEW SURVEY INSTRUMENT

The questionnaire used in villages surrounding five protected areas from November 2007 through August 2009 in east-central Thailand. The questions were asked in Thai, the national language, by students from Kasetsart University and research assistants from KARN.

Appendix A(1). Survey in Thai.

แบบสอบถามชาวบ้าน หน้า 1 ของ 10

แบบสัมภาษณ์เลขที่..... วัน ที่ เดือน ปี 2550

ชื่อ-สกุล (ผู้สัมภาษณ์) ..... ชื่อ-สกุล(เชาวบ้าน) .....

สถานที่/หมู่.....เวลา.....

GPS……

---

1. ผู้ถูกสัมภาษณ์เพศอะไร? □ ชาย □หญิง
2. คุณอายุเท่าไร? _____ ปี
3. คุณเป็นเจ้าของบ้านที่อาศัยอยู่หรือไม่? □ ใช่ □ไม่ใช่
4. คุณอาศัยอยู่ที่บ้านนี้นานเท่าไร ? _____ปี
5. ในบ้านของคุณมีสมาชิกกี่คน? _____ คน ในครอบครัวนี้มีคนที่อายุน้อยกว่า 18 ปี จำนวน_____ คน
6. การศึกษาขั้นสูงสุดของคุณคืออะไร? _____
7. คุณมีอาชีพหลักคืออะไร? _____
8. ปัจจุบันคุณรับราชการหรือไม่ □ ใช่ □ไม่ใช่
9. คุณเกษียนแล้วหรือยัง? □ ใช่ □ไม่ใช่
10. คุณกำลังศึกษาอยู่หรือไม่ ? □ ใช่ □ไม่ใช่
11. คุณปลูกพืช หรือทำสวน (ไร่) หรือไม่?ถ้าใช่ □ ใช่ □ไม่ใช่

    คุณปลูกอะไร? _____ข้าว ผลไม้ (ระบุชนิด) _____

    _____ ข้าวโพด อื่นๆ (อะไร) _____

    _____ ถั่ว
12. ช่วยดูการ์ดนี้ และบอกว่าตัวเลขไหนที่ใกล้เคียงกับรายได้ทั้งปีรวมของทั้งบ้านรับก่อนที่จะจ่ายภาษี

    ก. 30,000 หรือน้อยกว่า จ. 120,001 ถึง 150,000

    ข. 30,001 ถึง 60,000 ฉ. 150,001 ถึง 200,000

    ค. 60,001 ถึง 90,000 ช. มากกว่า 200,000

    ง. 90,001 ถึง 120,000 ซ. ไม่รู้

คำถามเกี่ยวกับสัตว์ป่าในพื้นที่อุทยานและรอบอุทยาน

(ยื่นรูปภาพที่ 1 ให้ผู้ถูกสัมภาษณ์ดู)

13. คุณรู้จักสัตว์ในภาพนี้ คือสัตว์ชนิดใด (เขียนชื่อสัตว์ที่ผู้ถูกสัมภาษณ์บอก) _____

14. คุณเคยเห็นสัตว์ชนิดนี้ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่ □ใช่ □ไม่ใช่ □ไม่แน่ใจ

15. คุณคิดว่าสัตว์ชนิดนี้อาศัยอยู่ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่ □ใช่ □ไม่ใช่ □ไม่แน่ใจ

ถ้าใช่ ในระยะเวลา 10 ปี ที่ผ่านมา คุณคิดว่าประชากรของสัตว์ชนิดนี้มีการเปลี่ยนแปลงหรือไม่

□ เพิ่มขึ้น

□ จำนวนคงที่

□ ลดลง

□ ไม่มี

□ ไม่แน่ใจ

(ยื่นรูปภาพที่ 2ให้ผู้ถูกสัมภาษณ์ดู)

16. คุณทราบไหมว่าสัตว์ในภาพนี้ คือสัตว์ชนิดใด (เขียนชื่อสัตว์ที่ผู้ถูกสัมภาษณ์บอก) _____

17. คุณเคยเห็นสัตว์ชนิดนี้ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่ □ใช่ □ไม่ใช่ □ไม่แน่ใจ

18. คุณคิดว่าสัตว์ชนิดนี้อาศัยอยู่ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่ □ใช่ □ไม่ใช่ □ไม่แน่ใจ

ถ้าใช่ ในระยะเวลา 10 ปี ที่ผ่านมา คุณคิดว่าประชากรของสัตว์ชนิดนี้มีการเปลี่ยนแปลงหรือไม่

□ เพิ่มขึ้น

□ จำนวนคงที่

□ ลดลง

□ ไม่มี

□ ไม่แน่ใจ

(ยื่นรูปภาพที่ 3 ให้ผู้ถูกสัมภาษณ์ดู)

19. คุณทราบไหมว่าสัตว์ในภาพนี้ คือสัตว์ชนิดใด (เขียนชื่อสัตว์ที่ผู้ถูกสัมภาษณ์บอก) _____

20. คุณเคยเห็นสัตว์ชนิดนี้ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่ □ใช่ □ไม่ใช่ □ไม่แน่ใจ

21. คุณคิดว่าสัตว์ชนิดนี้อาศัยอยู่ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่ □ใช่ □ไม่ใช่ □ไม่แน่ใจ

ถ้าใช่ ในระยะเวลา 10 ปี ที่ผ่านมา คุณคิดว่าประชากรของสัตว์ชนิดนี้มีการเปลี่ยนแปลงหรือไม่

□ เพิ่มขึ้น

□ จำนวนคงที่

□ ลดลง

□ ไม่มี

□ ไม่แน่ใจ

(ยื่นรูปภาพที่ 4 ให้ผู้ถูกสัมภาษณ์ดู)

22. คุณทราบไหมว่าสัตว์ในภาพนี้ คือสัตว์ชนิดใด (เขียนชื่อสัตว์ที่ผู้ถูกสัมภาษณ์บอก) _____

23. คุณเคยเห็นสัตว์ชนิดนี้ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่ □ใช่ □ไม่ใช่ □ไม่แน่ใจ

24. คุณคิดว่าสัตว์ชนิดนี้อาศัยอยู่ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่ □ใช่ □ไม่ใช่ □ไม่แน่ใจ

ถ้าใช่ ในระยะเวลา 10 ปี ที่ผ่านมา คุณคิดว่าประชากรของสัตว์ชนิดนี้มีการเปลี่ยนแปลงหรือไม่

□ เพิ่มขึ้น

□ จำนวนคงที่

□ ลดลง

□ ไม่มี

□ ไม่แน่ใจ

(ยื่นรูปภาพที่ 5 ให้ผู้ถูกสัมภาษณ์ดู)

