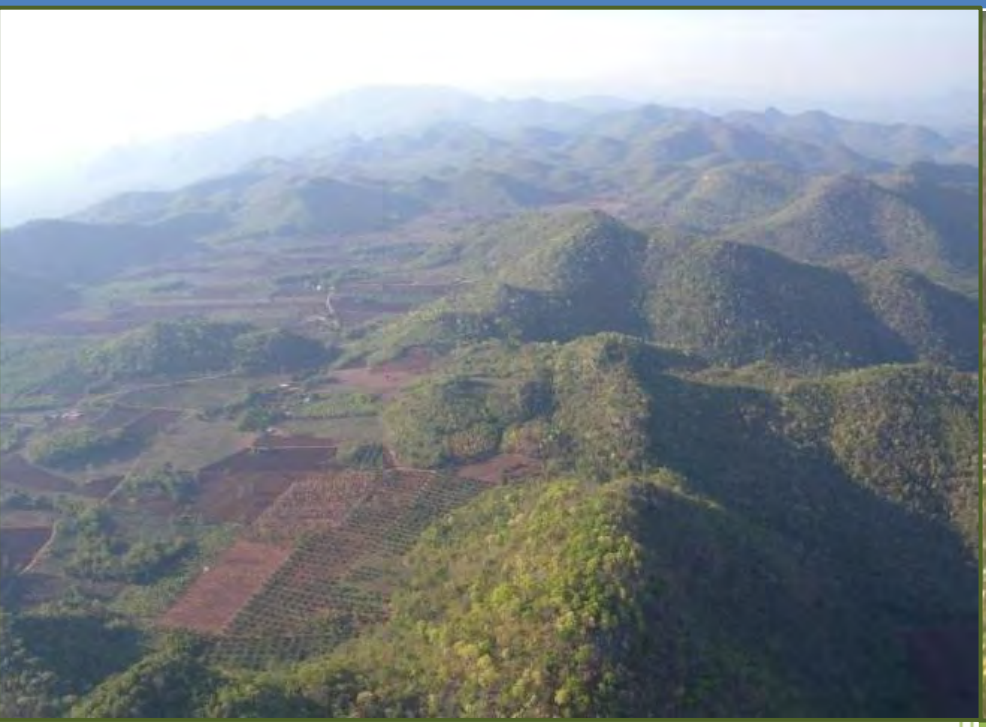
Investigation into the role of land beside the south-east boundary of Salakpra Wildlife Sanctuary for the conservation of elephants, other wildlife and ecosystem integrity of the conservation area.



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Undertaken with Salakpra as part of the
Salakpra Elephant Conservation Project
Kanchanaburi Province
West Thailand

Elephant Conservation Network

Project Report 2013

Contents

Acronyms

DNP	Department of National Parks, Wildlife and Plant Conservation
ECN	Elephant Conservation Network
GIS	Geographic Information System
GPS	Global Positioning System
HEC	Human Elephant Conflict
HECx	Human Elephant Coexistence
IUCN	International Union for Conservation of Nature
NGO	Non-Governmental Organisation
NP	National Park
NTFP	Non-Timber Forest Product
PA	Protected Area
RST	Recce-Survey-Transect
RTA	Royal Thai Army
WARPA	Wild Animals Reservation and Protection Act
WEFCOM	Western Forest Complex
WS	Wildlife Sanctuary

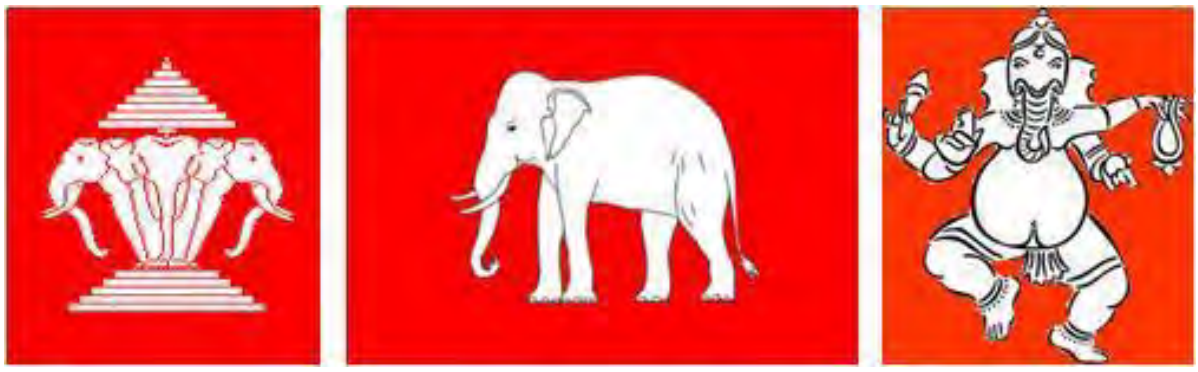

Figure 1: Elephants are national, cultural and religious icons in many Asian countries, including Thailand where they serve as a flagship species for conservation. Left to right: the multi-headed god Erawan, the royal white elephant on the old flag of Siam, and the elephant god Ganesh.

Cover pictures: Aerial view taken from paramotor of survey area; bull elephant photographed in cleared fields in Pha Lad.

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Figure 2: Survey teams from Salakpra Wildlife Sanctuary and ECN staff

1. Executive Summary

This project was undertaken as part of the Elephant Conservation Network's Salakpra Elephant Conservation Initiative which aims to help secure a sustainable future for Salakpra's elephants and their forest ecosystem for the benefit of local people and wildlife.

1.1. Project Aims

a) To investigate the conservation value and feasibility of improving the forest area adjoining the southeastern boundary of Salakpra Wildlife Sanctuary.

b) To recommend ways to upgrade the conservation status and integrity of this area in order to create a more suitable size and shape to protect elephants and other wildlife.

1.2. South Eastern Survey Project Activities

From January to March 2011, Elephant Conservation Network (ECN) field staff, local Department of National Parks, Wildlife and Plant Conservation (DNP) rangers and members of the local community undertook 14 days of field surveys in an area covering 140 km^2 adjoining the south-eastern boundary of Salakpra Wildlife Sanctuary (Salakpra WS). A variety of approaches were used to collect data on the presence/absence of elephants, wildlife signs, habitat type, and human activities. The data collected was linked to ECN's crop-raiding and land use data to highlight causal associations and environmental vulnerabilities.

1.3. Summary of Findings

a) The survey area lies within an unprotected important traditional elephant range:

- Elephants use resources and inhabit areas outside Salakpra WS which indicates that their range is not limited to the present boundary of Salakpra WS;
- Elephant encounter rates in the survey area are the same as encounter rates within the WS, indicating that elephant population density is the same as within the WS;
- The elephants in the survey area are a breeding population that includes adults, sub-adults, juveniles and calves.

b) The southern core of Salakpra is exposed and vulnerable to human encroachment:

- The survey zone closest to Thung Salakpra: the southern core of Salakpra, known as *Paak Nok Kaew* (referred to in this report as Salakpra PNK), has the highest density of elephants;
- The zones adjacent to the Thung Salakpra core also have high elephant density and should be protected as a buffer to the core of Salakpra;
- Natural resource exploitation such as bamboo collection, logging and non-timber forest product (NTFP) collection happens throughout the survey zone with a slight decrease in intensity with proximity to the wildlife sanctuary boundary.

c) The whole survey area is important for wildlife:

- Significant findings include the presence of Sunda pangolin (*Manis javanica*), Sumatran serow (*Capricornis sumatraensis*), sambar deer (*Rusa unicolor*) and hornbills (*Buceros spp*);
- Uncontrolled hunting in the survey area threatens wildlife.

d) HEC will escalate due to high levels of land use conversion and human activities:

- Extensive human presence and activities, most significantly active land clearance, in this area confirm that it is threatened by habitat loss and degradation;
- Ground and aerial observations show that the survey zone is in transition from predominantly forest to a human dominated land-use mosaic;
- The habitual presence of elephants close to an area of increasing crop raiding suggests that human elephant conflict (HEC) will escalate if the area is not protected from further encroachment.

1.4. Recommendations

The survey findings support the following recommendations:

a) Prevent further escalation of HEC by:

- Halting and where possible reversing land clearance;
- Promoting sensible land use planning;
- Improving understanding of elephant needs and behavior.

b) Upgrade the forest in the survey area to full protected status to benefit wildlife and to act as a physical buffer to Salakpra WS.

c) Extend Salakpra WS to better reflect the distribution of elephants and fully protect the core area of southern Salakpra.

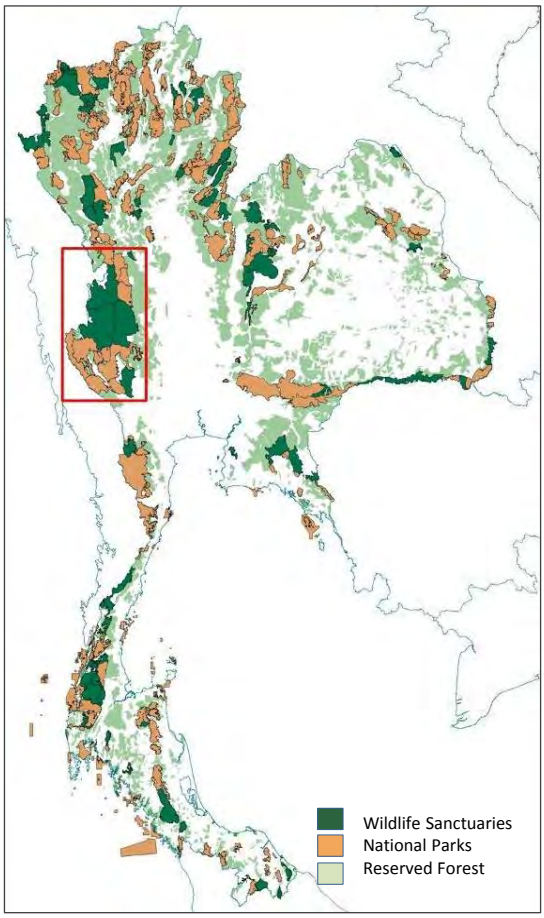
Figure 3: Elephant herd in Salakpra. This photo shows only nine of the sixteen individuals in the herd.

2. Project Background

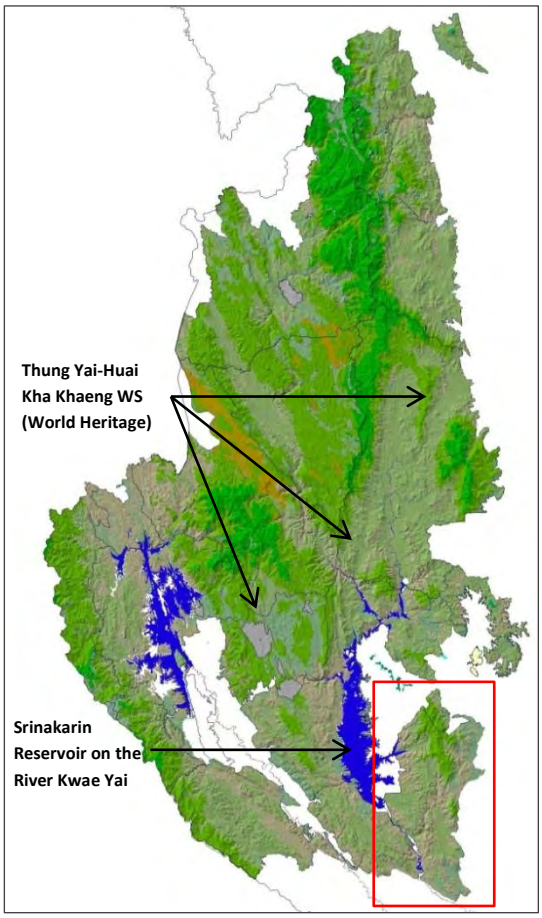
2.1. Overall Rationale

Asian elephants are endangered or threatened across all 13 range states. The most significant threats are habitat loss and fragmentation, and the increase in human elephant conflict (HEC) that results from this (IUCN, 2011). Thailand is home to an estimated 3,000 to 3,500 wild elephants scattered around 60 protected areas (PAs) with the majority living in 12 conservation complexes (Srikrachang, 2003). Every population is threatened by habitat fragmentation, agricultural encroachment, and other human activities, and HEC is an increasingly serious problem.

The largest population of 1000+ elephants, around one third of Thailand's wild population, inhabits the Western Forest Conservation Complex (WEFCOM), an area of 18,000 km^2 of diverse monsoon forest and the country's largest conservation area. WEFCOM is known to be an outstanding area for elephants and its protection has long been recommended as a priority area for their conservation (Olivier, 1978; Kempf & Santiapillai, 2000). The decline of Thailand's wild elephant population is well-documented (Storer, 1981; Santiapillai & Jackson, 1990). The irony is that landscapes such as WEFCOM could support many more individuals if better protected. Over half of WEFCOM, two WSs and eight national parks (NPs), lies within Kanchanaburi province, making it one of the most important provinces for wild elephant conservation in Thailand (Stewart-Cox, *et al*., 2001).



Map 2: Thailand's network of protected areas with WEFCOM highlighted



Map 1: WEFCOM with the Salakpra Wildlife Sanctuary highlighted

- ***Salakpra***

Salakpra was gazetted in 1965 as Thailand's first wildlife sanctuary, famous at that time for its large mammals including elephants, tigers and banteng. The official size of Salakpra is 868 km^2 but recent geographic information system (GIS) calculations suggest it may in fact be 970 km^2, or 10% larger. Together with the adjacent 60 km^2 Chalerm Rattanakosin NP to the north, this area represents the south-eastern arm of WEFCOM (see Map 2 & Map 1). By the time ECN began focusing on here in 2005 Salakpra had been diminished and degraded by encroachment, logging, hunting, cattle, fire and official neglect. This deterioration was greatly exacerbated in the late 1970s when the Srinakarin Hydroelectric Dam was built and Salakpra was severed from the Erawan and Srinakarin NPs by the reservoir that inundated around 500 km^2 of prime wildlife habitat. The dam's access road and associated ribbon developments also separated Salakpra from the River Kwae Yai, while human settlements and agriculture advanced from the east, turning the sanctuary into a narrow forest peninsula that is now threatened with isolation from the rest of WEFCOM. Moreover, when the Srinakarin Dam was built, 50km^2 of prime elephant habitat was excised from the western side of the sanctuary to make way for villages relocated from the inundation zone. Settlers have also appropriated prime areas of elephant habitat inside the sanctuary in the Chongla valley to the south and Nong Ree valley to the northeast.

Despite this history of exploitation, Salakpra remains an important area for elephants, supporting an estimated 175 individuals (Kongrit, *et al.*, 2007) or about 17.5% of WEFCOM's population and approximately 6% of Thailand's total number of wild elephants. Because elephants are a large, wide-ranging species, they need sizeable areas of contiguous habitat to provide adequate food, water, and tranquillity to support genetic dispersal. Wild elephants in Thailand are mostly found within protected areas so it is important that these areas meet their needs. The optimal shape of nature reserves has been long debated (Diamond, 1975; Boecklen, 1986), but it is widely accepted that the larger and more circular the area the bette,r as this reduces the area exposed to the 'edge effects' that degrade habitats (Woodroffe & Ginsberg, 1998). Based on this logic, being long and thin, Salakpra has an intrinsically suboptimal shape for a protected area. Moreover, it includes areas that are suboptimal for elephants, either because they are too steep or because they lack permanent water. The only sizeable area of optimal elephant habitat in Salakpra is the mineral rich bamboo-dominated basin of Thung Salakpra, the southern core of the sanctuary. However, this area is vulnerable to human impacts because its eastern side is so easily accessible. Consequently, there is persistent competition between people and elephants for the natural resources of this area.

Summary of rationale for study

- *To safeguard Salakpra's elephants it is necessary to maintain connectivity to the rest of WEFCOM and to protect large areas of high quality elephant habitat within Salakpra.*
- *Salakpra includes large areas that elephants cannot use either because they are not suited to elephants or because elephants have been excluded from them by human encroachment.*
- *The only sizable area of optimal elephant habitat in the whole of Salakpra is the mineral rich, bamboo dominated forest of Thung Salakpra, the southern core of Salakpra WS.*

2.2. HEC and HECx

The International Union for Conservation of Nature (IUCN) defines HEC broadly as:

> *Any human-elephant interaction which results in negative effects on human social, economic or cultural life, on elephant conservation or on* the *environment.* (Hoare, 2001).

Competition between people and elephants over space and resources is not new. In Asia, it has been documented for centuries. However, it is now increasing in severity and frequency (Sukumar, 2003). HEC may affect people both directly and indirectly. Direct effects include crop loss or damage, damage to property, human injury or death, and indirect effects include impinging freedom of movement and inhibiting collection of resources (Parker, *et al*., 2007) as well as impacts on human wellbeing, including mental health (Jadhav & Barua, 2012). The full impact of HEC on elephants is little understood but, like people, elephants are affected directly through loss of food and suitable habitat, exposure to injury, intentional or unintentional killing, and indirectly through the inhibition of movement and elevation of stress (Ahlering, *et al*., 2010).

○ *Crop raiding*

Crop raiding is the most prevalent form of HEC in Thailand but the terms 'crop raiding' and 'HEC' are often used synonymously, causing some confusion (Hedges & Gunayardi, 2009). Crop raiding is both a symptom of HEC and an example of it because it indicates that a wild elephant population is under pressure. Compared to other kinds of HEC such as the impacts of regular disturbance on long-term physical and mental health, crop-raiding is relatively easy to measure quantitatively.

Elephants raid crops because eating cultivated plants rather than wild food is an efficient way to forage: crops have a superior nutritive content and are grown in concentrated areas (Sukumar, 1990). Crop raiding behaviour is complex and is not necessarily caused by the close proximity of elephants and human settlement. Raiding occurs when natural sources of food are scarce (Fernando, *et al*., 2005). Studies suggest that if enough forest patches are interspersed within landscapes shared with people, crop raiding may not happen. This indicates that a critical threshold of habitat fragmentation must be reached before crop raiding occurs and HEC becomes a problem (Rood, *et al*., 2008; Chartier, *et al*., 2011). Elevated levels of stress hormone detected in crop-raiding elephants also indicate that it is not a preferential habit for elephants (Ahlering, *et al.*, 2010). Wherever people encroach into habitat still used by elephants, HEC occurs (map 3).

Map 3: Elephant and HEC distribution in Thailand (map courtesy of WCS-Thailand)

○ *Crop raiding in Salakpra*

In 1982, Salakpra was the first place in Thailand to record HEC in the form of crop raiding and remains at the frontline for HEC in Thailand. The first incident of crop raiding occurred in a relocated settlement due west of the wildlife sanctuary soon after the Srinakarin reservoir filled, thus blocking the elephant route across the river. From the 1980s to the mid-1990s, crop raiding occurred mostly in fields on the western side of Salakpra. The first crop raiding event due south of the sanctuary was recorded in 1990 in sugarcane fields, soon after the government introduced a sugar production subsidy. In 1999, the first raid occurred due east of the sanctuary (ECN, 2008b). ECN has been monitoring crop raiding in the Salakpra area since 2006. In the last six years, the most marked change has been the increase in crop raiding due east of the sanctuary, the target area of this study.