25. คุณทราบไหมว่าสัตว์ในภาพนี้ คือสัตว์ชนิดใด (เขียนชื่อสัตว์ที่ผู้ถูกสัมภาษณ์บอก) _____

26. คุณเคยเห็นสัตว์ชนิดนี้ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่ □ใช่ □ไม่ใช่ □ไม่แน่ใจ

27. คุณคิดว่าสัตว์ชนิดนี้อาศัยอยู่ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่ □ใช่ □ไม่ใช่ □ไม่แน่ใจ

ถ้าใช่ ในระยะเวลา 10 ปี ที่ผ่านมา คุณคิดว่าประชากรของสัตว์ชนิดนี้มีการเปลี่ยนแปลงหรือไม่

□ เพิ่มขึ้น

□ จำนวนคงที่

□ ลดลง

□ ไม่มี

□ ไม่แน่ใจ

(ยื่นรูปภาพที่ 6 ให้ผู้ถูกสัมภาษณ์ดู)

28. คุณทราบไหมว่าสัตว์ในภาพนี้ คือสัตว์ชนิดใด (เขียนชื่อสัตว์ที่ผู้ถูกสัมภาษณ์บอก) _____

29. คุณเคยเห็นสัตว์ชนิดนี้ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่ □ใช่ □ไม่ใช่ □ไม่แน่ใจ

30. คุณคิดว่าสัตว์ชนิดนี้อาศัยอยู่ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่ □ใช่ □ไม่ใช่ □ไม่แน่ใจ

ถ้าใช่ ในระยะเวลา 10 ปี ที่ผ่านมา คุณคิดว่าประชากรของสัตว์ชนิดนี้มีการเปลี่ยนแปลงหรือไม่

□ เพิ่มขึ้น

□ จำนวนคงที่

□ ลดลง

□ ไม่มี

□ ไม่แน่ใจ

(ยื่นรูปภาพที่ 7 ให้ผู้ถูกสัมภาษณ์ดู)

31. คุณทราบไหมว่าสัตว์ในภาพนี้ คือสัตว์ชนิดใด (เขียนชื่อสัตว์ที่ผู้ถูกสัมภาษณ์บอก) _____

32. คุณเคยเห็นสัตว์ชนิดนี้ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่ □ใช่ □ไม่ใช่ □ไม่แน่ใจ

33. คุณคิดว่าสัตว์ชนิดนี้อาศัยอยู่ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่□ใช่ □ไม่ใช่ □ไม่แน่ใจ

ถ้าใช่ ในระยะเวลา 10 ปี ที่ผ่านมา คุณคิดว่าประชากรของสัตว์ชนิดนี้มีการเปลี่ยนแปลงหรือไม่

□ เพิ่มขึ้น

□ จำนวนคงที่

□ ลดลง

□ ไม่มี

□ ไม่แน่ใจ

(ยื่นรูปภาพที่ 8ให้ผู้ถูกสัมภาษณ์ดู)

34. คุณทราบไหมว่าสัตว์ในภาพนี้ คือสัตว์ชนิดใด (เขียนชื่อสัตว์ที่ผู้ถูกสัมภาษณ์บอก) _____

35. คุณเคยเห็นสัตว์ชนิดนี้ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่ □ใช่ □ไม่ใช่ □ไม่แน่ใจ

36. คุณคิดว่าสัตว์ชนิดนี้อาศัยอยู่ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่ □ใช่ □ไม่ใช่ □ไม่แน่ใจ

ถ้าใช่ ในระยะเวลา 10 ปี ที่ผ่านมา คุณคิดว่าประชากรของสัตว์ชนิดนี้มีการเปลี่ยนแปลงหรือไม่

□ เพิ่มขึ้น

□ จำนวนคงที่

□ ลดลง

□ ไม่มี

□ ไม่แน่ใจ

(ยื่นรูปภาพที่ 9 ให้ผู้ถูกสัมภาษณ์ดู)

37. คุณทราบไหมว่าสัตว์ในภาพนี้ คือสัตว์ชนิดใด (เขียนชื่อสัตว์ที่ผู้ถูกสัมภาษณ์บอก) _____

38. คุณเคยเห็นสัตว์ชนิดนี้ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่ □ใช่ □ไม่ใช่ □ไม่แน่ใจ

39. คุณคิดว่าสัตว์ชนิดนี้อาศัยอยู่ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่□ใช่ □ไม่ใช่ □ไม่แน่ใจ

ถ้าใช่ ในระยะเวลา 10 ปี ที่ผ่านมา คุณคิดว่าประชากรของสัตว์ชนิดนี้มีการเปลี่ยนแปลงหรือไม่

□ เพิ่มขึ้น

□ จำนวนคงที่

□ ลดลง

□ ไม่มี

□ ไม่แน่ใจ

(ยื่นรูปภาพที่ 10 ให้ผู้ถูกสัมภาษณ์ดู)

40. คุณทราบไหมว่าสัตว์ในภาพนี้ คือสัตว์ชนิดใด (เขียนชื่อสัตว์ที่ผู้ถูกสัมภาษณ์บอก) _____

41. คุณเคยเห็นสัตว์ชนิดนี้ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่ □ใช่ □ไม่ใช่ □ไม่แน่ใจ

42. คุณคิดว่าสัตว์ชนิดนี้อาศัยอยู่ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่ □ใช่ □ไม่ใช่ □ไม่แน่ใจ

ถ้าใช่ ในระยะเวลา 10 ปี ที่ผ่านมา คุณคิดว่าประชากรของสัตว์ชนิดนี้มีการเปลี่ยนแปลงหรือไม่

□ เพิ่มขึ้น

□ จำนวนคงที่

□ ลดลง

□ ไม่มี

□ ไม่แน่ใจ

(ยื่นรูปภาพที่ 11 ให้ผู้ถูกสัมภาษณ์ดู)

43. คุณทราบไหมว่าสัตว์ในภาพนี้ คือสัตว์ชนิดใด (เขียนชื่อสัตว์ที่ผู้ถูกสัมภาษณ์บอก) _____

44. คุณเคยเห็นสัตว์ชนิดนี้ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่ □ใช่ □ไม่ใช่ □ไม่แน่ใจ

45. คุณคิดว่าสัตว์ชนิดนี้อาศัยอยู่ในอุทยานหรือพื้นที่รอบแนวเขตหรือไม่□ใช่ □ไม่ใช่ □ไม่แน่ใจ

ถ้าใช่ ในระยะเวลา 10 ปี ที่ผ่านมา คุณคิดว่าประชากรของสัตว์ชนิดนี้มีการเปลี่ยนแปลงหรือไม่

□ เพิ่มขึ้น

□ จำนวนคงที่

□ ลดลง

□ ไม่มี

□ ไม่แน่ใจ

ขอบคุณ ต่อจากนี้ ดิฉัน(ผม) จะถามคำถามเกี่ยวกับเสือโคร่ง (ยื่นรูปภาพที่ 1 ให้ผู้ถูกสัมภาษณ์ ดู) นี่คือเสือโคร่ง

46. คุณเคยเห็นสัตว์ชนิดนี้ในในอุทยานหรือพื้นที่รอบแนวเขต

□ เคย □ ไม่เคย □ ไม่แน่ใจ □ จำไม่ได้

ถ้าเคย ให้ถามคำถามข้อถัดไป ถ้า ไม่เคยให้ข้ามไปถามคำถามข้อที่ 49

47. ในระยะเวลา 12 เดือนที่ผ่านมา คุณเคยเห็นเสือโคร่งในในอุทยานหรือพื้นที่รอบแนวเขต

□ เคย □ ไม่เคย □ ไม่แน่ใจ □ จำไม่ได้

ถ้าเคย คุณเห็นเสือโคร่งกี่ครั้ง _____

ถ้าเคย คุณพอจะบอกได้ไหม ว่าคุณเห็นเสือโคร่งที่ไหน?

_____

_____

_____

_____

48. ในระยะเวลา 10 ปี ที่ผ่านมา คุณคิดว่าประชากรของเสือโคร่งเปลี่ยนแปลงอย่างไร

☐ เพิ่มขึ้น

☐ จำนวนคงที่

☐ ลดลง

☐ ไม่มี

☐ ไม่แน่ใจ

ทำไมคุณถึงคิดเช่นนั้น? _____

_____

_____

_____

_____

_____

_____

49. ในระยะเวลา 12 เดือนที่ผ่านมา คุณเคยได้ยินไหมว่าเสือโคร่ง ออกมาล่าสัตว์ของชาวบ้าน เช่น วัว หรือ ควาย

☐เคย ☐ไม่เคย ☐ไม่รู้

ถ้าเคยได้ยิน คุณพอจะทราบไหมว่า สัตว์ชนิดใดถูกล่า _____

สัตว์กี่ตัวที่ถูกฆ่าหรือบาดเจ็บ _____

คุณทราบไหมว่าเหตุเกิดที่ไหน _____

ขอบคุณ ต่อจากนี้ ดิฉัน(ผม) จะถามคำถามเกี่ยวกับหมาใน (เก็บรูปภาพที่ 1 แล้วยื่นรูปภาพที่ 2 ให้ผู้ถูกสัมภาษณ์ ดู) นี่คือหมาใน

50. คุณเคยเห็นสัตว์ชนิดนี้ในอุทยานหรือพื้นที่รอบแนวเขต

☐ เคย ☐ไม่เคย ☐ไม่แน่ใจ ☐ จำไม่ได้

ถ้าเคย ให้ถามคำถามข้อถัดไป ถ้า ไม่เคยให้ข้ามไปถามคำถามข้อที่ 53

51. ในระยะเวลา 12 เดือนที่ผ่านมา คุณเคยเห็นหมาในในอุทยานหรือพื้นที่รอบแนวเขต

☐ เคย ☐ไม่เคย ☐ไม่แน่ใจ ☐ จำไม่ได้

ถ้าเคย คุณเห็นหมาในกี่ครั้ง _____

ถ้าเคย คุณพอจะบอกได้ไหม ว่าคุณเห็นหมาในที่ไหน?

_____

_____

_____

_____

_____

_____

52. ในระยะเวลา 10 ปี ที่ผ่านมา คุณคิดว่าประชากรหมาไนเปลี่ยนแปลงอย่างไร

☐ เพิ่มขึ้น

☐ จำนวนคงที่

☐ ลดลง

☐ ไม่มี

☐ ไม่แน่ใจ

ทำไมคุณถึงคิดเช่นนั้น? _____

_____

_____

_____

_____

_____

53. ในระยะเวลา 12 เดือนที่ผ่านมา คุณเคยได้ยินไหมว่าหมาไน ออกมาล่าสัตว์ของชาวบ้าน เช่น วัว หรือ ควาย

☐เคย ☐ไม่เคย ☐ไม่รู้

ถ้าเคยได้ยิน คุณพอจะทราบไหมว่า สัตว์ชนิดใดถูกล่า _____

สัตว์กี่ตัวที่ถูกฆ่าหรือบาดเจ็บ _____

คุณทราบไหมว่าเหตุเกิดที่ไหน _____

ต่อประโยคที่ดิฉันจะกล่าวต่อไปนี้ คุณมีคำถามเกี่ยวกับความหมายของหมายเลข 1 ถึง 5 หรือไม่(ยื่น หมายเลข 1 ถึง 5 ให้ผู้ถูกสัมภาษณ์)

หมายเลข 1 คือ คุณไม่เห็นด้วยอย่างยิ่ง หมายเลข 2 คือ คุณไม่เห็นด้วย

หมายเลข 3 คือ คุณไม่มีความเห็น หมายเลข 4 คือ คุณเห็นด้วยพอสมควร

หมายเลข 5 คือ คุณเห็นด้วยอย่างยิ่ง ถ้าไม่มี คุณมีความคิดเห็นอย่างไรต่อ ประโยคต่อไปนี้ สเกล 1 ถึง 5

		ไม่เห็นอย่างยิ่ง	**ไม่เห็นด้วย**	**ไม่มีความเห็น**	**เห็นด้วย**	**เห็นด้วยอย่างยิ่ง**
54.	ถ้ามีโอกาส หมาไนจะทำร้ายคน					
55.	ถ้ามีโอกาส หมาไนจะทำร้ายสัตว์เลี้ยงของชาวบ้าน					
56.	หมาไนเป็นสัตว์ที่ดุร้ายและน่ากลัว					
57.	หมาไนมีประชากรมากเกินไป					
58.	ควรกำจัดหมาไน					
59.	ควรอนุรักษ์หมาไน					

ต่อจากนี้ ดิฉันจะถามความคิดเห็นของคุณเกี่ยวกับความหลากลายและจำนวนของสัตว์ป่าในอุทยานหรือพื้นที่รอบแนวเขต

60. คุณคิดว่ามีสัตว์อาศัย ในอุทยานหรือพื้นที่รอบแนวเขตหรือ
หรือป่ารอบอุทยานที่มีจำนวนลดลงอย่างยิ่งในช่วงระยะเวลา 10 ปีที่ผ่านมา
☐ มี ☐ไม่มี ☐ ไม่แน่ใจ
ถ้ามี คุณคิดว่าสัตว์ชนิดไหน _____
ทำไมคุณคิดว่าสัตว์ชนิดนี้มีจำนวนลดลง _____

ขอบคุณ ต่อจากนี้ ดิฉัน(ผม) จะถามคำถามเกี่ยวกับเสือลายเมฆ (ยื่นรูปภาพที่ 6 ให้ผู้ถูกสัมภาษณ์ ดู) นี่คือเสือลายเมฆ

61. คุณเคยเห็นสัตว์ชนิดนี้ในอุทยานหรือพื้นที่รอบแนวเขต หรือไม่
☐ เคย ☐ไม่เคย ☐ไม่แน่ใจ ☐ จำไม่ได้
ถ้าเคย ให้ถามคำถามข้อถัดไป ถ้า ไม่เคยให้ข้ามไปถามคำถามข้อที่ 64

62. ในหนึ่งปีที่ผ่านมา คุณเคยเห็นเสือลายเมฆในในอุทยานหรือพื้นที่รอบแนวเขตหรื อไม่
☐ เคย ☐ไม่เคย ☐ไม่แน่ใจ ☐ จำไม่ได้
คุณเห็นเสือโคร่ง _____กี่ครั้ง

คุณบอกได้ไหมว่าเห็นเสือเมฆที่ไหน?