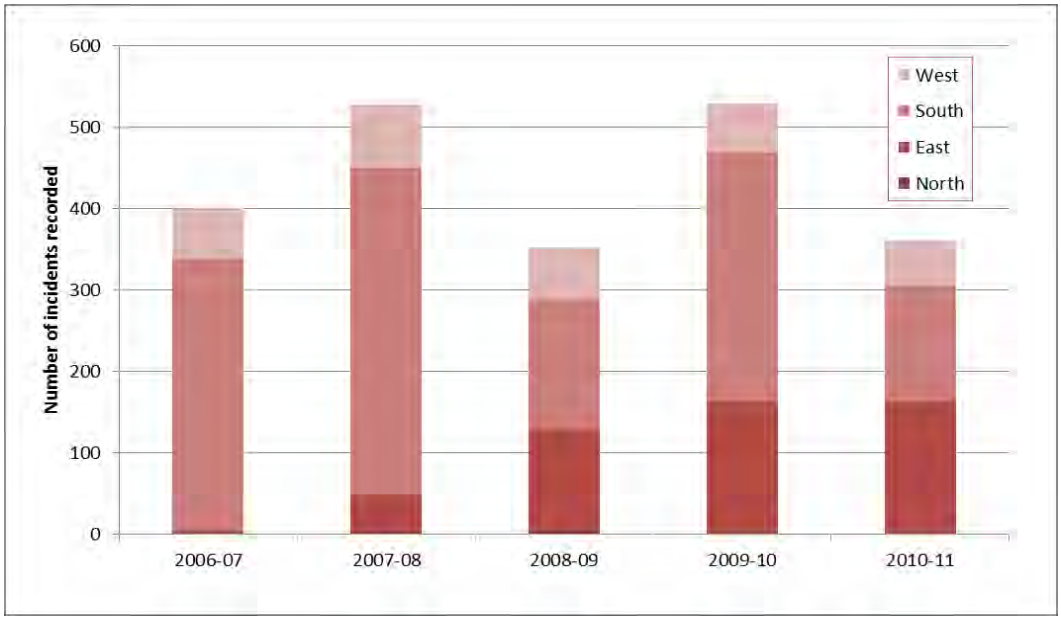


Figure 4: Incidents of crop raiding 2006 – 2011 in Salakpra by location

Crop raiding on the east side of Salakpra was less frequent and less intense than crop raiding due west and south/south-west of the WS (Sirisambhand & Stewart-Cox, 2007). However in the years that ECN has monitored crop raiding, the proportion occurring in the east has increased dramatically from 0.3% in 2006-07 to 43% in 2010-11. Over this 5-year period, the east had 20% of all crop-raids recorded (see Figure 4). The highest losses hit the large scale sugarcane farmers who dominate this area. Small scale farms are raided much less often because they grow a combination of crops interspersing fruit trees that elephants favour with crops they do not like (Ritthirat, 2008). However despite being raided less often, small scale farmers are more vulnerable if their crops are raided because the losses are proportionately greater. Until recently, farmers living due north of Salakpra (originally Karen people) either did not experience crop-raiding or did not report it.

○ *Human Elephant Coexistence (HECx)*

The escalation of HEC in all elephant range states has led to recognition amongst those concerned of a need to strike a balance so that people and elephants can coexist in the short and long term (Desai, 2006). The detrimental impact of HEC on local people fosters negative sentiments towards elephants, their conservation, the designation of protected areas and biodiversity conservation efforts in general (O'Connell-Rodwell, *et al*., 2000; Venkakaraman, *et al*., 2002; Sukumar, 2003;

Nyhus & Tilson, 2004; Naughton-Treves & Treves, 2005; Parker, *et al*., 2007). Human-elephant coexistence (HECx) is an approach to reducing HEC through an increased understanding of elephants' needs for space and resources together with community involvement in conservation decision-making (Stewart-Cox, 2010). Raising elephant awareness and involving local people in conservation decision-making can alleviate animosity towards elephant conservation efforts and is recommended for all stakeholders living near elephants in Thailand (Srikrachang, 2003). ECN's HECx programme has been working with stakeholders around Salakpra since 2010. More details on this programme are provided in the section below.

2.3. Past and current work by ECN (1999-2011)

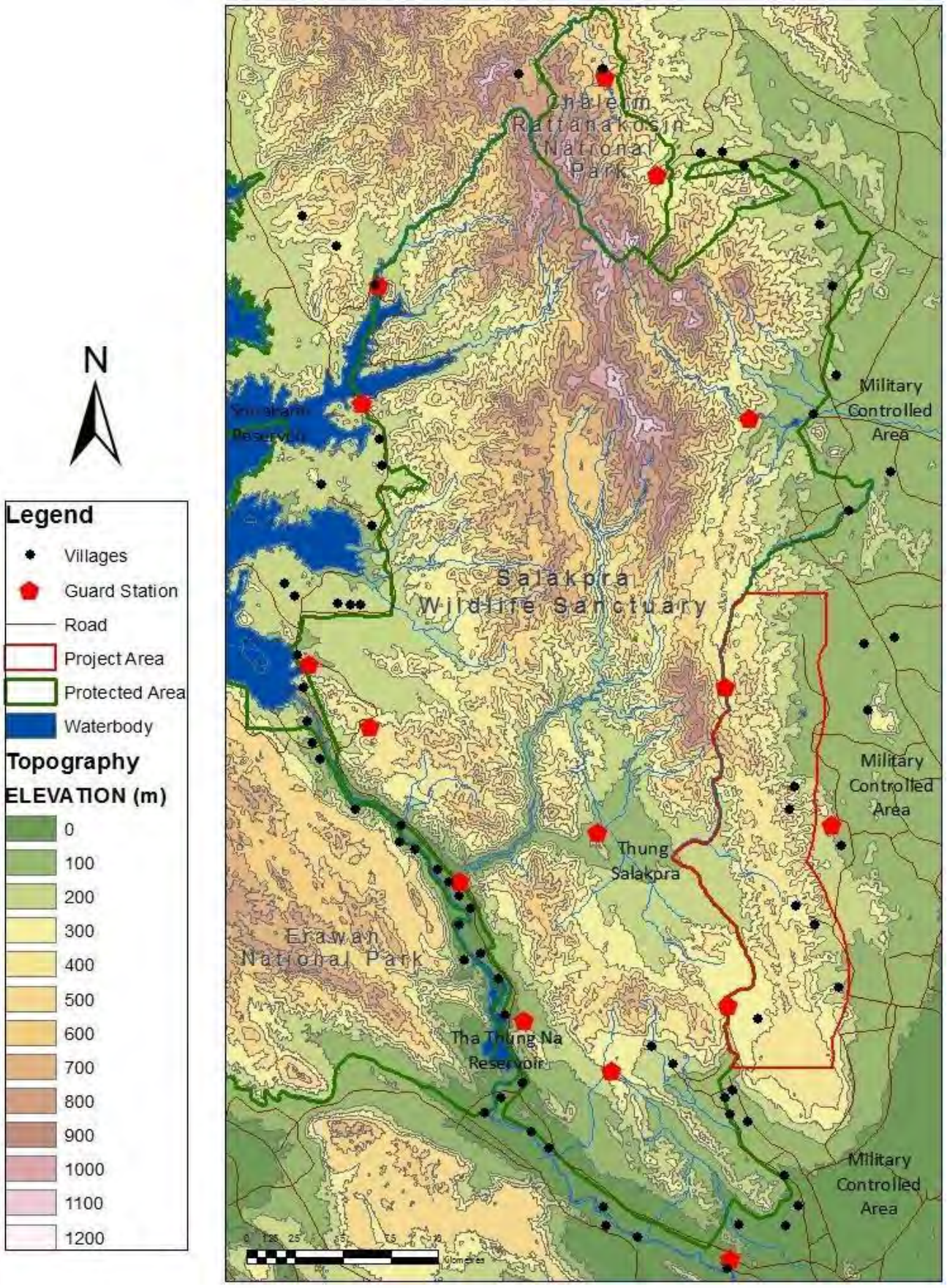
From 1999-2002, ECN carried out two surveys with rangers and villagers in WEFCOM, the first to find out where HEC was most intense (answer: Salakpra), the second to quantify the problem in and around Salakpra. These surveys under-pin ECN's commitment to finding sustainable solutions to human-elephant conflict. ECN's aim is to focus on Salakpra, testing different approaches to HEC mitigation, and then share lessons learned more widely in Kanchanaburi province (which contains half of WEFCOM), and elsewhere in Thailand. ECN's approach, since 2005, has been highly collaborative, each project emerging from the findings and feedback of previous projects. Decisions are made with local associates such as PA personnel, community leaders, villagers, and local non-governmental organisations (NGOs). Projects to date have been divided into two core programme areas, each with a geographical association inside and around protected areas. Projects that are relevant to this study include:

a) Elephant ecosystem conservation & protection programme

- *Salakpra forest survey* (2005-7): revealed the nature and scale of human impacts on elephants inside the conservation area and spawned an alternative livelihood, community forest restoration, and a smart patrol project.
- *Srisawat corridor surveys* (2007 + 2011 – 2012): the first survey persuaded the government to incorporate around 200 km^2 of poorly protected reserve forest into adjacent PAs. ECN's report on the second stage of surveys is forthcoming and aims to help identify wildlife corridors from Salakpra WS and Chalerm Rattanakosin NP to Huai Kha Khaeng in need of special protection.
- *Forest protection with smart patrols* (2010-ongoing): this project started with the Salakpra team and has now expanded to Chalerm Rattanakosin NP. Data from these patrols should reveal whether human impacts on the PAs are reducing, increasing or staying the same.

b) Human-elephant co-existence facilitation programme

- *HEC monitoring & mitigation* (2006-ongoing): provides data needed to know if interventions are reducing elephant impacts on people and/or changing elephant and farmer behaviour.
- *Study of alternative cattle management options* (2010-11): this project collected data to better understand the scale and conservation impact of the cattle problem in Salakpra, and proposed recommendations to help address the major conservation concerns. ECN is now trying to secure funding to implement these recommendations.
- *HEC-2-HECx awareness-raising* (2010-ongoing): this includes ECN's Arts-4-Elephants project (an Elephant Day initiative to create a Thai-English storybook) and an HECx training of trainers project modelled on the successful teaching package pioneered by ZOO-India.



Map 4: Salakpra WS with project survey area marked in red on eastern side.

2.4. Rationale for the survey

Salakpra supports an important population of Thailand's wild elephants (representing 17.5% of those inhabiting WEFCOM. In order to ensure the survival of these elephants, reduce crop-raiding and other forms of HEC, and support ECN's HECx programme, it is important to know the distribution of elephants, their habitat associations and the threats to them in and around Salakpra. The strip of unprotected forest beyond the south-east boundary of Salakpra acts as a natural buffer to the biodiversity rich but physically vulnerable core of the sanctuary. We know that crop-raiding has increased dramatically near this area which suggests that elephants in southern Salakpra may be under more pressure to meet their resource needs than they were before.

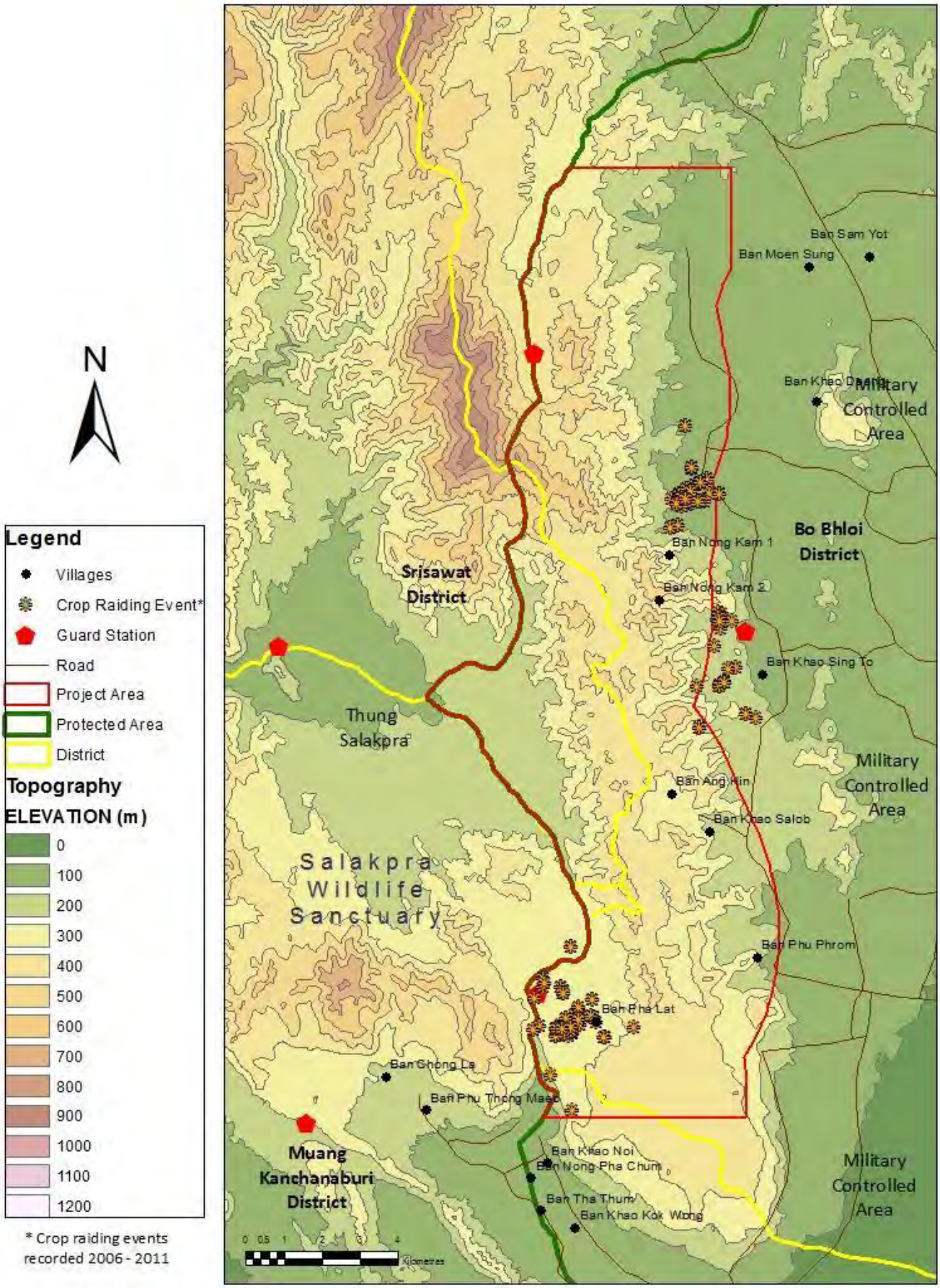
2.5. Profile of the survey area

The survey area is a tract of land adjoining the south-eastern boundary of Salakpra which belongs to the Treasury Department, but is under the control of the Royal Thai Army's (RTA) 9th Division (see Map 4). Although it lies outside the Wildlife Sanctuary, it has more-or-less continuous forest cover extending from the elephant range inside the sanctuary. During ECN's 1999-2000 interview surveys, villagers were asked to map the elephant range known to them. These maps include the survey area. The habitat suitability assessment done as part of that survey also included the survey area as highly suitable elephant habitat (Stewart-Cox, *et al.*, 2001). The survey area forms a natural buffer to the southern core of Salakpra, a lowland basin known as Thung Salakpra that is dotted with springs and mineral licks favoured by many wildlife species including elephants.

The survey area spans three districts (*amphoe*) and covers five sub-districts (*tambon*). Most of it lies within Bo Phloi district, including the villages of Khao Daeng, Khao Singto and Salob, but the strip closest to Thung Salakpra is in Sri Sawat district which has no villages. The south-west corner of the survey zone is in Muang Kanchanaburi district and this includes the village Ban Khao Noi and its extension Ban Pha Lat (see Map 5). The only forest that survives in the survey area is a strip of land 5km wide adjoining Salakpra along its south-east boundary.

○ *The area around the survey area*

The wider area east of Salakpra was first settled around 50 years ago by people from Tha Muang district in eastern Kanchanaburi province. Since then, most lowland forest has been cleared for settlement and agriculture and is now characterised by extensive tracts of monoculture crops, especially sugarcane, interspersed with smaller farming households growing a mix of cash crops (sugarcane, cassava, maize, and tobacco) (Sirisambhand & Stewart-Cox, 2007). Comparing areas within 2km of the boundary around Salakpra, the eastern side has undergone the highest level of conversion from natural forest to agricultural land in recent years, accounting for 51% of the total land conversion from 1997-2002, and 40% of the conversion from 2002-2007. Over the 15 years from 1992-2007, this eastern area accounts for 44% of total land clearance, presumably because of the easy availability of land suitable for agriculture (especially sugarcane) compared to other areas around the sanctuary which were already settled (Ritthirat, 2008).



Map 5: Close-up of survey area

3. Survey Profile

3.1. Aims

a) Investigate the conservation value of the forest area adjoining the south-eastern boundary of Salakpra WS.
b) Consider the feasibility of upgrading the status of this area in order to improve the shape and conservation integrity of Thung Salakpra for elephants and other wildlife.

3.2. Objectives

a) Record the presence/absence of elephants and other wildlife with associated habitat and human activities in the survey area.
b) Link project findings to crop-raiding and land use data and highlight any causal associations and environmental pressures.

3.3. Survey Design

Within the survey area east of Salakpra WS, we selected a 25 km long strip that encompasses sites affected by crop-raiding as well as areas of surviving forest. The northern and southern limits were defined by the location of settlements and areas entirely cleared for agriculture. We used Google Earth 6 (Google, 2011) remote sensing imagery to estimate the extent of forest cover, and thus possible elephant habitat and, on the basis of this we designated a 5km wide 'buffer' zone, plotting it onto the 1:50,000 base map using ArcGIS 10 (ESRI, 2011). After delineating the survey area, we determined 1km strip transects within four survey zones based on the area's natural features, accessibility from the Salakpra guard stations, and proximity to villages and crop-raided locations (see Figure 5). The four survey zones were surveyed from south to north because this was the easiest way to access them. They are listed below in the order they were surveyed:

(i) *Zone 1 – Pha Lad*: the southernmost area of the survey zone on a plateau at 300-400m altitude. Characterised by a mix of agriculture and forest, this zone encompasses the village of Pha Lat where crop raiding occurs.

(ii) *Zone 2 – Salakpra Paak Nok Kaew (Salakpra PNK)*: the central area adjacent to Thung Salakpra, the southern core of the Ssanctuary. The WS border follows a stream which forms a distinctive beak-like shape, carving out an area that is known as *Paak Nok Kaew* (the parrot's beak). This area is, in fact, a natural extension of Thung Salakpra. It is characterised by mixed deciduous and bamboo forest and has no human settlements.

(iii) *Zone 3 – Salob*: this zone is in the central part of the survey area further from the WS border. It is a mix of mixed deciduous and bamboo dominated forest that is being encroached by clearings for agriculture and cattle. It is adjacent to the villages of Salob, Khao Singto and Khao Daeng which experience high levels of crop raiding.

(iv) *Zone 4 – Chong Pratu*: the northern part of the survey area. It is characterised by steep slopes, dry dipterocarp forest and no permanent water.

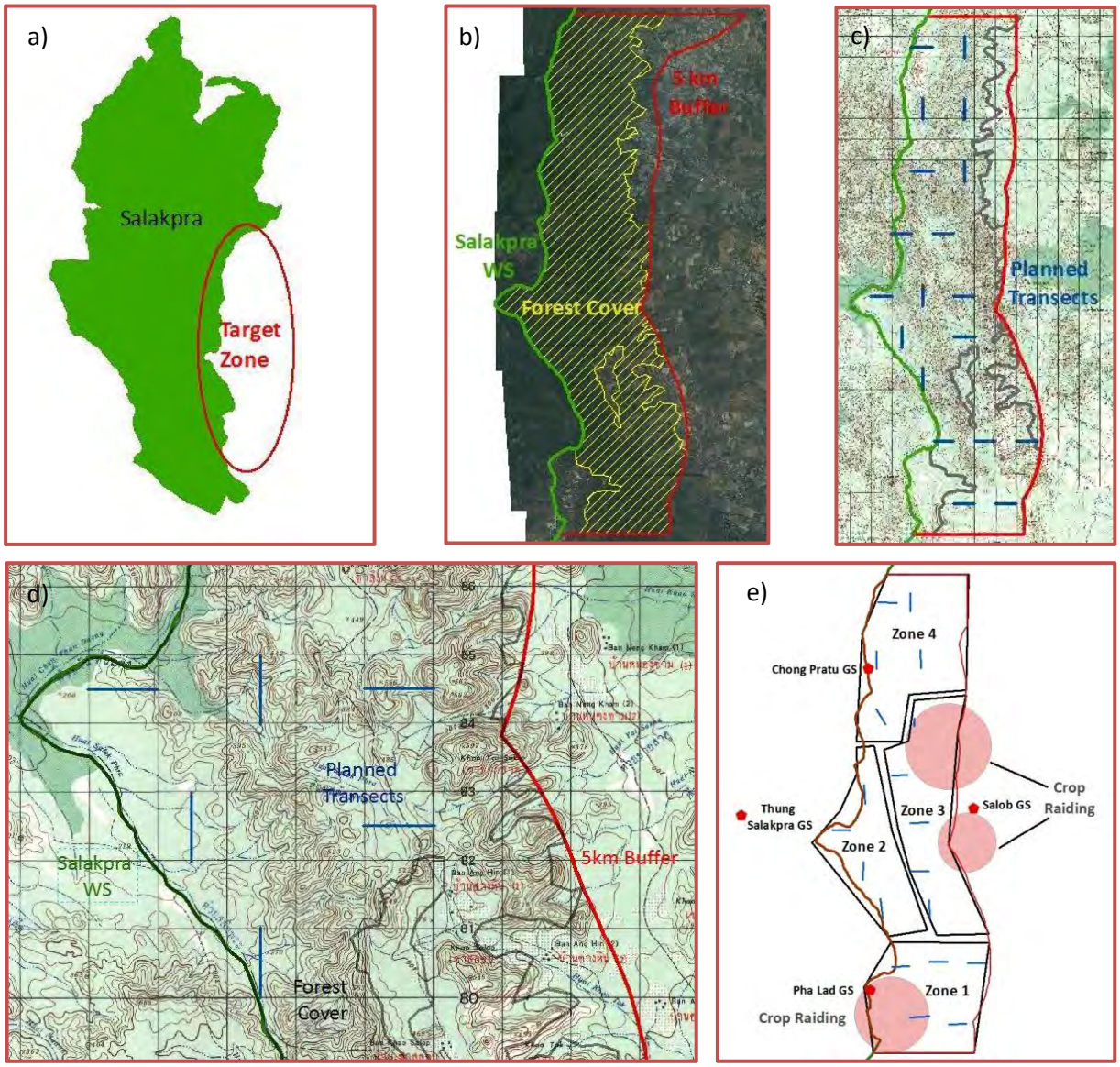


Figure 5: The study area: planning the survey, step-by-step; a) the target zone; b) using remote sensing imagery to identify the area still covered by forest within the target 5km buffer; c) planning transects on 1:50,000 maps; d) detail of the 1:50,000 map plan; e) the four survey zones with areas of crop raiding intensity highlighted.

3.4. Supplementary aerial survey

At the end of the survey period, we were given the opportunity to try aerial surveying using a two person paramotor. Paramotors are motorized paragliders, also known as ultra-lights, which fly at low speeds. Because they fly slow and low over the landscape, they provide unobstructed views and are useful for doing certain kinds of aerial surveys. In late March 2011, we spent two days flying a paramotor over the survey zone to take aerial photographs. Paramotor flying requires an open area for take-off and landing and the flight path must not go beyond the safe distance for gliding down to land if the engine fails. It is therefore not possible to fly over continuous forest cover, such as the interior of Salakpra WS. But it is suitable for flights over forest edges and disturbed habitats in open, flat areas with regular clearings. A significant proportion of the survey area is like this.

We chose to fly over Zones 1 and 3 because they were accessible and because they were the zones with the most overlap between human and elephant activity. We planned flight paths to cover as many of the transects in these zones as possible so that we could take aerial photographs to supplement the survey data and provide additional evidence of forest cover and land use change (see Figure 6). The transect waypoints were loaded on to a Garmin 60 GPS and the flight tracklogs were later used to georeference the photographs taken during the flight using the Geotag software program (Geotag, 2011).

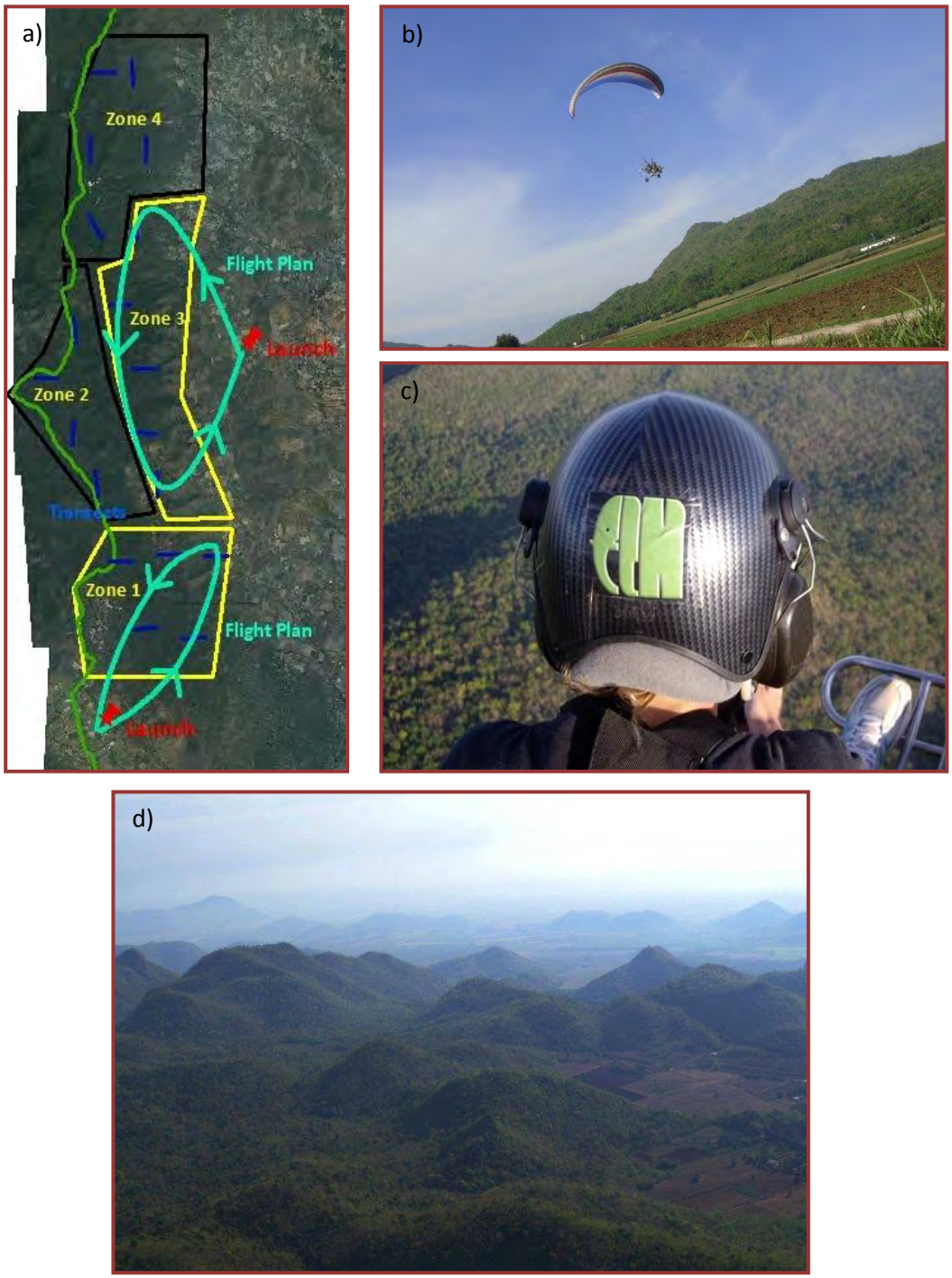


Figure 6: The aerial survey: a) planning the flight paths; b) the paramotor taking off; c) taking aerial photographs; d) aerial view over Zone 1.

3.5. Survey methods

The survey was based on the Recce-Survey-Transect (RST) method approved for the Monitoring the Illegal Killing of Elephants (MIKE) programme (Hedges & Lawson, 2006) and adapted by ECN for other forest surveys (Wacher, 2006; ECN, 2007; ECN, 2008a). An optimal number of 1km-long 10-metre strip-transects was planned using a 1:50,000 topographical map to maximise coverage of areas likely to be used by elephants in the target zone (see Figure 5). A combination of reconnaissance walks and planned line transects allows for more data to be collected than using line transects alone (Walsh & White, 1999). So, when possible, we collected data on the way to, from and in between transects using the recce walk methodology along 'paths of least resistance' (White & Edwards, 2000).

A team of 4-7 people walked the survey routes, with 3-5 local rangers and villagers joining two ECN project staff. The survey team walked each route on foot using existing tracks and trails to locate the start point of the designated transects. If we encountered a logistical or topographical barrier to the mapped transect, we altered the transect route accordingly. We used a Garmin 60 GPS to record the start and end point of each recce walk and each transect.

3.6. Data collected

The primary data recorded were elephant signs and indications of human activity. We also recorded signs of other wildlife and significant natural features. A GPS measurement was recorded for each data point collected and we noted the habitat type in which it occurred on a standardised data form (see Appendix I).

3.6.1. Elephant signs

Elephant signs were recorded as evidence of their presence and of their association with a particular habitat. Dung was the main sign recorded for elephant abundance calculations (see figure 7).

Figure 7: Elephant dung being measured and classified according to ECN's elephant dung age classification system (see Appendix II): a) fresh dung in stage D1; b) fresh calf dung, stage D1; c) dung stage D3; d) measuring elephant dung; e) disintegrated dung, stage D6; f) dry dung eaten by termites, stage D5.

Other signs of elephants such as footprints, vegetation damaged by elephants feeding, tusk marks, scrapes in mineral licks and marks made by elephants rubbing against trees or rocks were also recorded (see Figure 8). We took measurements of elephant dung and footprints to estimate the individual's age. The age of elephant dung was recorded using ECN's elephant dung age classification system to determine the approximate time elapsed since dung deposition (see Appendix II).

Figure 8: Elephant signs: a) mud marks where an elephant has rubbed against a tree; b) tusk marks on a tree; c) bamboo broken by an elephant feeding; d) footprints of an adult and calf on a dusty road; e) a salt lick used by elephants; f) footprint of an adult; g) tree bark of *Bauhinia racemosa* stripped by an elephant; h) a rock rubbed smooth by elephants.

3.6.2. Human activities

The team recorded key signs of human presence and activity in the survey area, such as agricultural activities, land clearance, livestock farming, logging, bamboo cutting, fires, hunting, rubbish left behind, foot trails, and vehicle tracks (see Figure 9 and Figure 10). The data collection form is included as Appendix I.

Figure 9: Human activities involving land clearance and agriculture: a-c) markings made by people to demarcate land they intend to clear; d) area burned for agriculture; e) smallholding in the forest with a charcoal pit in use; f) spikey bamboo fence around a smallholding; g) cattle graze in a forest clearing.

Figure 10: Human activities in the forest: a-c) logging; d) bamboo cutter's hut; e-f) stems of cut bamboo that will be sold and the 'top & tail' trimmings left behind; g) charcoal pit; h) human-lit scrub fire and leftovers of cut bamboo; i) white-rumped shama (*Copsychus malabaricus*) caught in a mist net ; j) '*pak waan*' (*Melientha suavis*) wild forest vegetable collected in the forest; k) litter left in the forest.

3.6.3. Other wildlife

While the primary focus was to record elephant and human signs, the team also used the opportunity to document other wildlife signs (see Figure 11). To gain a better understanding of other species present in the area. The signs included sightings, faeces and tracks.

Figure 11: Wildlife signs: a) oriental whip-snake (*Ahaetulla prasina*); b) jungle fowl (*Gallus gallus*) eggs; c) jackal scat (*Canis aureus*); d) Sunda pangolin scat (*Manis javanica*); e) serow (*Capricornis sumatraensis*) droppings; f) barking deer (*Muntiacus muntjak*) droppings; g) animal burrow; h) civet scat; i) a wild pig (*Sus scrofa*) track; j) sambar deer droppings (*Rusa unicolor*).

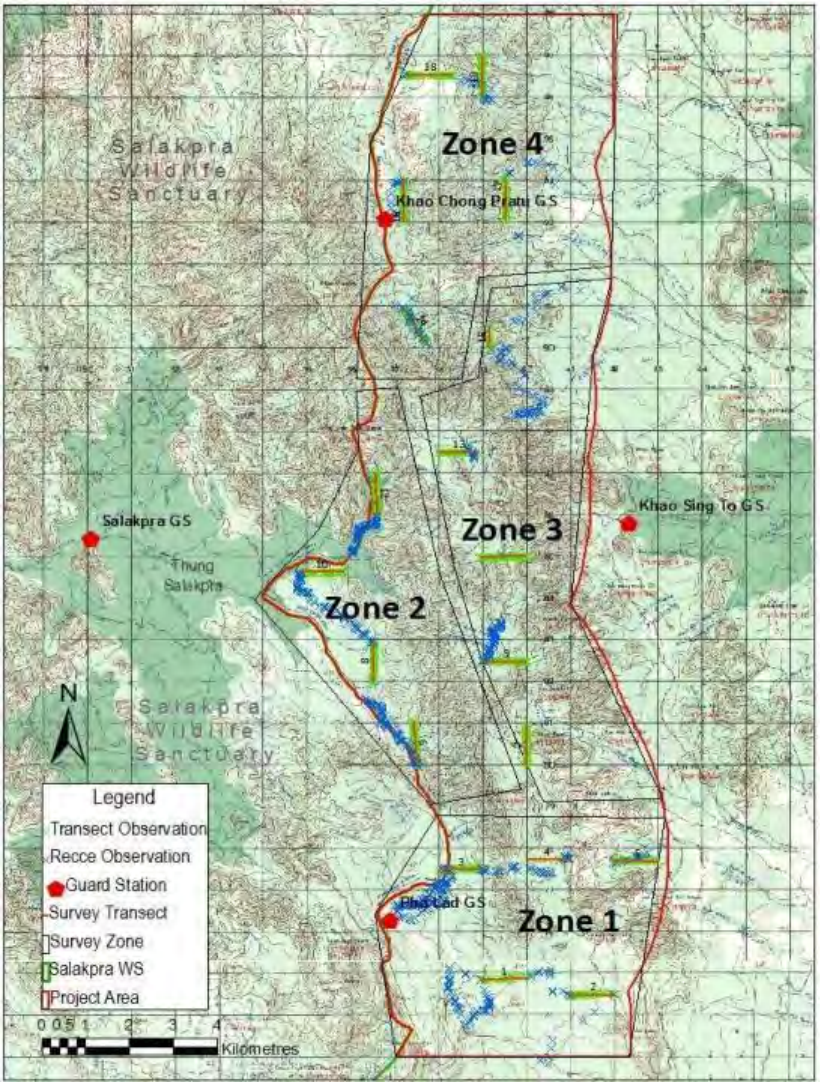
3.7. Analysis methods

Relative abundance: Encounter rates were used to calculate relative abundance per kilometre for elephant, human activity and other wildlife signs. The encounter rates are presented as a mean, a standard deviation, and as a range for each survey zone. The distance walked on each survey was calculated from the GPS waypoints using ArcGIS 10. The data collected walking to and from the transects in each survey zone is included as recce data which was analysed both separately and together with the transect data.

Human impacts: Human activity data was analysed both as a whole and as separate activities, and the activities were mapped by geographical distribution, and by intensity to help assess their effect on elephant distribution.

Influences on elephant distribution: Human and natural variables influencing elephant distribution were examined by using:

- Correlation matrices to identify significant correlations between elephants and other variables.
- Linear regressions to identify the strength of the associations between the variables.



Map 6: Survey zones and transects on the 1:50,000 map with transect and recce observations marked.

4. Results

The survey area covered a total of 142 km^2. Within this area, we recorded data on 19km of transect and 56km of recce walk. The survey team walked or accessed these routes by motorcycle depending on the terrain and accessibility (see Map 6).

4.1. Elephant signs

4.1.1. Elephant encounter rates

We recorded elephant signs on 50% of all transects, these transects were located in the central and southern locations of the study area (See Figure 12). The number of elephant signs per kilometre on transects where elephants were detected ranged from 4 to 77. Dung accounted for 57% of the elephant sign recorded on transects, and was always encountered on transects where elephant signs were recorded. Elephants were also recorded on recce routes to and from transects and the recce and transect data together shows elephants recorded on or around 64% of transects (see Map 7 and Figure 12). This indicates that elephant distribution in this area includes, and is larger than, the elephant ranges mapped from interview surveys in 1999/2000 (Stewart-Cox, *et al.*, 2001).