_____
_____
_____
_____
_____
_____

63. ในระยะเวลา 10 ปี ที่ผ่านมา คุณคิดว่าประชากรของเสือเมฆเปลี่ยนแปลงอย่างไร?
☐ จำนวนคงที่ ☐ เพิ่มขึ้น ☐ ลดลง ☐ ไม่มี ☐ไม่แน่ใจ
เพราะอะไรคุณจึงคิดเช่นนั้น?

_____
_____
_____
_____
_____

64. ในระยะเวลา 12 เดือนที่ผ่านมา คุณเคยได้ยินไหมว่าเสือเมฆออกมากินสัตว์เลี้ยงของชาวบ้าน เช่น วัว หรือ ควาย
☐ เคย ☐ไม่เคย ☐ไม่รู้
ถ้าเคยได้ยิน สัตว์ชนิดใดที่ถูกเสือล่า_____กี่ตัว _____
เกิดเหตุการณ์นี้ขึ้นเกิดที่ไหน _____

ในระยะเวลา 10 ปีที่ผ่านมา	**ไม่เห็นอย่างยิ่ง**	**ไม่เห็นด้วย**	**ไม่มีความเห็น**	**เห็นด้วย**	**เห็นด้วยอย่างยิ่ง**
65. กวางป่ามีจำนวนมากขึ้น					
66. มีจำนวนเก้งในป่ามากขึ้น					
67. มีจำนวนหมูป่าในป่ามากขึ้น					
68. บางครั้งสัตว์ป่าทำความเดือดร้อนให้คุณและครอบครัว					

ถ้าผู้ถูกสัมภาษณ์ให้หมายเลข 4 หรือ 5 สำหรับคำถามข้อที่ 68 ถามคำถามต่อไปนี้

69. สัตว์ชนิดไหนที่ก่อความเดือดร้อนให้คุณ _____

70. คุณมีมาตรการที่จะควบคุมหรือป้องกันอย่างไร _____

71. มาตรการของคุณได้ผลหรือไม่ _____

เราเกือบจะเสร็จ แล้ว ดิฉันมีคำถามอีกไม่กี่ข้อ

72. เจ้าหน้าที่ของวนอุทยานเคยเข้ามาตรวจเยี่ยมหมู่บ้านของคุณหรือไม่ □เคย □ ไม่เคย

ถ้าเคย คุณพอจะทราบสาเหตุของการตรวจเยี่ยมหรือไม่ (เช็คข้อที่เกี่ยวข้อง)

□ ไม่ทราบเหตุผล

□ มีคนรายงานว่าสัตว์ถูกทำร้าย

□ ผ่านมาเฉยๆ

□ ซื้อของ

□ สอนหรือเผยแพร่ความรู้

□ ตรวจร่องรอยของสัตว์ป่า

□ อื่นๆ

73. ในเดือนที่ผ่านมา คุณเคยเห็น(ได้ยิน)ข้อความเกี่ยวกับสัตว์ป่าหรือไม่ □เคย □ ไม่เคย

ถ้าเคย คุณเห็นจากแหล่งใด?

□ โปสเตอร์

□ ทีวี ช่องไหน_____

□ วิทยุ

□ สำนักงานต้อนรับนักท่องเที่ยวของอุทยานแห่งชาติเขาใหญ่

□ โรงเรียน

□ อื่นๆ

ถ้าเคย คุณเห็นหรือได้ยินข้อความเกี่ยวกับอะไร _____

_____

_____

_____

_____

เราเกือบจะเสร็จแล้ว ตอนนี้ดิฉันอยากจะทราบข้อมูลเกี่ยวกับตัวคุณ และพฤติกรรม (อาชีพ) ของคุณ

74. ในระยะเวลา 6 เดือนที่ผ่านมา คุณเข้าไปในป่ากี่ครั้ง? (มีจำกัดเหตุผล) _____ครั้ง

บอกเหตุผล……

75.ในระยะเวลา 12 เดือนที่ผ่านมา คุณเข้าไปเก็บเห็ดในเขตอุทยานหรือไม่?

☐เคย ☐ ไม่เคย ☐จำไม่ได้

ถ้าเคย คุณพอจะประมาณได้ไหมว่า จำนวนของเห็ดที่คุณเก็บได้ สามารถบรรจุใส่ถุงข้าวสาร 5 กิโล ได้กี่ถุง

76.ในระยะเวลา 12 เดือนที่ผ่านมา คุณเข้าไปเก็บหน่อไม้ในเขตอุทยานหรือไม่?

☐เคย ☐ ไม่เคย ☐จำไม่ได้

ถ้าเคย คุณพอจะประมาณได้ไหมว่า จำนวนของหน่อไม้ที่คุณเก็บได้ สามารถบรรจุใส่ถุงข้าวสาร 5 กิโล ได้กี่ถุง _____

77.ในระยะเวลา 12 เดือนที่ผ่านมา คุณเข้าไปจับปลาในเขตอุทยานหรือไม่?

☐เคย ☐ ไม่เคย ☐จำไม่ได้

ถ้าเคย คุณพอจะประมาณได้ไหมว่า จำนวนของปลาที่คุณจับได้ สามารถบรรจุใส่ถุงข้าวสาร 5 กิโล ได้กี่ถุง_ _____

78.ในระยะเวลา 12 เดือนที่ผ่านมา คุณเข้าไปจับสัตว์อื่นในเขตอุทยานหรือไม่ (เช่น กบ เขียด กระรอก กระแต) ?