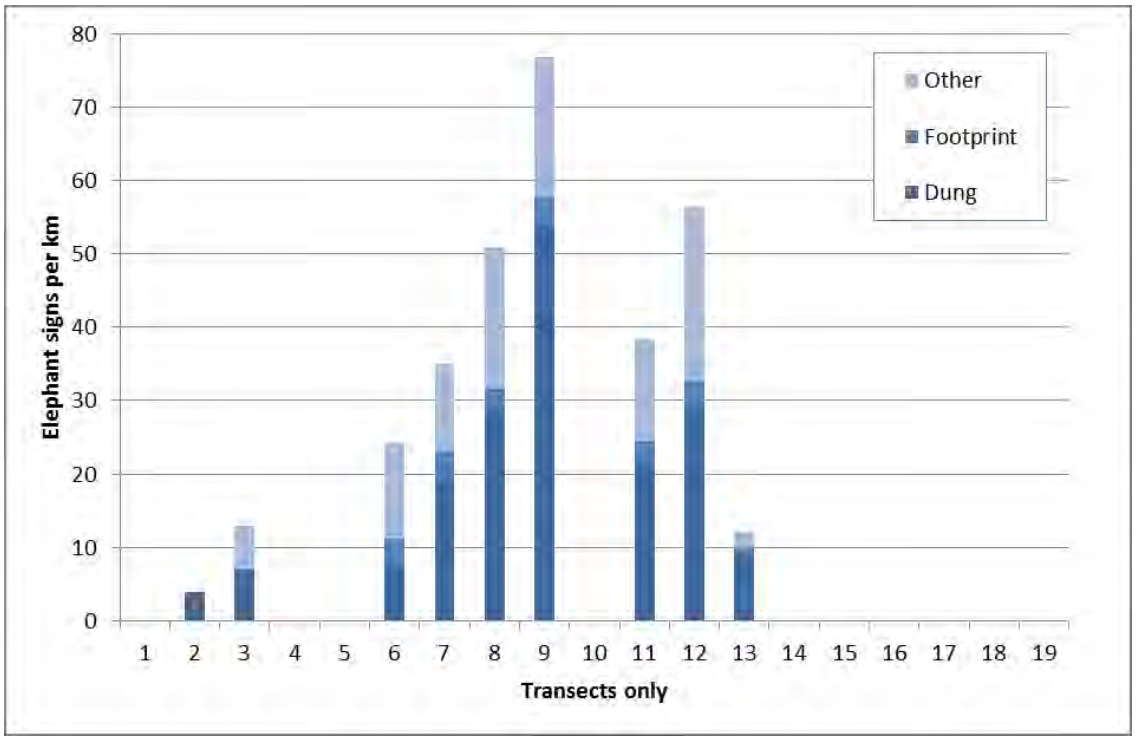


Figure 12: Elephant signs recorded on transects only

Table 1: Dung encounter rates per km recorded on transects

Area	Mean encounter rate	Standard Deviation	Range
Whole survey zone (19 transects)	9.7	14.7	0-53.8
Elephant area of survey zone (13 transects)	13.8	16.1	0-53.8

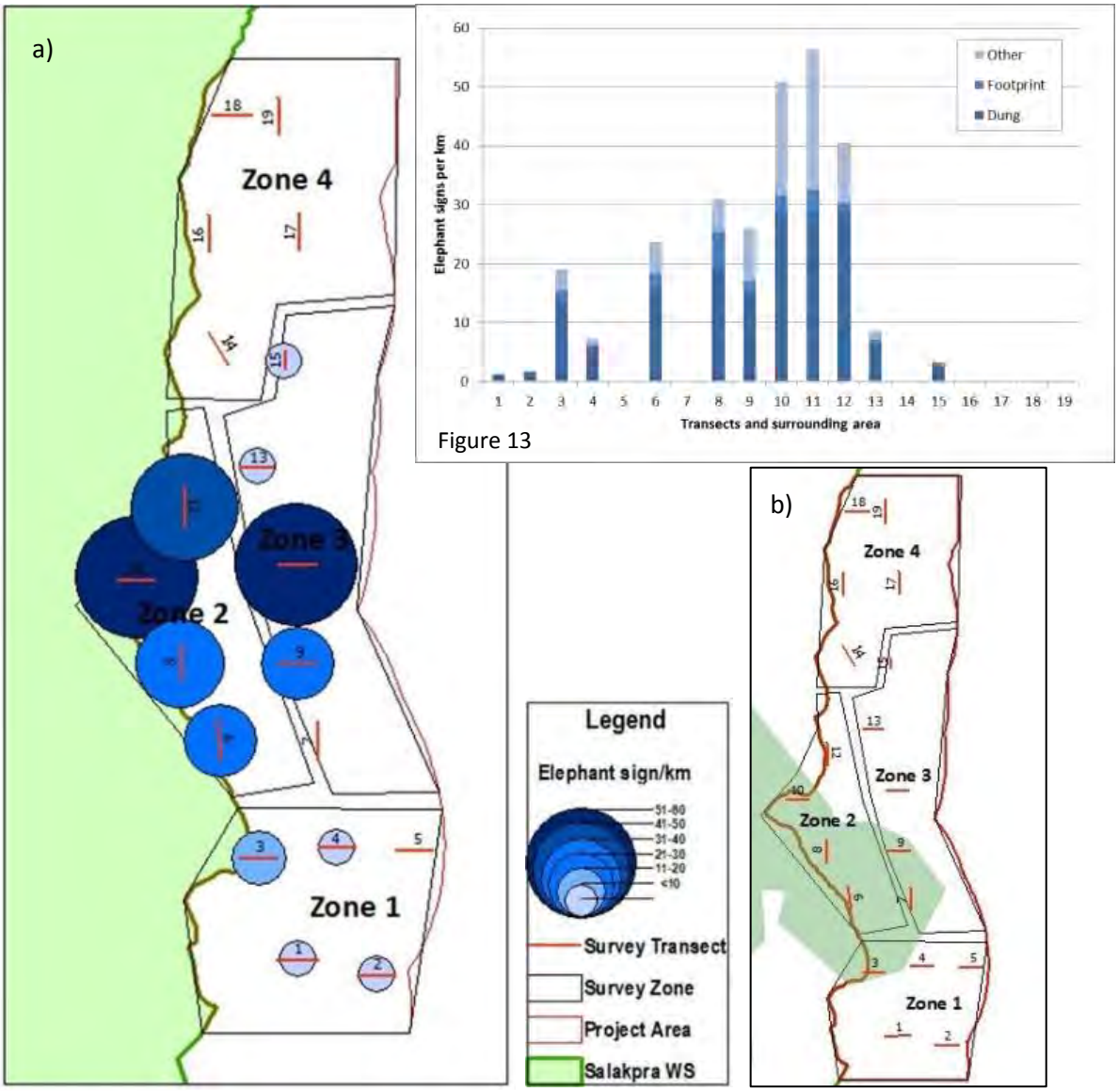


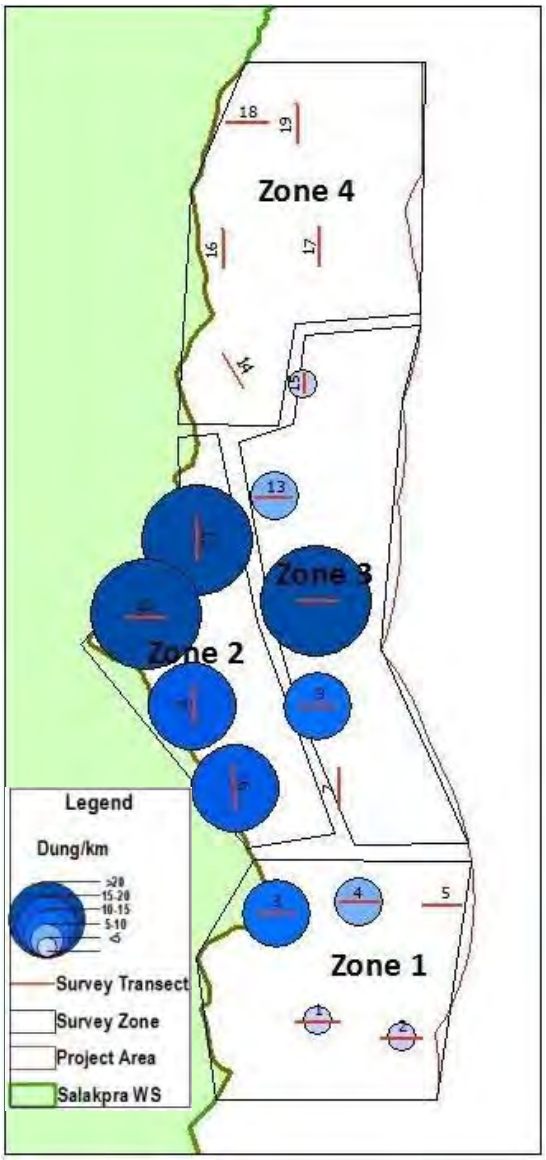
Figure 13

Map 7: a) map of elephant sign recorded on and around each transect on recce routes and transect strips per km; b) map of the previously estimated elephant range from ECN's interview survey in 2000, shaded in green (Stewart-Cox, et al., 2001).

Figure 13: Elephant signs recorded per kilometre during this survey on and around each transect

Table 2: Dung encounter rates per kilometre recorded on recces and transects in each survey zone

Survey Zone	Location	Mean Encounter Rate	Standard deviation	Range
1	Pha Lad	4.5	5.6	0.0-13.6
2	Salakpra PNK	21.8	6.5	15.8-28.8
3	Salob	7.0	11.6	0.0-28.7
4	Chong Pratu	0.0	0.0	0.0
Total	**7.6**	**10.8**	**0.0-28.8**	



Map 8: Map of Elephant dung recorded/km

We used the mean rate of dung detection per km as an indication of the relative abundance of elephants. The overall encounter rate was 9.7 dung piles per km. However, when we excluded the part of the survey area where elephants were not found, the encounter rate was 13.8 per km (see Table 1). These rates are within the range recorded on previous forest surveys undertaken by ECN inside Salakpra. The surveys inside the sanctuary noted encounter rates of 9.2 to 22.4 per km in the dry season of 2006/7 (ECN, 2008a) (see Appendix III). On this survey, signs were recorded at a higher rate on transects than on recce routes, possibly due to greater observer effort. Elephant signs decreased in frequency per km with distance from the WS boundary (see Figure 14).

The four survey zones had different dung encounter rates (see Table 2). Zone 2: *Salakpra PNK*, adjacent to the core of the WS, had the highest mean encounter rate at 21.8 (27.1/km when only counting transect data). Zone 3: *Salob* which is further from the WS boundary and closer to human settlements had 7 per km (13.4/km on transects). Zone 1: *Pha Lad*, the zone closest to concentrated human settlement, had the lower rate of 4.5 per km (2.1/km on transects) and Zone 4: *Chong Pratu*, the area with the steepest topography and no permanent water, had no elephant signs recorded at all.

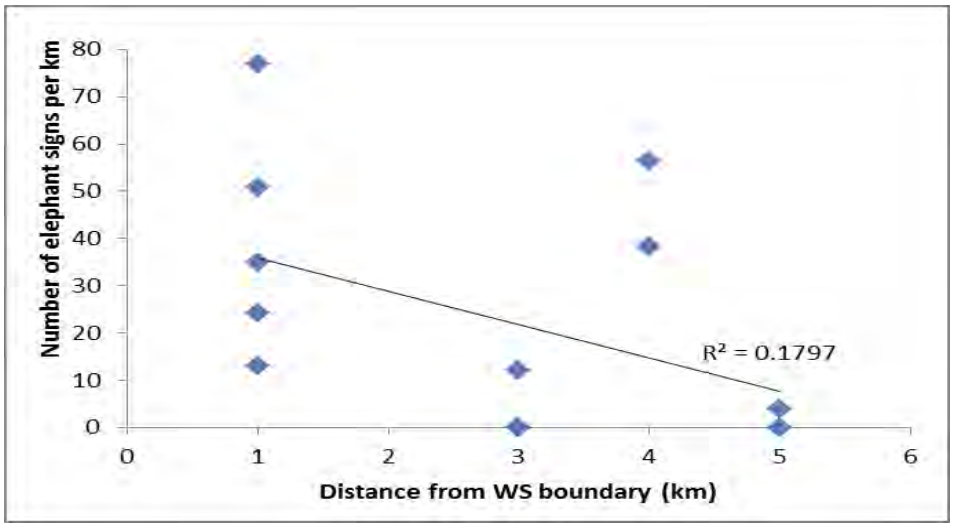


Figure 14: Elephant signs per km recorded on transects in the area where elephants were recorded

4.1.2. Elephant population structure

We measured and recorded the size of elephant dung encountered in order to get an idea of the demography of the elephant population in the survey area. Age classes were defined by dung bolus circumference (see Appendix II) and the data reveals 54% adult, 30% sub-adult, 15% juvenile with one calf (see Figure 15). This shows that the survey area is important for at least one breeding group as well as for individual bulls. Moreover, it is reasonable to assume that calves (under 1 year old) are under-represented in the sample because they rely on their mothers' milk for food rather than grazing, so they do not produce much dung, and the dung they do produce is small and protein rich and therefore degrades quickly. Our results give only a rough idea of population structure. A more extensive study using measures calibrated for the local population would provide more accuracy, but this data does reveal that the survey area outside Salakpra WS is used by both family groups and bulls. Footprints can also be used to estimate population structure. In this survey, only 11 footprints were clear enough to be measured and indicated elephants with a height at shoulder from 192 and 200 cm tall, i.e. adult elephants (Sukumar, 1989).

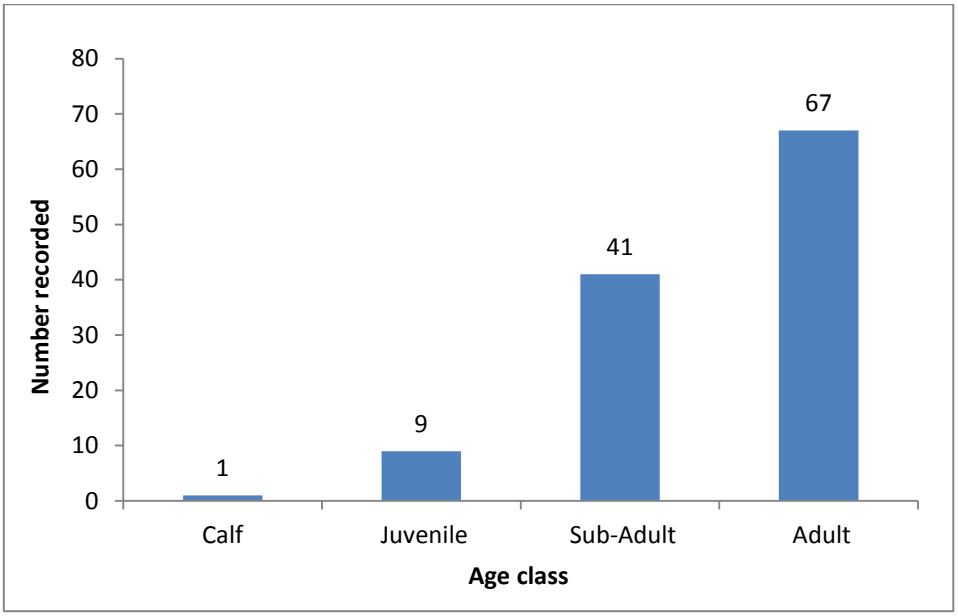


Figure 15: Age structure of the elephant population by dung sizes sampled in the survey area

Figure 16: Elephant calf signs: a) fresh elephant calf dung; b) elephant calf footprint.

4.1.3. Elephant dung age

We also recorded dung age (see Appendix II), finding dung samples of all age classes in most areas where signs of elephants were noted, indicating that this area is habitually used by elephants. We found very little fresh dung but that may simply be because we did this survey during the dry season when dung progresses quickly through the age categories, surviving as fresh or semi-fresh dung for only a few hours. However, dung dropped in the dry season survives longer than it does in the wet season because it is not washed away by rain or demolished by dung eating insects.

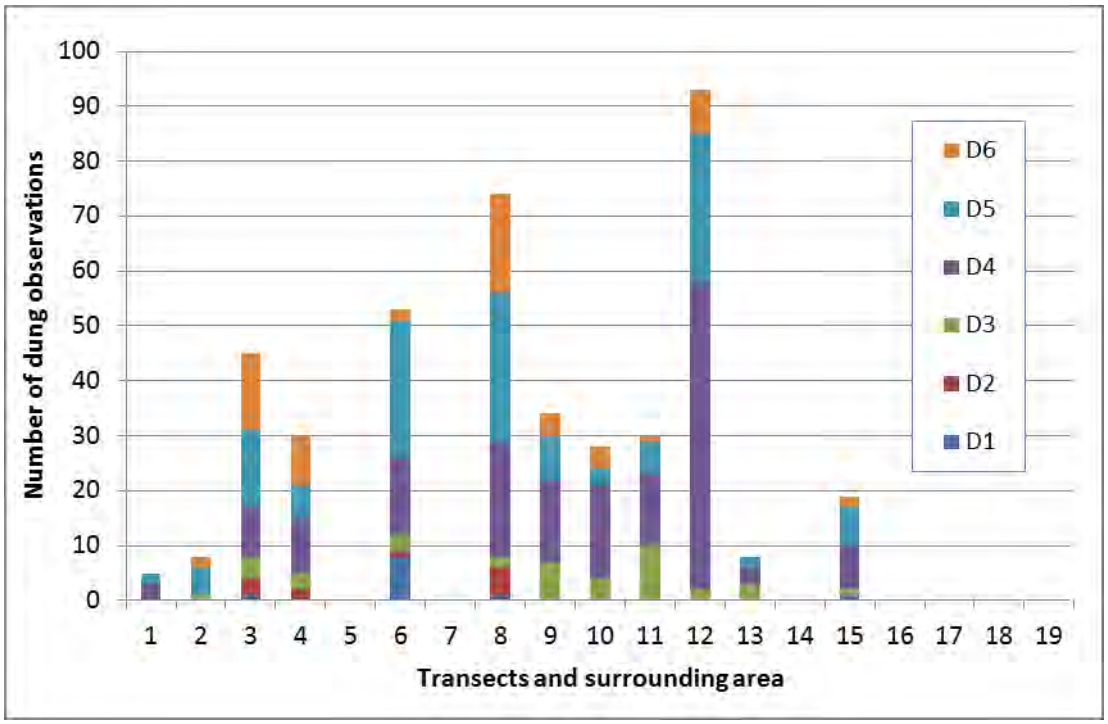


Figure 17: Dung age classes recorded by transect

Summary of elephant findings

- *The survey area is habitually used by elephants as part of their traditional range*
- *The elephant population density in this area is the same as it is inside Salakpra*
- *Elephants using the survey area include a breeding group with at least one calf*

4.2. Human activity signs

We encountered signs of human activity on all the survey routes and on every transect. The mean overall encounter rate was 18.9 signs per km. The mean encounter rate for transect data only was much higher at 41.2 signs per km. As with the elephant data, this is may be due to higher observer concentration and effort on transects. Human activities do not have the same spatial scale, e.g. a single observation of land clearance covers a larger area than a single observation of litter dropped. This variability is reflected in the different encounter rates found in each zone. The human activity encounter rate was lowest in Zone 2, Salakpra PNK, the area closest to the WS boundary. It is an area

with no human settlement. The other zones include areas further from the WS boundary with human settlements (see Figure 18 and Map 9). The area with the highest human activity encounter rate was zone 4, Chong Pratu, an area that is heavily used for resource extraction including logging and bamboo collection. This was also the survey zone where elephants were not recorded on transects.

Table 3: Signs of human activity per kilometre recorded on recces and transects in each survey zone

Survey Zone	Location	Mean Encounter Rate	Standard deviation	Range
1	Pha Lat	13.0	7.3	9.7-27.3
2	Salakpra PNK	5.7	3.2	3.1-9.6
3	Salob	26.8	29.9	3.7-81.3
4	Chong Pratu	32.5	23.2	10.5-73.9
	Total	**18.9**	**25.6**	**3.1-81.3**

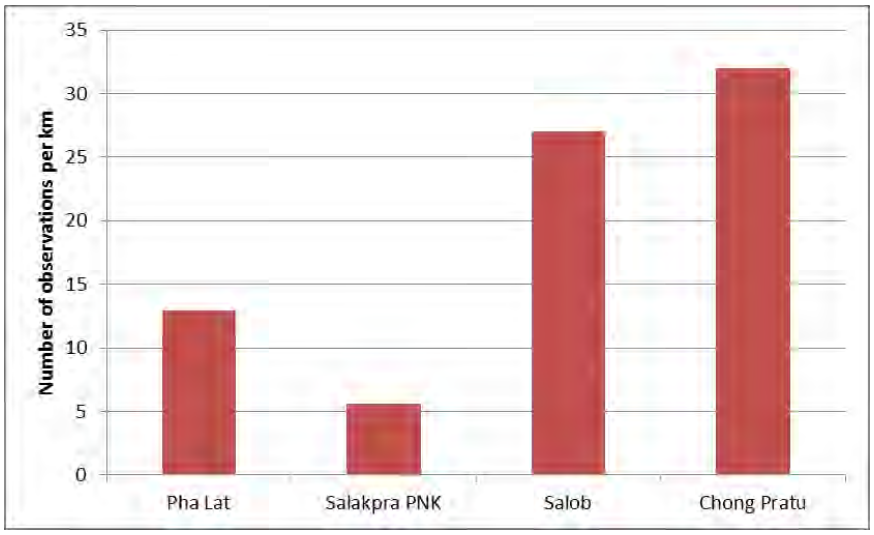


Figure 18: Incidence of human activities per km in each survey zone

Signs of 14 different human activities were seen in the survey area (see Table 4). The main human activities were bamboo collection (34% of all signs), logging (18.5%) and cattle (19.5%), all of which were higher than the equivalent rates found by ECN on earlier forest surveys inside Salakpra (Stewart-Cox, *et al.*, 2007; ECN, 2008a). Signs of other activities were at much lower frequencies and included vehicle tracks, rubbish 6%, charcoal production, non-timber forest product (NTFP) collection, agriculture, fire, land clearance, foot trails, and 'people doing other things' (a category for miscellaneous activities not included in the other categories). These findings are comparable with data collected within the WS. We saw evidence of hunting but the rate (0.4%) was much lower rate than that recorded during the Salakpra forest surveys undertaken by ECN in 2007 (ECN, 2008a). This is either because hunting signs are hard to see, or because the survey period was not the main hunting season, but the most likely reason is that prey numbers in this area are much diminished after years of hunting pressure.