☐เคย ☐ ไม่เคย ☐จำไม่ได้

ถ้าเคย คุณพอจะประมาณได้ไหมว่า จำนวนของสัตว์ที่คุณจับได้ สามารถบรรจุใส่ถุงข้าวสาร 5 กิโล ได้กี่ถุง

_____ถุง โปรดระบุชนิดสัตว์ _____

_____ถุง โปรดระบุชนิดสัตว์ _____

_____ถุง โปรดระบุชนิดสัตว์ _____

79.คุณมีความคิดเห็นและข้อเสนอแนะเกี่ยวกับการอนุรักษ์สัตว์ป่าภายในอุทยานหรือพื้นที่รอบแนวเขตอย่างไรบ้าง

_____

_____

_____

_____

_____

_____

_____

_____

_____

Appendix A(2). Survey in English.

Interview No. _____ **Date** **Month** **Year**

Interviewer _____

Location_____ Time _____

GPS Location _____

(Greeting of your choice). I'm with a research team, and we are interviewing people concerning wildlife protection and management. Can I ask you a few questions that will take less than 20 minutes? Your responses will be kept confidential.

1. What is your gender? ___male ___female
2. How old are you? **_____years**
3. Do you own a home?

   ___ Yes ___ No

4. How long have you lived there? **_____ years**
5. What is the total number of people in your household? **_____ people**

   How many children are living with you that are under the age of 18? **Number _____**

6. What is the highest grade or year of school you have completed?

   _____

7. What is your primary occupation or job? _____
8. Are you presently employed by the government? **___Yes ___ No**
9. Are you retired?_____ **Yes ___No**
10. Are you a full-time student? **____Yes ____No**

11. Do you grow crops? **___Yes ___No**

If yes, what crops do you grow?

____ rice **____fruit (specify) _____**

____corn **____other (specify) _____**

____beans

12. Finally, please look at this card, and tell me which letter most closely represents the amount of money your household made last year before taxes?

A) = 30,000 baht or less **E) = 120,001 to 150,000 baht**

B) = 30,001 to 60,000 baht **F) = 150,001 to 200,000 baht**

C) = 60,001 to 90,000 baht **G) = more than 200,000 baht**

D) = 90,001 to 120,000 baht **H) = Don't Know**

(Hand picture #1 to respondent)

13. Can you tell me the name of this animal? **(List name given)_____**

14. Have you ever seen this animal in the park or surrounding forest? **___Yes ___No ___Not Sure**

15. Do you think the animal is currently found in this protected area? **___Yes ___No ___Not Sure**

If YES, Over the last 10 years, how has the number of this animal you have seen in this area changed?

_____ Stable (no change)

_____ Increasing

_____ Decreasing

_____ There are none

_____ **Not Sure / Don't Know**

(Hand picture #2 to respondent)

16. Can you tell me the name of this animal? **(List name given)**_____

17. Have you ever seen this animal in the park or surrounding forest? ___**Yes** ___**No** ___**Not Sure**

18. Do you think the animal is currently found in this protected area? ___**Yes** ___**No** ___**Not Sure**

If YES, Over the last 10 years, how has the number of this animal you have seen in this area changed?

_____ **Stable (no change)**

_____ **Increasing**

_____ **Decreasing**

_____ **There are none**

_____ **Not Sure / Don't Know**

(Hand picture #3 to respondent)

19. Can you tell me the name of this animal? **(List name given)**_____

20. Have you ever seen this animal in the park or surrounding forest? ___**Yes** ___**No** ___**Not Sure**

21. Do you think the animal is currently found in this protected area? ___**Yes** ___**No** ___**Not Sure**

If YES, Over the last 10 years, how has the number of this animal you have seen in this area changed?

_____ **Stable (no change)**

_____ **Increasing**

_____ **Decreasing**

_____ **There are none**

_____ **Not Sure / Don't Know**

(Hand picture #4 to respondent)

22. Can you tell me the name of this animal? **(List name given)**_____

23. Have you ever seen this animal in the park or surrounding forest? ___**Yes** ___**No** ___**Not Sure**

24. Do you think the animal is currently found in this protected area? ___**Yes** ___**No** ___**Not Sure**

If YES, Over the last 10 years, how has the number of this animal you have seen in this area changed?

_____ **Stable (no change)**

_____ **Increasing**

_____ **Decreasing**

_____ **There are none**

_____ **Not Sure / Don't Know**

(Hand picture #5 to respondent)

25. Can you tell me the name of this animal? **(List name given)**_____

26. Have you ever seen this animal in the park or surrounding forest? ___**Yes** ___**No** ___**Not Sure**

27. Do you think the animal is currently found in this protected area? ___**Yes** ___**No** ___**Not Sure**

If YES, Over the last 10 years, how has the number of this animal you have seen in this area changed?

_____ **Stable (no change)**

_____ **Increasing**

_____ **Decreasing**

_____ **There are none**

_____ **Not Sure / Don't Know**

(Hand picture #6 to respondent)

28. Can you tell me the name of this animal? **(List name given)**_____

29. Have you ever seen this animal in the park or surrounding forest? ___**Yes** ___**No** ___**Not Sure**

30. Do you think the animal is currently found in this protected area? ___**Yes** ___**No** ___**Not Sure**

If YES, Over the last 10 years, how has the number of this animal you have seen in this area changed?

_____ **Stable (no change)**

_____ **Increasing**

_____ **Decreasing**

_____ **There are none**

_____ **Not Sure / Don't Know**

(Hand picture #7 to respondent)

31. Can you tell me the name of this animal? **(List name given)**_____

32. Have you ever seen this animal in the park or surrounding forest? ___**Yes** ___**No** ___**Not Sure**

33. Do you think the animal is currently found in this protected area? ___**Yes** ___**No** ___**Not Sure**

If YES, Over the last 10 years, how has the number of this animal you have seen in this area changed?

_____ **Stable (no change)**

_____ **Increasing**

_____ **Decreasing**

_____ **There are none**

_____ **Not Sure / Don't Know**

(Hand picture #8 to respondent)

34. Can you tell me the name of this animal? **(List name given)**_____

35. Have you ever seen this animal in the park or surrounding forest? ___**Yes** ___**No** ___**Not Sure**

36. Do you think the animal is currently found in this protected area? ___**Yes** ___**No** ___**Not Sure**

If YES, Over the last 10 years, how has the number of this animal you have seen in this area changed?

_____ **Stable (no change)**

_____ **Increasing**

_____ **Decreasing**

_____ **There are none**

_____ **Not Sure / Don't Know**

(Hand picture #9 to respondent)

37. Can you tell me the name of this animal? **(List name given)**_____

38. Have you ever seen this animal in the park or surrounding forest? ___**Yes** ___**No** ___**Not Sure**

39. Do you think the animal is currently found in this protected area? ___**Yes** ___**No** ___**Not Sure**

If YES, Over the last 10 years, how has the number of this animal you have seen in this area changed?