Table 4: Incidents of recorded human activities inside the survey zones

Activity	Pha Lad		Salakpra PNK		Salob		Chong Pratu		Total Survey Zone	
	No.	%	No.	%	No.	%	No.	%	No.	%
Hunting	2	0.8	1	1.5	0	0.0	1	0.3	4	0.4
Bamboo Collection	58	22.9	27	41.5	116	33.3	158	40.5	359	34.0
Logging	41	16.2	10	15.4	47	13.5	97	24.9	195	18.5
Cattle	39	15.4	8	12.3	96	27.6	63	16.2	206	19.5
Rubbish	17	6.7	5	7.7	19	5.5	22	5.6	63	6.0
Fire	11	4.3	2	3.1	17	4.9	1	0.3	31	2.9
People doing other things	19	7.5	1	1.6	8	2.3	1	0.3	29	2.8
Charcoal	5	2.0	0	0.0	4	1.1	0	0.0	9	0.9
Agricultural activity	28	11.1	0	0.0	7	2.0	1	0.3	36	3.4
Land clearance	6	2.4	0	0.0	0	0.0	0	0.0	6	0.6
NTFP	1	0.4	0	0.0	0	0.0	11	2.8	12	1.1
Vehicle track (new)	19	7.5	3	4.6	30	8.6	16	4.1	68	6.4
Vehicle track (old)	2	0.8	2	3.1	1	0.3	1	0.3	6	0.6
Foot trail	5	2.0	5	7.7	6	1.7	12	3.1	28	2.7
Total	**253**	**100**	**64**	**100**	**351**	**100**	**384**	**100**	**1052**	**100**

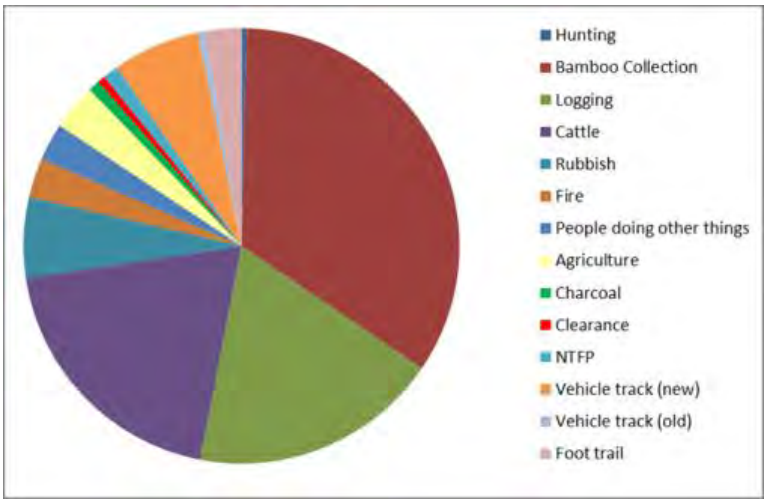
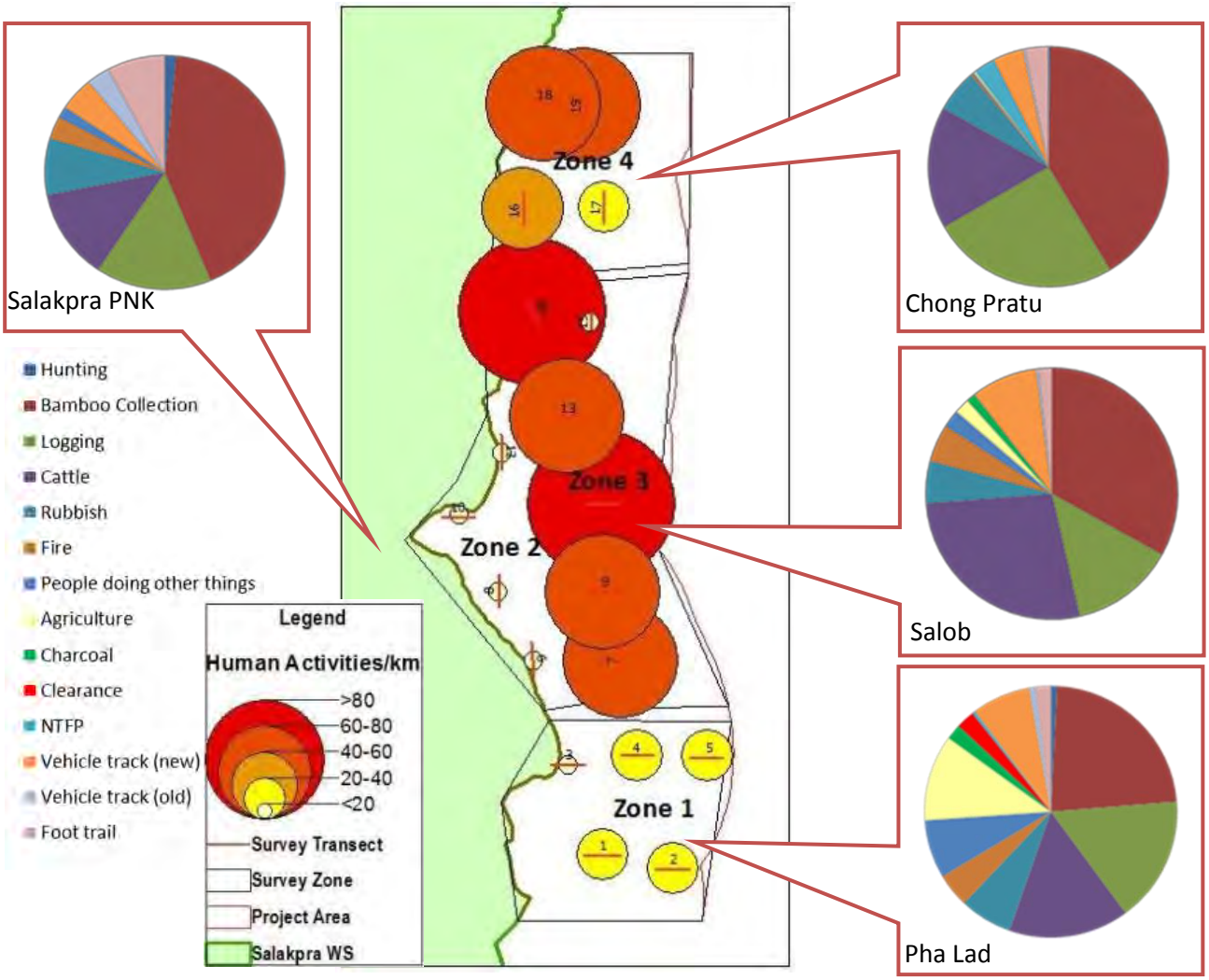


Figure 19: Human activities recorded in the whole survey area



Map 9: Intensity of human activity in the survey zone with pie charts showing the breakdown of human activities overall and zone by zone.

Bamboo collection, logging and cattle were the top three human activities in the survey area as a whole and within each zone. The frequency of other signs showed some variation between the zones (see
Map 9 and Table 4).

- *Zone 1 – Pha Lad:* this zone had the highest number of activities overall (13) and a more even spread of the other human activities. Although the human activity level overall was the second lowest, charcoal burning, agriculture and land clearance were more significant in this zone than in any other. These activities indicate a high level of human disturbance.

- *Zone 2 – Salakpra PNK:* this zone had the lowest rate of human activities (see Figure 18) and the fewest types of activity (9). It is closest to the WS boundary, it is ecologically contiguous with Thung Salakpra, the southern core of the sanctuary, and it has no human settlements.

- *Zone 3 – Salob:* this zone had a high rate of human activity and 11 types of activity. It is not connected to Salakpra and is close to human settlements.

- *Zone 4 – Chong Pratu:* the highest rate of human activities was recorded in this zone, with 11 types of activities, but most of them were at low frequencies.

4.3. Elephant habitat associations

With each observation, we recorded the habitat type in which it occurred. This data cannot give a direct representation of the proportion or distribution of each habitat type but it does indicate which habitat types are found in the survey area, and which ones elephants are using. Every forest type we encountered on the survey had been disturbed at some time and could be classified as secondary, but we recorded only the forest type. Bamboo dominated mixed deciduous forest (29%) and mixed deciduous forest (28%) accounted for the majority of observed habitat types. These forest types were dominant in Salakpra PNK (Zone 2) and Salob (Zone 3). Dry dipterocarp forest accounted for 18% of records and was especially significant in Chong Pratu (see Table 5).

Table 5: Habitat types recorded on the survey

Habitat type	Pha Lad		Salakpra PNK		Salob		Chong Pratu		Total Survey Zone	
	No.	%	No.	%	No.	%	No.	%	No.	%
Mixed Deciduous	5	1.1	291	53.0	157	29.0	87	19.4	540	27.8
Bamboo Dominated Mixed Deciduous	100	22.8	103	18.8	248	45.8	171	38.1	569	29.3
Dry Dipterocarp	79	18.0	99	18.0	7	1.3	146	32.5	348	17.9
Grassland	1	0.2	0	0.0	0	0.0	0	0.0	1	0.1
Secondary Forest	11	2.5	0	0.0	0	0.0	0	0.0	11	0.6
Scrub	103	23.5	10	1.8	15	2.8	25	5.6	153	7.9
Bamboo Forest	65	14.8	46	8.4	89	16.4	18	4.0	215	11.1
Plantation	0	0.0	0	0.0	2	0.4	0	0.0	2	0.1
Agricultural land	75	17.1	0	0.0	24	4.4	2	0.4	102	5.3
Total	**439**	**100**	**549**	**100**	**542**	**100**	**449**	**100**	**1941**	**100**

Habitat is an important determinant of elephant distribution. The correlation half matrix analysis indicated a positive association between elephants and mixed deciduous forest (r = 0.85) and between elephants and mineral licks (r = 0.59) (see Appendix IV). The linear regression analysis also indicated a strongly positive association between elephants and mixed deciduous forest (R^2=0.51). Our results further show that elephant distribution is not significantly associated with dry dipterocarp forest (see Figure 20b). A large proportion of this forest type was found in the Chong Pratu area (zone 4) which is not frequented by elephants because it is separated from Salakpra by a steep, rocky outcrop, and does not have permanent water. However, previous ECN forest surveys found that elephants do use dry dipterocarp forest in the southern part of Salakpra during the wet season when grass in abundant and water is available (ECN, 2008a). In this survey, elephants were also negatively associated, but only slightly, with scrub and agricultural land (see Figure 20c-d) which suggests that they may avoid areas associated with human disturbance and land clearance.

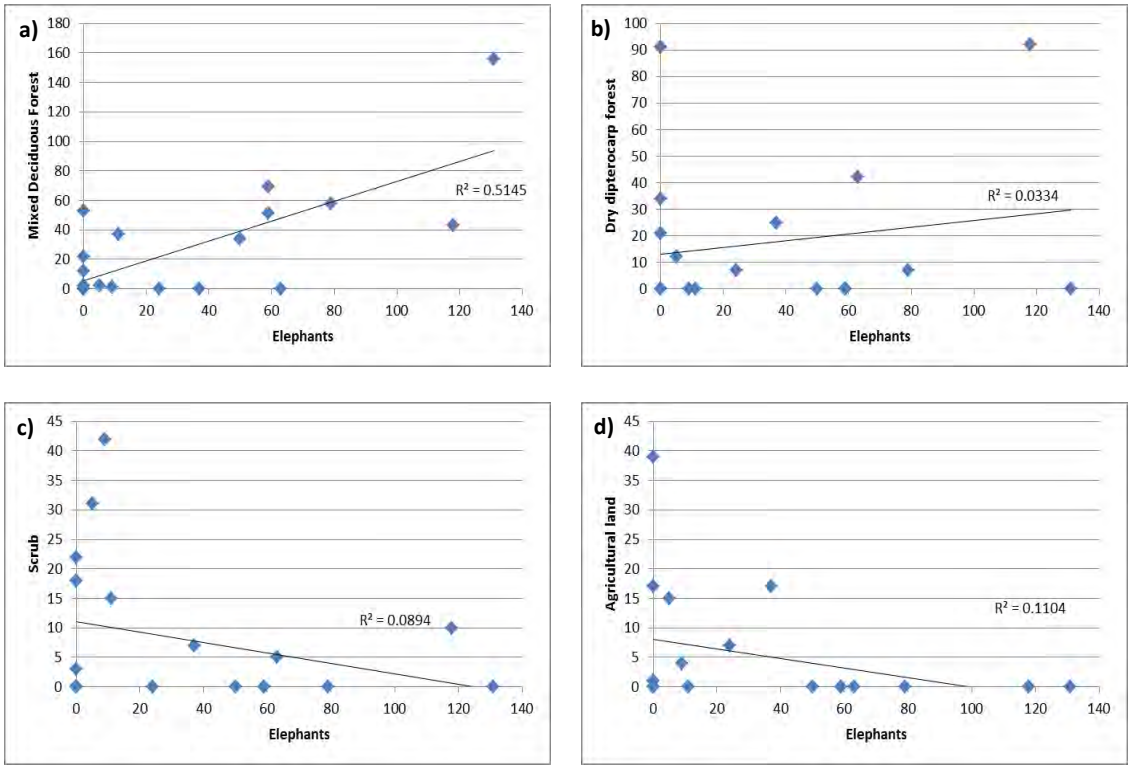


Figure 20: linear regressions of elephant habitat associations: elephants and (a) mixed deciduous forest; (b) dry dipterocarp forest; (c)degraded scrubland; (d) agricultural land.

4.4. Human activity and elephants

The distribution of elephant and human activity signs in relation to one another is shown in Map 10: human activities were seen throughout the survey zone but elephants were concentrated in the area nearest the WS, especially the core area of Thung Salakpra. However, there is an area of significant overlap between elephants and human activities in zones 1 and 3. When elephant signs are plotted against human activities, the data point distribution is not simple and does not fit a linear regression (see Figure 21). Some points cluster on the left of the chart where elephants occur alongside a lower rate of human activity signs per km. These points fit a strong negative correlation pattern. Data collected in Zone 3 is spread over the right of the chart (transects 9, 11 and 13). This area has significant overlap between high levels of human activity and signs of elephant.

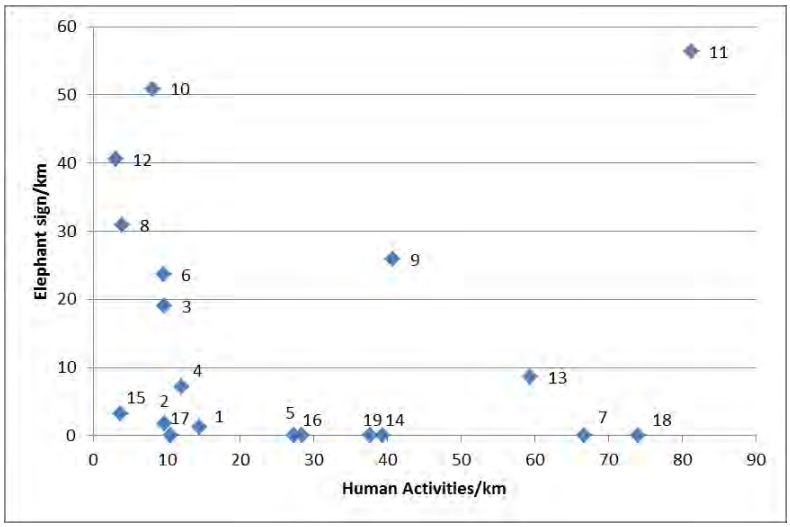
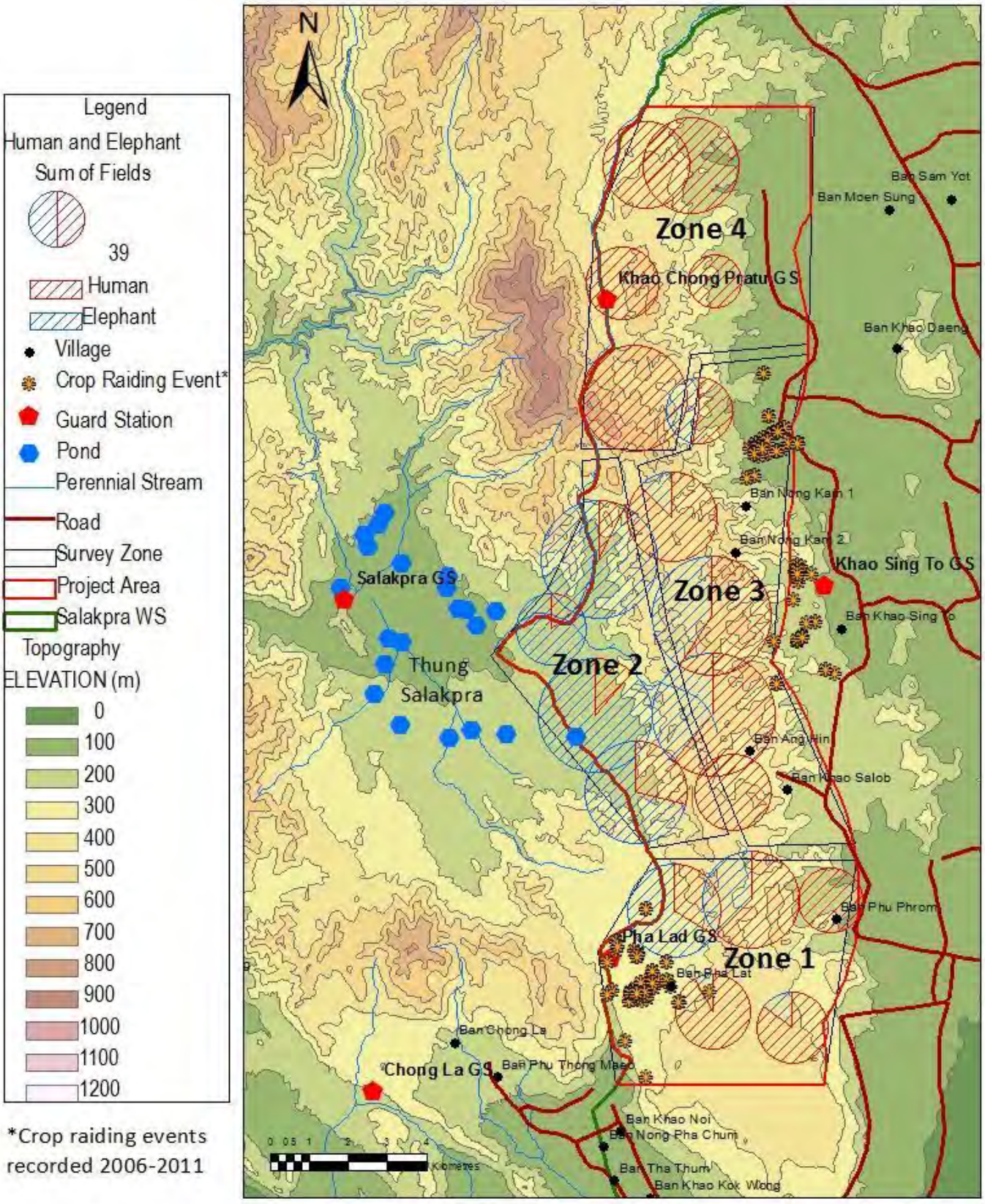


Figure 21: Relationship between human activities and elephants in the transect areas



Map 10: Elephant and human activity observations in the survey zone

Human activities were plotted against elephant sign with regression charts and on maps to show their abundance relative to one another. These charts and maps show that the different types of human activity have different associations with elephant abundance:

- ***Human activities with negative associations to elephant abundance:***

Logging, bamboo collection, rubbish, agriculture and land clearance had the strongest negative association with elephant abundance which suggests they have a negative impact on elephants. It has been suggested elsewhere (Stewart-Cox, *et al*., 2007; ECN, 2008a) that elephants also avoid areas of high human activity in Salakpra. The association of elephants with agriculture was fairly low but this was also influenced by survey planning: transects were deliberately placed in areas unlikely to be agricultural. Agriculture was also recorded as a habitat type and this had a stronger negative association with elephant abundance (see Figure 20d).

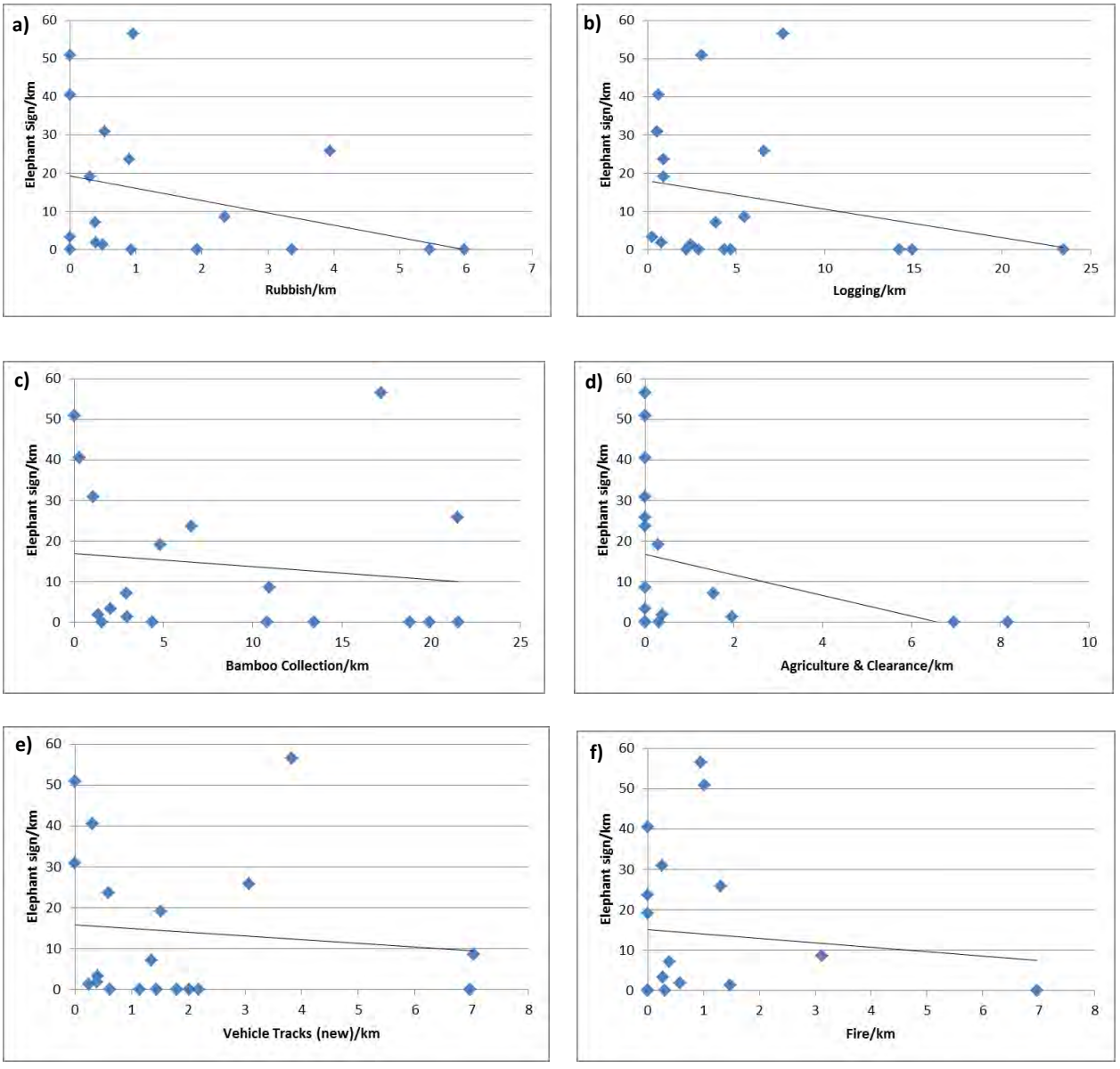


Figure 22: Linear regression analysis showing the negative association of elephant signs/km with some human activity signs/km (a) Rubbish; (b) Logging; (c) Bamboo collection; (d) Agriculture and clearance; (e) Vehicle tracks (new); (f) Fire.

- ***Human activities with positive associations with elephant abundance:***

Human activity signs that had a positive association with elephants were foot trails and cattle, indicating significant overlap in the use of forest resources by people and elephants. Elephants and people often use the same paths through the forest – many trails used by people were first used by elephants - and elephants are known to favour disturbed forest edges (Olivier, 1978).

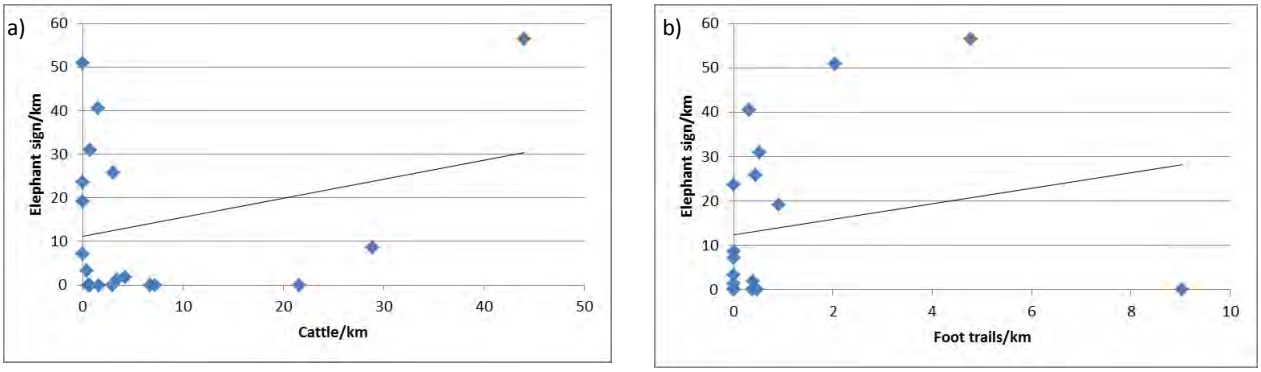
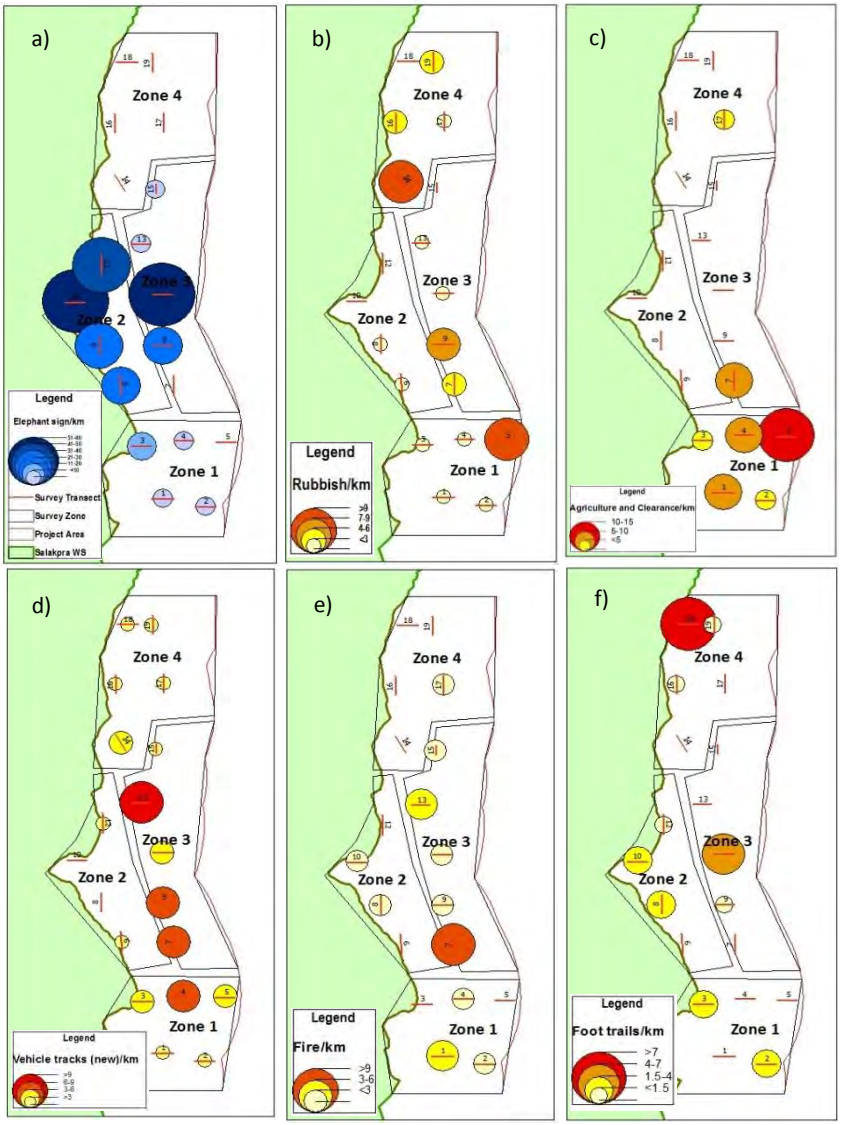


Figure 23: Linear regression analysis showing positive associations between elephant signs/km and human activity signs/km: (a) Cattle; b) Foot trails



Map 11: Elephant distribution compared to the distribution of selected human activities encountered in the survey area:

(a) Elephant encounter rates

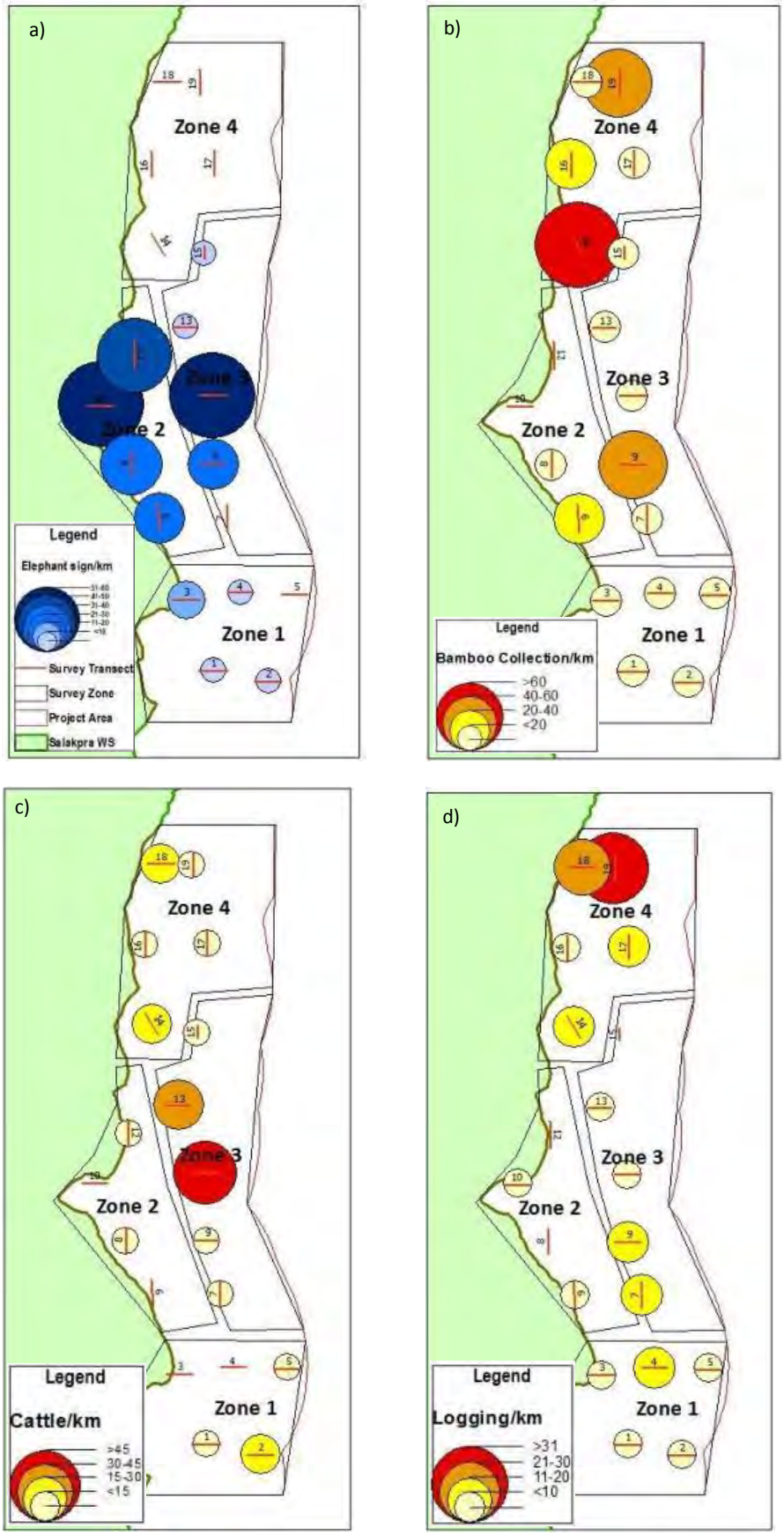
(b) Rubbish

(c) Agriculture and land clearance

(d) New vehicle tracks

(e) Fire

(f) Foot trails



Map 12: Elephant distribution compared to the distribution of the three most intense human activities encountered in the survey area: (a) Elephant encounter rates; (b) Bamboo collection; (c) Cattle; (d) Logging.

4.5. Other wildlife

Ninety-eight (98) signs of wildlife species other than elephants were recorded, producing an overall encounter rate of 1.9 per km (see Table 6 and Table 7). As elephant sign were the primary data collected, it is likely that data on other wildlife is under representative and biased toward species with more obvious sign. Despite these limitations, the results are important as they indicate the high conservation value of the survey area as a whole.

Mammal, reptile and avian fauna were encountered during this survey; wildlife signs were identified to species level if possible although some were identified to genus or a higher taxonomic level only (see Table 6). The mammal species signs most often seen were Sunda pangolin (*Manis javanica*), wild pig (*Sus scrofa*) and common barking deer (*Muntiacus muntjak*). The relatively high number of pangolin sign is significant as the Sunda pangolin once ranged throughout the lowlands of Thailand and has now been largely extirpated as a result of habitat loss and hunting. This species is heavily targeted for the illegal wildlife trade and is now listed as endangered on the IUCN Red List for Thailand. Pangolins are listed on Appendix II of the Convention on International Trade in Endangered Species (CITES) but with a "zero annual export quota" meaning that international trade is currently prohibited. All *Manis* spp. are classified as Protected Wild Animals under Thailand's Wild Animals Reservation and Protection Act (WARPA) of 1992 (Duckworth, et al., 2008a). Other notable findings included sign of the Sumatran serow (*Capricornis sumatraensis*) and sambar deer (*Rusa unicolor*). Both species are listed as vulnerable on the IUCN Red List (Duckworth, *et al*., 2008b; Timmins, *et al*., 2008). The Sumatran serow is also listed on Appendix I of CITES (CITES, 2012) and is on Thailand's list of Reserved Species under WARPA 1992.

Table 6: Wildlife species and taxonomic groups found in the survey area

Species or taxon recorded	Recorded on transects	Recorded on recces	Total
Pangolin (*Manis javanica*)	8	18	26
Wild pig (*Sus scrofa*)	15	1	16
Jungle fowl (*Gallus gallus*)	0	10	10
Common barking deer (*Muntiacus muntjak*)	8	1	9
Siamese hare (*Lepus peguensis*)	6	2	8
Jackal (*Canis aureus*)	0	7	7
Bamboo rat (*Cannomys* sp.)	5	1	6
Serow (*Capricornis sumatraensis*)	3	1	4
Civet (unidentified)	0	3	3
Squirrel (unidentified)	1	1	2
Small cat (unidentified)	0	2	2
Sambar deer (*Rusa unicolor*)	1	0	1
King cobra (*Ophiophagus hannah*)	0	1	1
Oriental whip snake (*Ahetulla prasina*)	0	1	1
Hornbill (*Buceros spp.*)	0	1	1
Mongoose (*Herpestes* sp.)	0	1	1
Total number of taxa recorded = 16	**47**	**51**	**98**

Table 7: Wildlife sign per km recorded on transects and recces

Survey Zone	Location	Mean Encounter Rate	Standard deviation	Range
1	Pha Lad	1.7	1.8	0-4.2
2	Salakpra PNK	2.6	1.2	1.6-4.1
3	Salob	1.3	1.7	0-3.8
4	Chong Pratu	2.1	2.1	0.4-5.8
	Total	**1.9**	**1.7**	**0-4.2**

The survey zone with the most signs of wildlife was Salakpra PNK (zone 2), the area adjacent to Thung Salakpra, the southern core of the wildlife sanctuary. Chong Pratu (zone 4) was the area with the next highest wildlife encounter rate indicating that Chong Pratu is important for wildlife other than elephants. The signs of wildlife decreased with distance from the Salakpra boundary (see Figure 24). Signs of wildlife showed a positive association with elephant abundance indicating that elephant habitat is also valuable for other wildlife (see Figure 25).