_____ **Stable (no change)**

_____ **Increasing**

_____ **Decreasing**

_____ **There are none**

_____ **Not Sure / Don't Know**

(Hand picture #10 to respondent)

40. Can you tell me the name of this animal? **(List name given)**_____

41. Have you ever seen this animal in the park or surrounding forest? ___**Yes** ___**No** ___**Not Sure**

42. Do you think the animal is currently found in this protected area? ___**Yes** ___**No** ___**Not Sure**

If YES, Over the last 10 years, how has the number of this animal you have seen in this area changed?

_____ **Stable (no change)**

_____ **Increasing**

_____ **Decreasing**

_____ **There are none**

_____ **Not Sure / Don't Know**

(Hand picture #11 to respondent)

43. Can you tell me the name of this animal? **(List name given)**_____

44. Have you ever seen this animal in the park or surrounding forest? ___**Yes** ___**No** ___**Not Sure**

45. Do you think the animal is currently found in this protected area? ___**Yes** ___**No** ___**Not Sure**

If YES, Over the last 10 years, how has the number of this animal you have seen in this area changed?

_____ Stable (no change)

_____ Increasing

_____ Decreasing

_____ There are none

_____ Not Sure / Don't Know

Thank you. Now, I am going to ask you specific questions about tigers.

(Hand picture #1 to respondent)

Tell the respondent: This is a tiger.

46. Have you *ever* seen this animal in the protected area or surrounding forest?

___Yes ___No ___Not Sure ___Can't Remember

If yes, move to next question. If no, move to question 49.

47. Within the last 12 months, have you personally seen a tiger(s) in the protected area or surrounding forest?

___Yes ___No ___Not Sure ___Can't Remember

If yes, how many times? **_____ times**

If yes, Can you tell me all of the locations where you have seen a tiger or tigers in the past 12 months?

_____

_____

_____

_____

48. Over the last 10 years, how has the number of tigers you have seen in the surrounding forest changed?

_____ Stable (no change)

_____ Increasing

_____ Decreasing

_____ There are no tigers

_____ Not Sure / Don't Know

Reason for the above answer?

_____

49. Within the past 12 months, are you aware of any situations where tigers have killed livestock?

___Yes ___No ___Don't Know

If yes, **what type of livestock was killed? Species_____**

How many were killed or injured? _____ number

Where did this incident happen?

_____

_____

_____

Thank you. Now, I am going to ask you specific questions about dholes.

(Pickup picture #1 and hand picture #2 to respondent)

Tell the respondent: This is a dhole.

50. Have you *ever* seen this animal in the protected area or surrounding forest?

___Yes ___No ___Not Sure ___Can't Remember

If yes, move to next question. If no, move to question 53.

51. Within the last 12 months, have you personally seen dholes in the protected area or surrounding forest?

___Yes ___No ___Not Sure ___Can't Remember

If yes, how many times? **_____ times**

If yes, Can you tell me all of the locations where you have seen a dhole or dholes in the past 12 months?

_____

_____

52. Over the last 10 years, how has the number of dholes you have seen in the surrounding area changed?

_____ Stable (no change)

_____ Increasing

_____ Decreasing

_____ There are no dholes

_____ Not Sure / Don't Know

Reason for the above answer?

_____

53. Within the past 12 months, are you aware of any situations where dholes have killed livestock?

___Yes ___No ___Don't Know

If yes, **what type of livestock was killed? Species_____**

How many were killed or injured? _____ number

Where did this incident happen?

_____

(Hand 1-5 scale to respondent)

On the scale I gave to you from 1 to 5, 1 means you strongly disagree with the statement I will read to you, 2 means that you moderately disagree, 3 means that you neither agree nor disagree (you have no opinion), 4 you moderately agree with the statement, and 5 means that you strongly agree with the statement. Do you have any questions about how to use this scale?

Please respond to the following statements based on the 1-5 scale.

	Strongly Disagree	Moderately Disagree	No Opinion	Moderately Agree	Strongly Agree
54. If given a chance, dholes will attack a person	**1**	**2**	**3**	**4**	**5**
55. If given a chance, dholes will attack livestock	**1**	**2**	**3**	**4**	**5**
56. Dholes are dangerous	**1**	**2**	**3**	**4**	**5**
57. Dholes are over-populated	**1**	**2**	**3**	**4**	**5**
58. Dholes should be eliminated from the park and surrounding forest	**1**	**2**	**3**	**4**	**5**
59. Dholes should be protected	**1**	**2**	**3**	**4**	**5**

Now, I am going to ask about your views of wildlife abundance in the park and surrounding forest.

60. Are there any species or types of wildlife within the park or surrounding forest that have declined significantly in numbers over the past 10 years? **___Yes ___No ___Not Sure**

If yes, **which species or type? _____**

Why do you think they are less common than before?

_____

Thank you. Now, I am going to ask you specific questions about clouded leopards.

(Pickup picture #2 and hand picture #6 to respondent)

Tell the respondent: This is a clouded leopard.

61. Have you *ever* seen this animal in the protected area or surrounding forest?

___Yes ___No ___Not Sure ___Can't Remember

If yes, move to next question. If no, move to question 64.

62. Within the last 12 months, have you personally seen clouded leopards in the protected area or surrounding forest?

___Yes ___No ___Not Sure ___Can't Remember

If yes, how many times? **_____ times**

If yes, Can you tell me all of the locations where you have seen clouded leopards in the past 12 months?

_____

_____

_____

63. Over the last 10 years, how has the number of clouded leopards you have seen in the protected area changed?

_____ Stable (no change)

_____ Increasing

_____ Decreasing

_____ There are no clouded leopards

_____ Not Sure / Don't Know

Reason for the above answer?

_____

64. Within the past 12 months, are you aware of any situations where clouded leopards have killed livestock?

___Yes ___No ___Don't Know

If yes, **what type of livestock was killed? Species_____**

How many were killed or injured? _____ number

Where did this incident happen?

_____

Again, please respond to the following statements based on the 1-5 scale.

	Strongly Disagree	Moderately Disagree	No Opinion	Moderately Agree	Strongly Agree
65. There are more **Sambar deer** in the park and surrounding forest than 10 years ago	**1**	**2**	**3**	**4**	**5**
66. There are more **Barking deer** in the park and surrounding forest than 10 years ago	**1**	**2**	**3**	**4**	**5**
67. There are more **wild pigs** in the park and surrounding forest than 10 years ago	**1**	**2**	**3**	**4**	**5**
68. Sometimes wildlife cause problems for me and my family	**1**	**2**	**3**	**4**	**5**

If person indicates a 4 or a 5 on the above question, then ask:

69. What types of problems do you have with wildlife?

_____

70. What are the measures you take to control wildlife?

_____

71. Are the measures you take to control wildlife effective?

_____

Thanks, just a few more questions about the adjacent protected area.