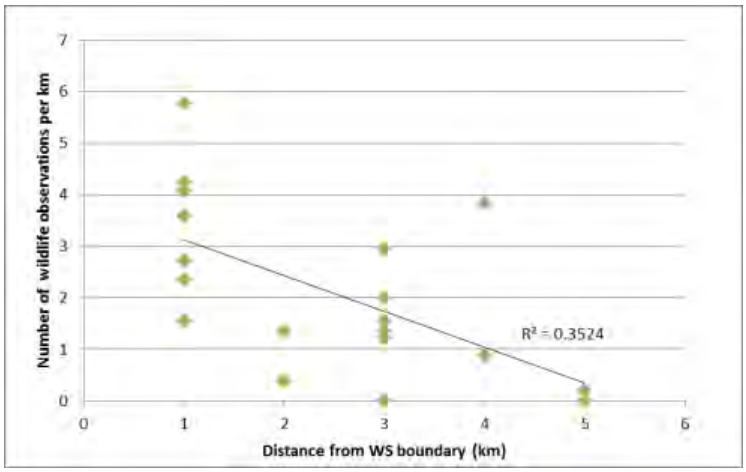


Figure 24: Wildlife signs seen on recces and transects by distance from the WS boundary

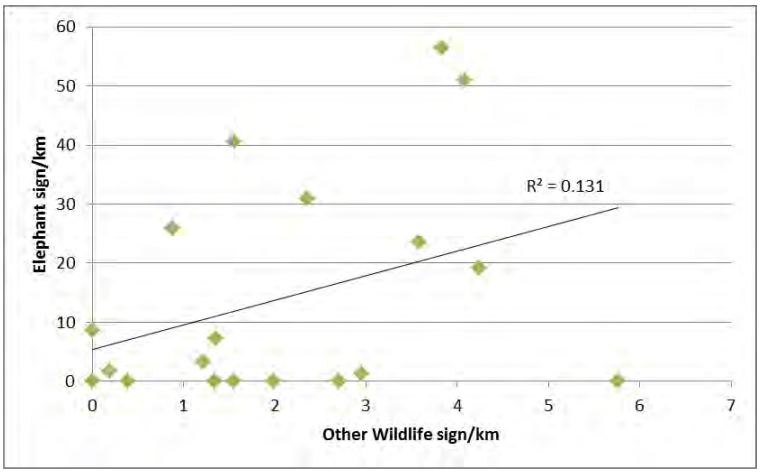


Figure 25: Signs of elephants and signs of other wildlife, a positive association

5. Discussion

This study shows that the survey area is an unprotected part of traditional elephant range which is also important for other wildlife species, and that there are high levels of human activities here. Different human activities have different detrimental impacts on the elephants and wildlife. The activities that have the biggest negative impact on elephants and wildlife are the ones that cause habitat loss, degradation and fragmentation.

5.1. Elephant distribution and movement

Elephants require large areas of suitable habitat to meet their daily, seasonal and lifetime needs for food, water, tranquillity and genetic dispersal. Seasonally, elephant herds may range 100 km^2 and bulls may need to range up to 300km^2 in order to breed with unrelated females (Sukumar, 1989). Within the 1,029 km^2 combined area of Salakpra WS and Chalerm Rattanakosin, a sizeable proportion of the PA is sub-optimal or unsuitable habitat for elephants because of the elevation, the harsh limestone substrate, and a lack of permanent water sources. Elephants have also been excluded from large areas of their former range by human settlements. Because of this, Salakpra's estimated population of around 175+ elephants (Srikrachang, 2003; Kongrit, *et al*., 2007) are not distributed evenly throughout Salakpra. Although elephants are an adaptable species that can make use of suboptimal areas, the fact that some areas cannot support elephants may contribute to crop-raiding (Sukumar, 2003). It is therefore vital to protect surviving areas of optimal elephant habitat.

Habitat associations

Asian elephants live in a wide range of tropical habitats but are generally known as a forest-dwelling species that depend on broad-leaved forests for shade and browse (McKay, 1973; Sukumar, 2003). However, they also favour grasslands and disturbed areas of secondary forest with open canopies as this increases the volume of graze and browse available to them (Olivier, 1978; Sukumar, 1989). We also know that elephants feed in Salakpra's dry dipterocarp forests during the cool and rainy seasons when grasses comprise much of the ground-cover (ECN, 2008a). In the survey area, elephants were most associated with mixed deciduous forest types rather than with dry dipterocarp or secondary forest. However, the survey was done during the dry season when the latter forest types were dry or burned and thus unlikely to be used by elephants. Moreover, when disturbed forest deteriorates into impenetrable scrub dominated by unpalatable species such as *lantana camera* and *chomolaena odorata* as a result of repeated fires, cattle grazing or agriculture clearance, habitat that was once good for elephants becomes unsuitable. Habitat degradation within the home range of an elephant group makes it difficult for them to forage for wild food, especially during the dry season. It is easier and more effective for them to consume high-calorie cultivated plants, thus encouraging crop raiding. This trend from habitat degradation to increased crop raiding is evident in the study area.

Water sources and mineral licks

Elephants seek mineral-rich soils to supplement their diet (Srikrachang, 2003). They also need 100-200 litres of water a day for drinking and bathing (Sukumar, 1989). This survey did not find a strong association between elephants and water sources *per se*, but elephants were more concentrated in areas with permanent water and mineral licks. This survey was conducted during the dry season when the presence of permanent water is likely to be a strong influence on elephant distribution. Elephants prefer to stay close to permanent water sources, rather than switch between seasonal ones (Pastorini, *et al*., 2010).

In 2010, 21 seasonal ponds in the core area of Thung Salakpra were deepened by DNP to make them hold water year-round. The area also has many natural, and a number of recently made artificial salt licks, some of which lie very close to the study area (see Map 10). Unfortunately, DNP did not do a baseline survey of elephant distribution and movement in Thung Salakpra before the ponds were dug, so we do not know how they have affected the distribution of elephants in the area.

Figure 26: An elephant herd at a pond in Thung Salakpra near the study area. This family group includes calves, juveniles and adult females. This is a camera trap photo from the ECN-Salakpra pilot pond survey 2012 (Breach, 2012).

Seasonal movement

The seasonal pattern of elephant movements is the same in Salakpra as elsewhere in Asia and Africa. Elephants are found at higher densities in areas with perennial water and food sources in the hot, dry season, and spread into other areas at lower densities during the wet season (Sukumar, 1989; Smit, et al., 2007; ECN, 2008a). In this study, the highest elephant density was in zone 2 which adjoins the core area of Thung Salakpra. As we know that elephants in southern Salakpra concentrate in the core area all year round, and especially during the dry season because it still has food and water (ECN, 2008a), we may predict that zones 1-3 of the survey area are similarly important to them all year round, but especially during the dry season. This is confirms by the survey data as elephants were found using this area in the dry season. ECN's crop raiding data also shows that crop raiding in this area is highest during the dry season although it occurs throughout the year. This simple fact also indicates that the survey area is used by elephants year round (see Figure 27).

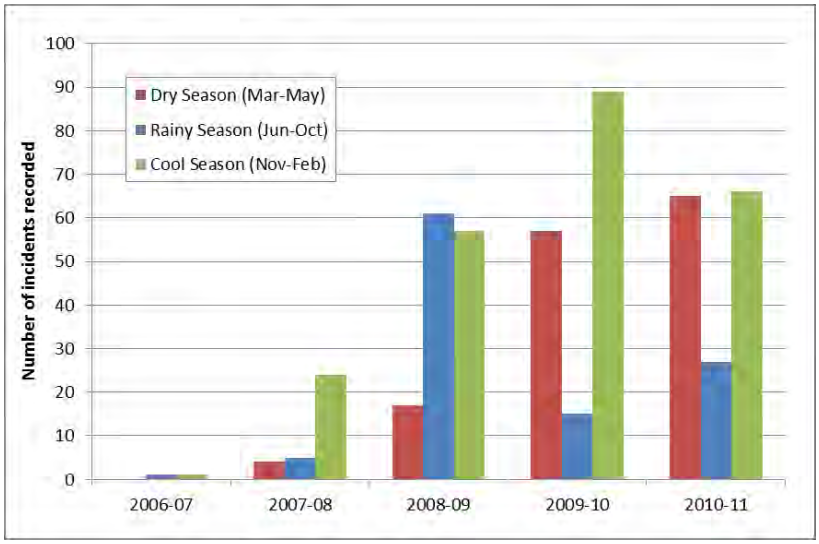


Figure 27: Incidents of crop raiding from 2006 – 2011 in the eastern area by season.

5.2. Impacts of human activities

The survey area is unprotected and near to areas of settlement and agriculture so it is not surprising that human activities are widespread. The relative abundance of each activity type mirrors the pattern found inside Salakpra in 2006-7 before the sanctuary began implementing a more effective patrol system, with rates that are equivalent or higher, depending on the area and the activity (Stewart-Cox, et al., 2001; ECN, 2008a). Many studies have found a negative correlation between people and elephants (Parker & Graham, 1989; Stewart-Cox, *et al*., 2007; Buij, *et al*., 2007), while others noted that human activity can be used as a predictor of elephant distribution (Barnes, *et al*., 1991; Hoare & Du Toit, 1999; Blake, *et al*., 2007; Buij, *et al*., 2007). The high levels of human activity found in the study area are likely to have increasingly negative direct and indirect impacts on these elephants and their distribution. In fact, in June 2012, after this study was completed, a female elephant died in Bo Phloi near to zone 2 after being shot by a hunter.

Figure 28: Forestry officials and veterinarians examining and treating gunshot wounds before the elephant died in Bo Phloi district, Kanchanaburi June 2012 (Bangkok Post, 2012)

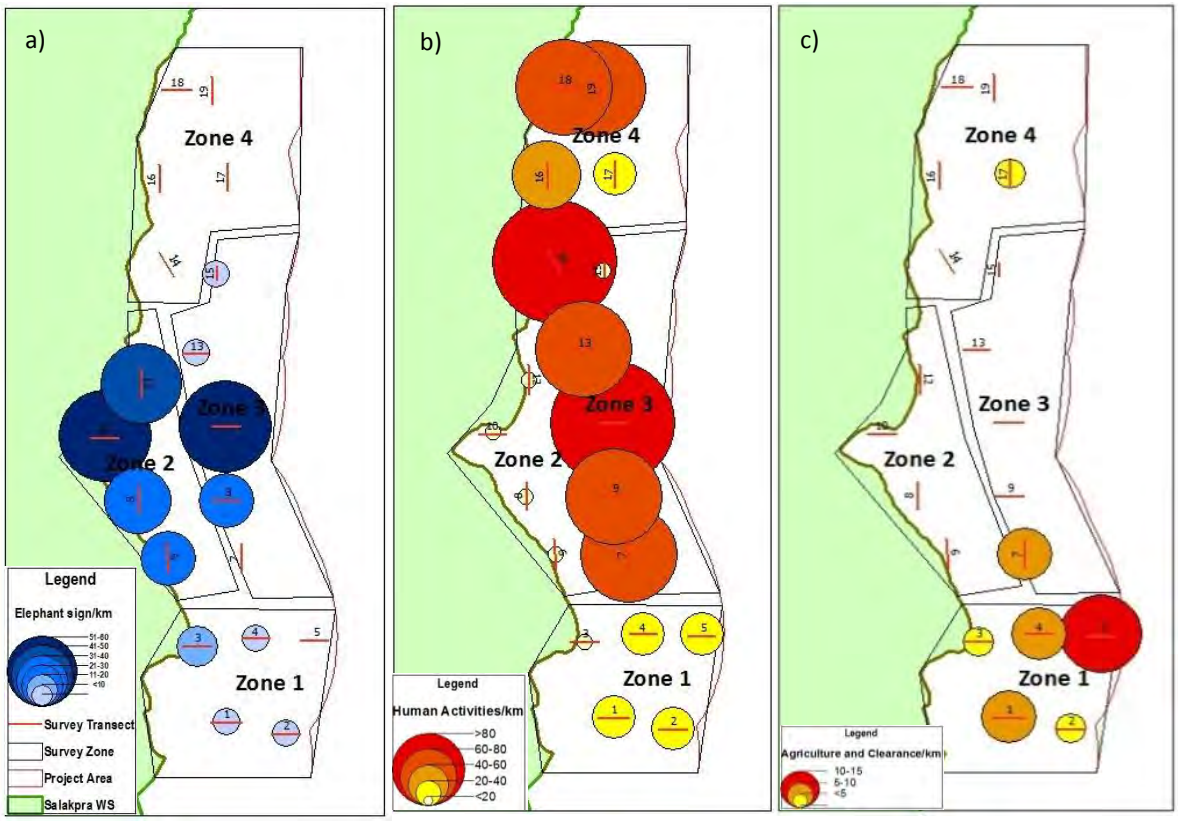
Different human activities that were found in the survey area have different direct and indirect impacts on elephants. These are summarised below:

Table 8: Summary of the direct and indirect impacts on elephants of human activities in the survey area

Human activity	Direct impacts on elephants	Indirect impacts on elephants
Logging and charcoal burning	○ Loss of food sources ○ Land clearance reduces area available to elephants	○ Presence of people inhibits elephant movement and feeding ○ Habitat degradation
Bamboo collection	○ Loss of protein rich food ○ Habitat degradation to scrubland ○ Suppression of forest regeneration.	○ Human disturbance prompts elephants to move away, inhibiting feeding and rest. ○ Increased human access to elephant habitat
Hunting and other NTFP collection	○ Illegal killing of elephants ○ Elephants injured or killed by traps set for other species ○ Harvesting bamboo shoots deprives elephants of valuable food source	○ Presence of people inhibits elephant movement and feeding ○ Habitat degradation/reduced biodiversity leads to poorer ecosystem function
Cattle	○ Competition for food ○ Exposure to cattle diseases	○ Reduced habitat quality: soil impaction, reduced infiltration, inhibited regeneration and increased vulnerability to fire
Fire	○ Loss of food ○ Risk of injury	○ Displacement from burnt / burning areas ○ Regular fires degrade habitat quality and impede forest regeneration
Vehicle tracks and foot trails	○ Elephants use tracks and foot trails	○ Vehicle tracks facilitate human access
Agriculture and clearance	○ Loss of food sources ○ Loss of habitat	○ Agricultural areas in traditional elephant areas encourage crop raiding / HEC ○ Increased human access to elephant habitat

The results show that in zones 1 and 2 there is a negative correlation between elephant abundance and human activity. However in zone 3, in the area that represents the natural outer boundary of Thung Salakpra there is a notable overlap between elephant distribution and high levels of human activity. The main human activities in this area are bamboo collection and keeping cattle. Zone 1 has a lower relative abundance of human activities, however, agriculture and land clearance are higher here than in the other zones.

The agricultural activities recorded as part of the survey were either within areas of established agriculture or in the process of being cleared. Signs of agriculture were recorded both as observations of human activities, and as a habitat/land use type in which observations were made. Both data sets revealed a negative association with elephant abundance echoing findings elsewhere in Salakpra and all elephant range areas. Land clearance was evident in areas that had been marked for clearance, and areas that were in the process of being cleared by hand, machinery or fire (see Figure 29). This process of clearance and habitat fragmentation was evident from the RST survey and is supported by the images captured on the aerial survey (see Section 5.3). The whole area is vulnerable to land use conversion and zones 1 and 3 are presently at different stages of transition from predominantly forest to a human dominated landscape mosaic.



Map 13: Maps showing distribution of a) elephants, b) human activities and c) agriculture and clearance. Human activities are highest in zone 3 where agriculture and land clearance are now directly impinging on traditional elephant distribution.

Habitat loss and fragmentation are major threats to Asian elephants across their range. The presence of newly established fields in close proximity to elephants under pressure to meet their resource needs in what was traditional habitat is known to lead to escalated HEC and crop-raiding (IUCN, 2011). Studies elsewhere have found that elephant numbers will often remain high in recently cleared areas despite high levels of human activity. These areas will experience high levels of HEC until a cut-off point is reached beyond which elephant activity disappears (Hoare & Du Toit, 1999; Nyhus & Tilson, 2004). A critical threshold has been noted and usually occurs when land use is 40-50% human activity. At this point elephants tend to disappear from the landscape (Hoare & Du Toit, 1999). Elsewhere in Asia a critical threshold of habitat conversion where HEC starts occurring is between 30-40% forest cover (Chartier, *et al*., 2011). Past studies suggested this pattern in Salakpra WS (Stewart-Cox, *et al*., 2007), and the findings of this study further support this.

Figure 29: The process of land clearance: a) areas marked, b) forest is cleared using machinery, c) burning of vegetation in preparation for cultivation, d) forest habitat is degraded to impenetrable scrub, e) newly cleared agricultural land with vegetation being burned in the background, f) and g) recently established agricultural area in Pha Lat ready for crops. Background hills represent unsuitable habitat for elephants.

5.3. Supplementary paramotor survey findings

To supplement the information gathered on the ground, the additional georeferenced imagery from the paramotor survey is useful to illustrate the landscape more broadly. The images reveal a mosaic of land uses with patches of forest surrounded by agriculture and pockets of cleared areas surrounded by forest. A number of human activities are visible including agriculture, cattle farming, and tracks and trails. The images show that secondary and degraded forest cover remains over large tracts of the survey area including locations with high human activity. The paramotor was only suitable for flying over the outer edges of the survey area. The photographic images highlight the sharp contrast of the forest/agricultural boundary showing flat areas encroached for agriculture and settlement and forest remaining on the slopes. The steeper areas are not suitable for the preferred agricultural practices of the area: sugarcane, cassava and mixed farming. The paramotor was also able to access areas beyond this sharply visible border characterised by mixed usage with small patches of clearance. Human activities that are more suitable to the varied terrain and disturbed forest habitat such as cattle raising are seen here. These areas seen in the RST survey under transition from forest to agricultureare actively being illegally cleared.