72. Have any rangers from the adjacent protected area visited your town/village in the last year?
___Yes ___No

If yes, do you know what they were doing or the purpose of their visit? (check all that apply)

___ don't know purpose of visit

___ animal damage report

___ passing through

___ shopping

___ teaching

___ checking for animal tracks

___ other (specify)

_____

73. In the last month, have you heard or seen any messages about wildlife? **___Yes ___No**
If yes, where did you see the message?

___ poster

___ TV (which station?) _____

___ radio

___ KYNP Visitor's Center

___ school

___ other (please list) _____

If yes, what was the message about?

_____

_____

Ok, (we are almost done). I would like to finish up by asking you a few questions about yourself and your habits. Remember, your answers are confidential.

74. Within the last 6 months, how many trips did you make into the forest of the adjacent protected area (for any reason)? **_____trips**

If trips were made, what was the reason for each trip:

75. Within the last 12 months, did you collect any **mushrooms** from the forest inside the adjacent protected area?

___Yes ___No ___Can't Remember

If yes, about how many 5kg. rice bags full of mushrooms? **____bags**

76. Within the last 12 months, did you collect any parts of **bamboo** from the forest inside the adjacent protected area?

___Yes ___No ___Can't Remember

If yes, about how many 5kg. rice bags full of bamboo? **____bags**

77. Within the last 12 months, did you ever catch **fish** from inside the adjacent protected area?

___Yes ___No ___Can't Remember

If yes, about how many 5kg. rice bags full of fish? **____bags**

78. Within the last 12 months, did you ever **harvest any other animals** (such as jungle fowl, squirrels, frogs, or pangolin) from inside the adjacent protected area?

___Yes ___No ___Can't Remember

If yes, about how many 5kg. rice bags full? **____bags _____species**

____bags _____species

____bags _____species

79. Is there anything you would like to tell us about wildlife conservation?

Appendix A(3). Photos Used for Species Identification Questions.

Dhole Interview Picture Key. Numbers indicate the order in which pictures were shown. Number and name of species were on the back of the picture and not visible to respondents. Pictures were shown in color.

1. Tiger (*Panthera tigris*)

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2. Dhole (*Cuon alpinus*)

3. Leopard Cat (*Prionailurus bengalensis*)

4. Asiatic Jackal (*Canis aureus*)

5. Leopard (*Panthera pardus*)

© Centre for Wildlife Studies, K. Ullas Karanth

6. Clouded Leopard (*Neofelis nebulosa*)

7. Maned Wolf (*Chrysocyon brachyurus*)

© Conservation International, photo by Leandro Silveira

8. Large Indian Civet (*Viverra zibetha)*

9. Sambar Deer (*Rusa unicolor*)

10. Barking Deer (*Muntiacus muntjak*)

11. Banteng (*Bos javanicus*)

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Appendix A(4). Handouts Used for Question Clarification.

Please look at this card, and tell me which letter most closely represents the amount of money your household made last year before taxes?

A) = 30,000 baht or less

B) = 30,001 to 60,000 baht

C) = 60,001 to 90,000 baht

D) = 90,001 to 120,000 baht

E) = 120,001 to 150,000 baht

F) = 150,001 to 200,000 baht

G) = more than 200,000 baht

H) = Don't Know

Strongly Disagree	Moderately Disagree	No Opinion	Moderately Agree	Strongly Agree
1	2	3	4	5

ก) = 30,000 บาท หรือน้อยกว่า

ข) = 30,001 ถึง 60,000 บาท

ค) = 60,001 ถึง 90,000 บาท

ง) = 90,001 ถึง 120,000 บาท

จ) = 120,001 ถึง 150,000 บาท

ฉ) = 150,001 ถึง 200,000 บาท

ช) = มากกว่า 200,000 บาท

ซ) = ไม่รู้

ไม่เห็นด้วยอย่างยิ่ง	ไม่เห็นด้วยบางส่วน	ไม่มีความเห็น	เห็นด้วยบ้าง	เห็นด้วยอย่างยิ่ง
1	2	3	4	5

APPENDIX B.

CAMERA-TRAP EVIDENCE OF LARGE-SPOTTED CIVET *VIVERRA MEGASPILA* IN KHAO ANG RUE NAI WILDLIFE SANCTUARY AND KHAO YAI NATIONAL PARK, THAILAND

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Abstract

Large-spotted Civet *Viverra megaspila* records warrant documentation with publicly verifiable evidence because the species is currently IUCN Red-Listed as Vulnerable. We present camera-trapping and habitat records of the species from two protected areas lacking previous verifiable records. Locations support past suggestions that it is a lowland forest species; given the heavy clearance of plains forest in Thailand, it is likely to be genuinely very localized in the country now.

Introduction

There are few published data on the status and patterns of geographic variation of the Large-spotted Civet *Viverra megaspila*. Across its range in Cambodia, Laos, Myanmar, Thailand, Vietnam, Peninsular Malaysia, and Southern China, *V. megaspila* occurs mainly in fragmented

populations in lowland evergreen forests (Francis 2008). Lynam et al. (2005), reviewing some recent records, found that most were from below 300 m elevation. The Large-spotted Civet is listed as Vulnerable on the IUCN Red List (IUCN 2008), and the Action Plan of the [then] IUCN/SSC Mustelid and Viverrid Specialist Group (Schreiber et al. 1989) recommended field studies focusing on causes of the "natural scarcity" of the species, specifically noting a lack of records from the generally well-studied Khao Yai National Park (KYNP), Thailand.

In Thailand, despite several carnivore studies (e.g. Srikosamatara 1993, Austin 2002, Lynam et al. 2003, Grassman et al. 2005a, b), there are published recent records only of an unverified sighting by staff in Huay Kha Khaeng Wildlife Sanctuary in the Western Forest Complex (Rabinowitz & Walker 1991) and photographs from two locations in Tapraya National Park on the eastern edge of the Dong Phayayen–Khao Yai Forest Complex (Lynam et al. 2005). A record from KYNP of a Large-spotted Civet camera-trapped during 2000–2002 gave no evidence of how the photograph was identified (Suzuki et al. 2006). The specie's localized distribution and current threat categorization urge documentation of occurrences with public evidence. Here, we present camera-trapping records of the species and habitat data from two protected areas in Thailand.

Methods

We conducted camera trapping surveys in KYNP and Khao Ang Rue Nai Wildlife Sanctuary (KARN) using passive infrared sensors for heat and motion (CamTrakker® CamTrak South, Inc., Watkinsville, GA 30677 USA). Cameras are effective in covering a wide area to document, verifiably, species presence (e.g. Griffiths & van Schaik 1993; Carbone et al. 2001, Moruzzi et al. 2002). Cameras were set approximately 50 cm above ground, 10–20 m from the

intended monitoring area, camouflaged with foliage, and, in some locations in KARN baited with commercial scent lures (Minnesota Trapline Products, Pennock, MN 56279 USA) or Sambar *Rusa unicolor* road kill. Photographs of *V. megaspila* clearly show lines of relatively large, bold, and boldly edged spots on the flank and a black dorsal stripe to the tail (Fig. B1) which are the most easily seen body features to differentiate between *V. megaspila* and Large Indian Civet *V. zibetha* (Duckworth 1994).

Study Site and Records

Field surveys in KYNP (2,168 km^2, 14º05–15'N; 101º05–50'E) in south-central Thailand covered each of the 22 management zones of the park (Lynam et al. 2003) at least once. Cameras were set at elevations of 40–1,340 m in a wide range of habitats: tropical rainforest, dry evergreen forest, hill evergreen forest, mixed deciduous forest, dry dipterocarp forest, and grassland. Camera trapping was conducted from October 2003 through March 2007 during all seasons of the year. From 6,253 total trap nights in the park, four photos of Large-spotted Civet were recorded at two locations near the park boundary of zone KY04 (Table B1; Figure B1). Both locations were within 350 m of the nearest stream and the park boundary, and separated by 890 m.

KARN (1,079 km^2; 13°00'–13°32'N, 101°40'–102°09'E), in eastern Thailand, encompasses Thailand's last remaining lowland rainforest. Elevations from 0 m to 170 m were camera trapped in KARN from January 2008 through September 2009. From 3,650 trap nights, 23 photos (at eight locations) of Large-spotted Civets were recorded (Table B2). All sites excluding one detecting Large-spotted Civet were within 2 km of Ban Phu Thai, the location of the Chachoengsao Wildlife Research Station in secondary forest. All sites are on waterways and

two are near Samsao Canal, a permanent water source. Six out of 14 camera sessions that yielded Large-spotted Civet photos included a scent lure/bait; All Call, Pro's Choice, or Old Yeller lures were used, but not repeatedly enough to confirm whether or not they are specifically effective for attracting Large-spotted Civets.

Discussion

These records verify the presence of Large-spotted Civet in KYNP where there have been no recent confirmations of its presence (Lynam et al. 2003, but see Suzuki et al. 2006). We speculate that we detected Large-spotted Civet when previous camera-trapping (Lynam et al. 2006) did not because our intensive sampling went beyond the park's core area to include all zones and edges; some camera locations were a few hundred meters lower than the general study area of Khao Yai where most surveyors spend their time.

Even so, the records from KYNP are from slightly higher than the 300 m general cutoff suggested by Lynam et al. (2005), albeit based on rather few records. There is no other low-elevation habitat in the surroundings: south is a high-elevation ridge and north lies human habitation and agricultural lands, still above 400 m. The area is scrubby dry evergreen forest close to the border of the national park in an area of high human use. One camera trap also photographed hunters carrying small-animal traps, recalling Large-spotted Civet records from Tapraya National Park (Lynam et al. 2005), corroborating that the species is not particularly sensitive to edge/degraded areas (Duckworth 1994, Austin 1999).

It was not possible to determine if photographs at KYNP were of the same individual because only the left flank was recorded at one site and only the right flank at the other. Large Indian Civets reportedly average 1.7 km in daily movements (Rabinowitz 1991), so both camera

locations could be within the home range of one individual Large-spotted Civet. The record of one Large-spotted Civet contrasts with the many (n=42) Large Indian Civets photographed throughout KYNP.

In dry evergreen lowlands of KARN, Large-spotted Civet was more commonly found than Large Indian Civet (n=7) with no camera trap location recording both. Our data agree with previous assessments of Large-spotted Civet as a lowland species able to cope with degraded habitat (Austin 1999, Lynam et al. 2005, Francis 2008). The low detection of Large Indian Civet in predominantly lowland KARN, where populations of Large-spotted Civet seem higher, (see also Austin 1999) contrasts with other, higher-altitude protected areas, such as KYNP, where the reverse is true. Further research with exclusion experiments would help determine the level of direct competition, and what causes Large-spotted Civet to be more successful in the lowland forests. Given that most of the lowland forest in Thailand has been converted to agricultural areas (Hirsch 1990), the outlook for the country's Large-spotted Civets is grim.

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Table B1. Camera trap records of Large-spotted Civet in Khao Yai National Park, Thailand

Location of Camera Trap	Date	Time	Elevation (m)	Habitat
14°20′N, 101°43′E Zone KY04 (Klongpa Gung); north of Khao Kamphaeng along the Lam Phra Phloeng River	22 Oct 2006*	18h31	470	Dry evergreen forest
	22 Oct 2006*	18h32		
14°21′N, 101°43′E Approx. 250 m outside the park boundary of Zone KY04; along the Lam Phra Phloeng River	20 Oct 2006	02h18	460	Patchy dry evergreen forest/agricultural area
	29 Oct 2006	18h41		

*same individual identified by coat pattern
Elevation was estimated from a Thailand 1:50,000 topographic map, edition: 3_RTSD, series L7017, sheet and year unknown.

Table B2. Camera trap records of Large-spotted Civets in Khao Ang Rue Nai Wildlife Sanctuary, Thailand

Location of Camera Trap	Date	Time	Elevation (m)	Habitat
13°29′N, 101°52′E	31 Apr 08	21h24	105	Agricultural area
13°25′N, 101°53′E	14 May 08	18h51	120	Dry evergreen forest
	13 Aug 08	22h02		
13°25′N, 101°52′E	09 Oct 08	02h47	100	Teak plantation
13°24′N, 101°53′E	05 Dec 08	01h45	105	Dry evergreen forest
	09 Dec 08*	23h03		
	10 Dec 08	00h43		
13°23′N, 101°52′E	11 Dec 08	05h15	100	Teak plantation
	11 Dec 08	20h35		
	19 Dec 08*	00h23		
13°24′N, 101°52′E	30 Dec 08	21h13	100	Teak plantation
13°25′N, 101°53′E	23 Jun 09	19h51	115	Dry evergreen forest
	04 Aug 09	21h07		
	14 Aug 09	06h15		
	27 Aug 09*	05h46		
	04 Sep 09	06h09		
	13 Sep 09	04h36		
	14 Sep 09	02h06		
	24 Sep 09	03h52		
	02 Oct 09*	04h51		
	08 Oct 09	19h57		
	16 Oct 09	19h53		
13°24′N, 101°54′E	01 Oct 09	20h10	120	Dry evergreen forest

*same individual identified by coat pattern
Elevation was estimated from a Thailand 1:50,000 topographic map, edition: 3_RTSD, series L7017, sheet: 53351, year: 1991.

Figure B1. Large-spotted Civet (*Viverra megaspila)* in dry evergreen forest in northeastern Khao Yai National Park, Thailand.

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