Figure 31: Flat areas are cleared for agriculture and forest remains on unsuitable steep slopes (Zone 2)

Figure 30: New areas are being cleared even in the more inaccessible areas within the remaining forest (Zone 2)

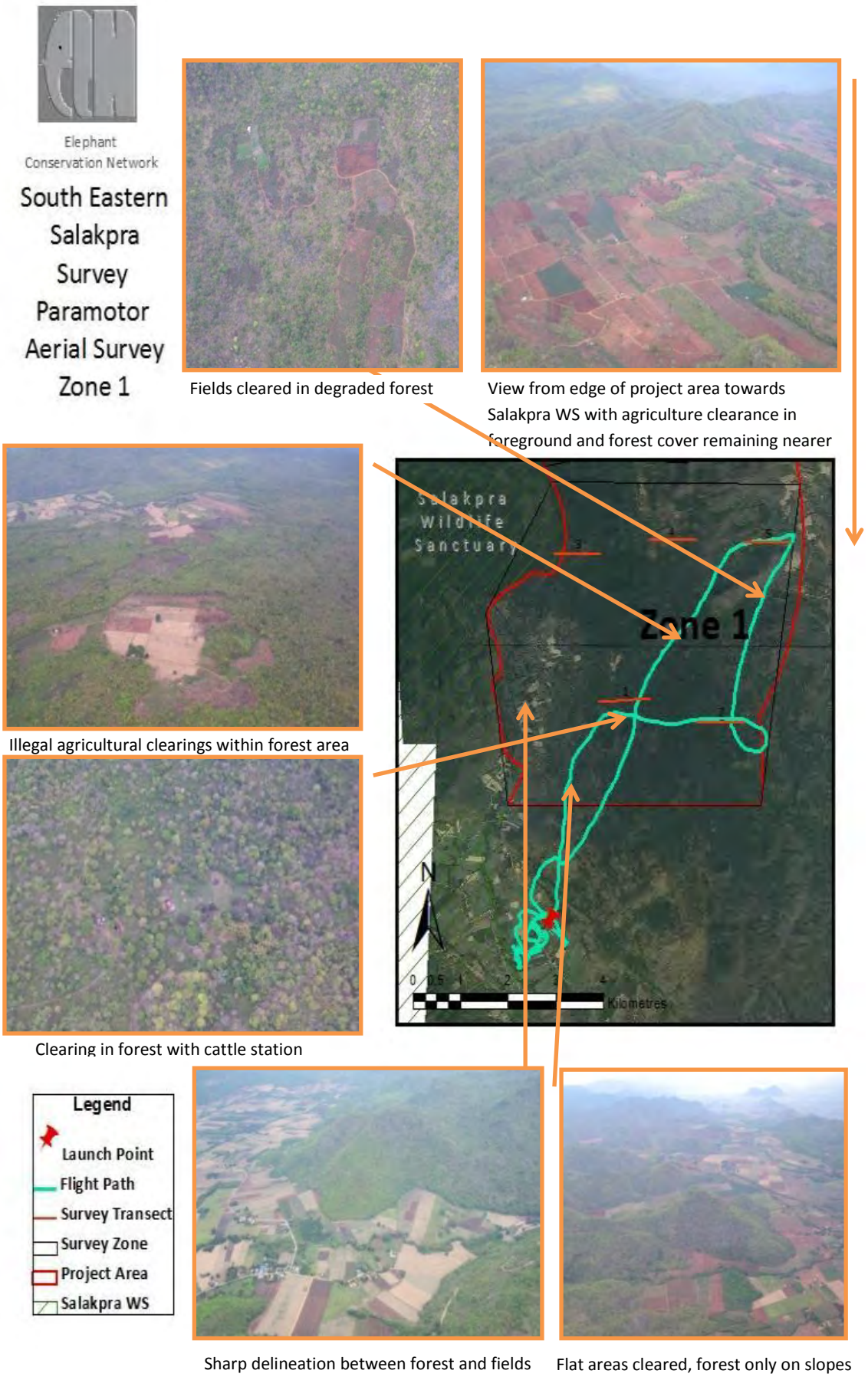
During the aerial survey, we observed that forest cover generally increased with proximity to the WS boundary particularly in the central area of Zone 2 where the core of southern Salakpra borders the edge of the WS. We couldn't fly over these areas with the paramotor because it would have been unsafe, however, we could clearly see the forest cover stretching into the interior of Salakpra.

The aerial photos support our findings that the survey area is in transition from forest to a human dominated landscape with remnant forest patches. The two zones covered in the aerial survey have different topographical and habitat characteristics which influence the distribution of elephants found there, and the extent and type of human activities undertaken in these areas. The maps below of the flight routes of the two survey zones are illustrated with georeferenced aerial photographs and show these findings:

Zone 1 – Pha Lat – Map 14: This is a relatively flat area with an average altitude between 300-400m which is currently being illegally encroached upon and cleared for settlements and small scale agriculture.

Zone 3 – Salob – **Error! Reference source not found.**: This area is flanked to the east by larger scale farms, predominantly growing sugar cane. It is more sharply divided, topographically, from the forest interior by steep, rocky outcrops which make the forested area near the WS less accessible. However, these locations have been used for cattle grazing for some time and are now being encroached upon for smaller scale illegal clearings.

Figure 32: View over Zone 1 of survey area showing the land use mosaic of forest and agriculture



Map 14: Paramotor Survey Zone 1

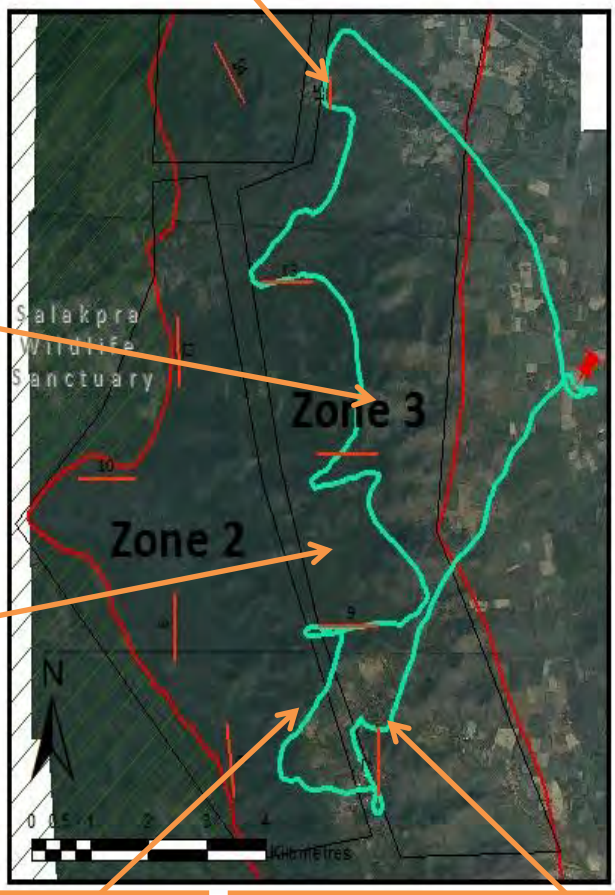
Elephant Conservation Network

South Eastern Salakpra Survey Paramotor Aerial Survey

Forest/agricultural boundary, larger scale farms dominate in this area

An area of mixed deciduous forest

View of forest over Zone 2 towards Thung Salakpra, the southern core of Salakpra WS



Legend

- Launch Point
- Flight Path
- Survey Transect
- Survey Zone
- Project Area
- Salakpra WS

Illegal clearance in degraded forest area

Flat areas encroached for agriculture

Map 15: Paramotor Survey Zone 3

5.4. Crop raiding and land use in and around the survey area

The data from this survey indicates a negative association between elephant distribution and agriculture. However, we know from the crop raiding data that elephants do not remain exclusively within the WS and are now frequently and increasingly raiding crops outside the eastern boundary.

Crop raiding in this area is centred around three villages: Pha Lat, Khao Singto and Khao Daeng and is increasing in all these places (see Figure 33, Map 5). The dominant crop in this area since 1990 is sugarcane which is especially favoured by elephants and accounts for 59% of all crop-raiding (see Figure 35). Sugarcane is raided by elephants at every stage of the growth cycle. Recently, there have been significant conversions of eucalyptus plantations to sugar cane in areas close to the WS boundary increasing the area's attractiveness and vulnerability to crop raiding (ECN, 2008b).

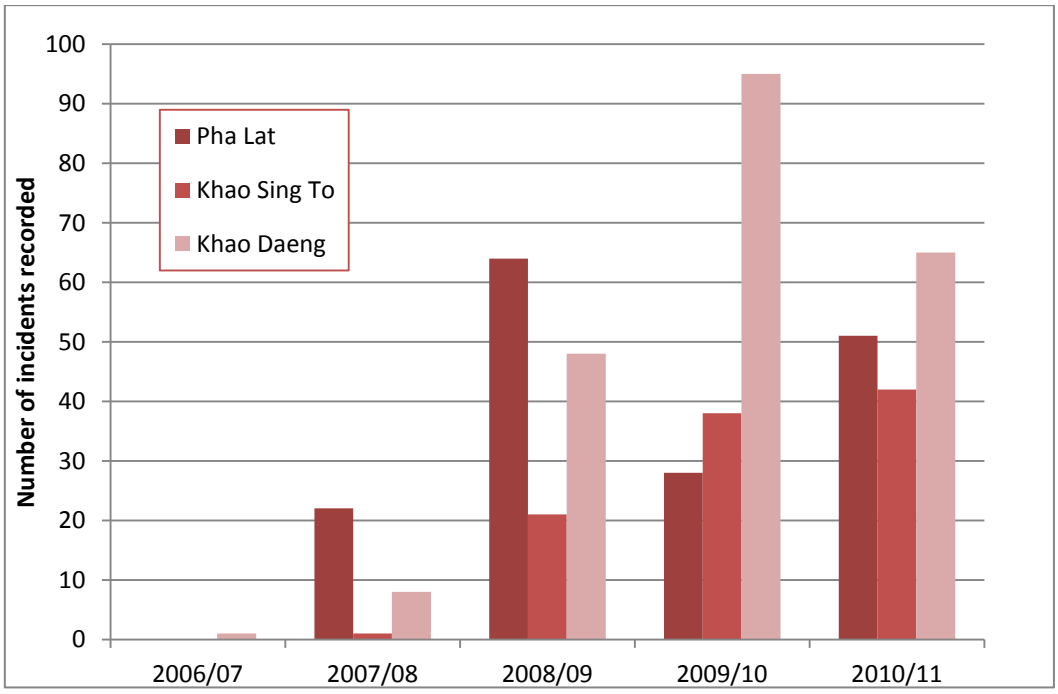


Figure 33: Crop raiding around the survey zone has increased dramatically

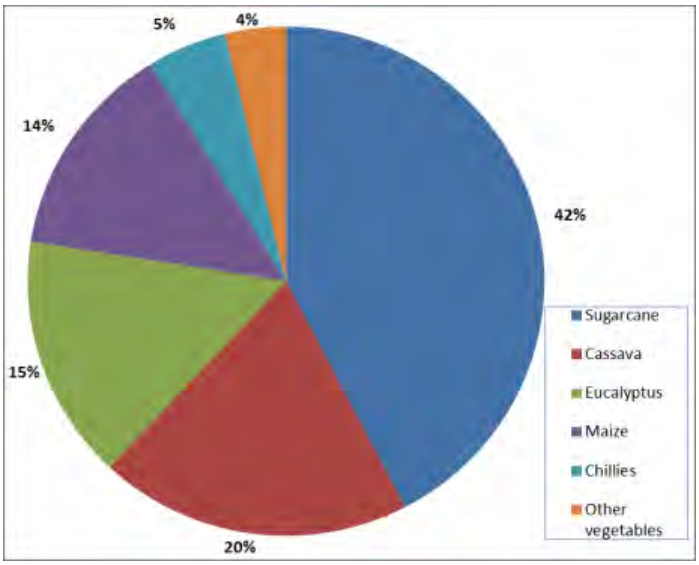


Figure 34: Main crops in the area to the east of Salakpra in 2007 (Ritthirat, 2008).

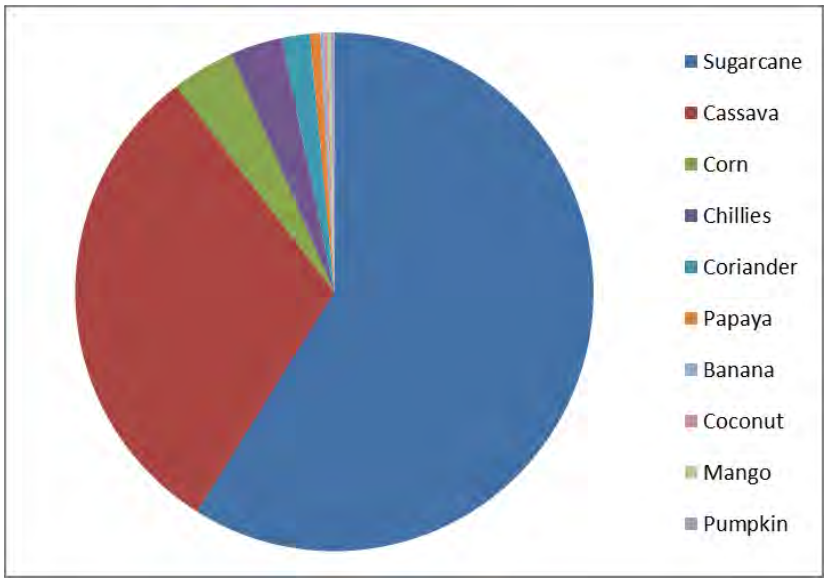


Figure 35: Crops raided in the vicinity of the survey area 2006-2011

Factors identified by local farmers as influencing the likelihood of crop raiding occurring were the proximity of the farm to the WS, and to traditional elephant routes from the forest (Sirisambhand & Stewart-Cox, 2007). Farmers also report that elephants tend to raid the same fields repeatedly following the same route from the forest each time. Findings elsewhere in Salakpra, in the southern corridor to Erawan NP (Hayworth, 2011) and in Assam, NE India, show that elephants stay in forest fragments and raid repeatedly over several days. (Chartier, *et al*., 2011). At the time of this study, a farmer in Khao Daeng reported this behaviour by two elephants that remained in a forest area close to sugarcane cultivation and made repeat forays to the fields to crop raid over several nights.

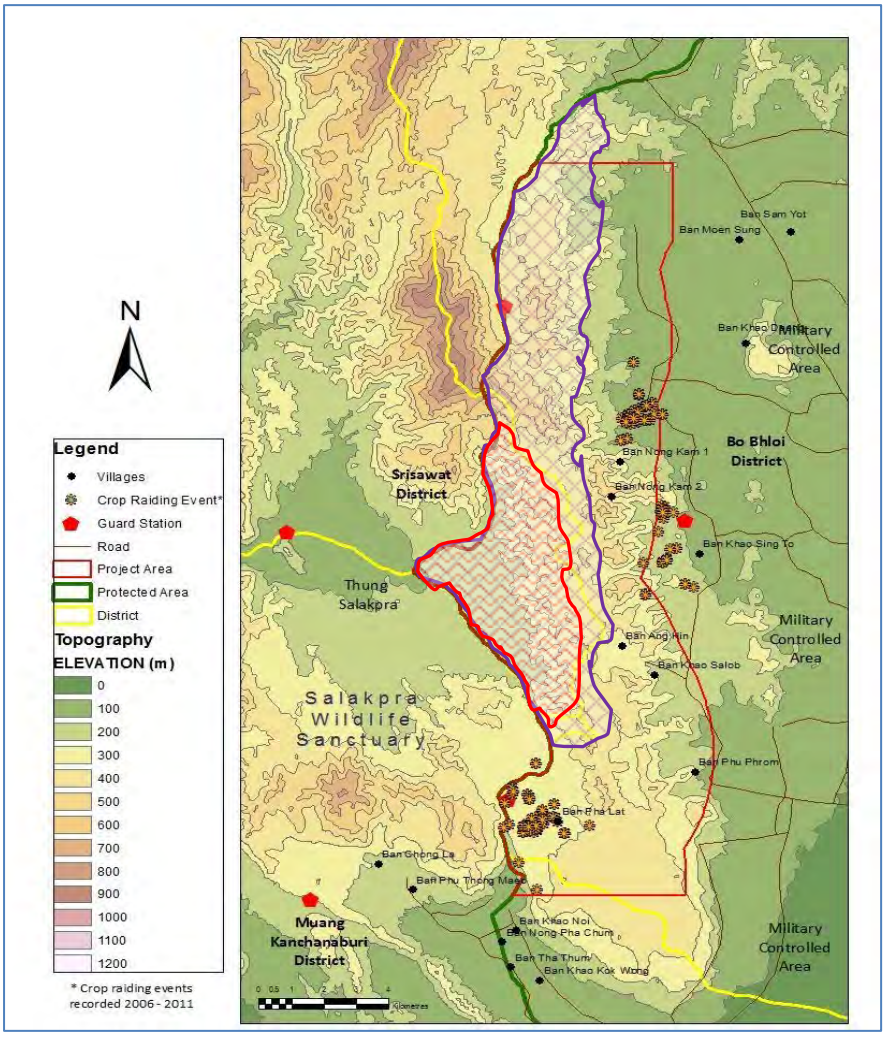
Habitat loss and degradation, coupled with resource competition with people and domestic cattle, may lead to elephants being unable to get adequate nutrition from natural sources and therefore seeking other sources of food. Crop raiding is also influenced by elephant behavioural ecology. Elephants remain near to permanent water during the dry season in order to expend less energy, and herds with calves need to remain closest to water sources (Smit, *et al*., 2007; Pastorini, *et al*., 2010). Dominant males and males in musth stay closest to herds and their prime habitats, while younger, subordinate males are pushed into suboptimal areas. Young males are more likely to adopt risky strategies such as crop raiding in order to survive in confined areas, and to gain fitness and strength and thus increase their chances of reproductive success (Sukumar & Gadgil, 1988). Many cultivated crops have a higher nutritive value than forest plants during the dry season. Asian elephants typically spend more than 12 hours a day feeding. The higher nutritive value of crops may allow them to consume their daily nutritional requirements in far fewer hours (Sukumar, 2003). This high risk / high gain activity is part of male strategy to enhance reproductive success, making crop raiding a natural extension of an animal's optimal foraging strategy (Sukumar, 1989). In 2006, results showed that crop raiding around Salakpra was carried out predominantly by bulls (mostly one or two bulls at a time) accounting for about half of all raids (ECN, 2008b). In this area, herds are also known to occasionally foray into agricultural areas. This was confirmed during this survey (see Figure 36), suggesting that the local elephant population is under pressure to meet its resource needs during the dry season, and that the survey area is traditional elephant habitat, only recently cleared.

Figure 36: Crop raiding evidence: (a) elephant damage to sugarcane at Khao Daeng viewed from the paramotor; (b) elephant deterrent ditch that has filled with earth and been walked over by crop raiding elephants; (c) a papaya farmer shows elephant footprints on/around the ditch where a group of elephants came the previous night; (d) various size footprints indicating a herd visit; e) elephant damaged cassava crop; f) elephant print in the cassava field.

6. Conclusions

This study shows that the survey area is critically important for elephants and other wildlife and is effectively unprotected. Full protected area status would not only safeguard this traditional elephant habitat, thus helping to ensure adequate resources for elephants year-round which in turn would reduce crop-raiding, it would also improve the conservation integrity of Salakpra by protecting the entire basin of Thung Salakpra within its natural topographical boundaries.

Signs of creeping habitat degradation and encroaching human activity evident in the survey area highlight the urgent need to protect Salakpra's heartland by incorporating the elephant habitat that is currently outside the sanctuary boundary but which lies within the natural boundary of the Thung Salakpra basin. At present, the elephant core area of Thung Salakpra is highly vulnerable on its eastern side, like an exposed under-belly, because the current sanctuary boundary follows a dry streambed, not the line of hills that ring the basin and form a natural barrier. Until this is done, the conservation integrity of Salakpra is highly compromised because Thung Salakpra is so easy to access on its eastern side. Moreover, it is as easy for elephants as for people to access the unprotected area of eastern Thung Salakpra, and since it has long been part of their traditional natural habitat, human-elephant conflict will always be high in this area. This will make human-elephant coexistence practically impossible, causing endless problems for settlers, local leaders and government. It makes more sense to incorporate this area into Salakpra while it is still possible.



Map 16: Topographical map of the survey area.

The red hatched zone is topographically part of the lowland basin ringed by hills that constitutes the southern heartland of Salakpra, an area known as the field or grassland of Salakpra (*Thung Salakpra*). At present, the sanctuary's eastern boundary in this area follows a dry streambed rather than the more obviously protective outcrop of hills that encircles this lowland basin. This area has long been and still is a natural part of Salakpra elephants' home range. The purple hatched zone still supports other rare species that also need protection, so this area is worth incorporating too.

a) The survey area is part of the traditional home range of Salakpra's elephants

The Salakpra elephants' natural home range does not coincide with the current boundary of the sanctuary because that boundary follows a dry streambed that does not represent a barrier of any kind. The habitat on either side is the same. As a result, elephants move back and forth across the sanctuary's unnatural boundary line. This study found that elephant encounter rates in the survey area (i.e. beyond the boundary) are the same as encounter rates within the sanctuary, suggesting that elephants are using the whole basin equally. This study also found that elephants in the survey area (i.e. outside the sanctuary) are a breeding population comprising adults, sub-adults, juveniles and calves. They are not itinerant males. The boundaries of the wildlife sanctuary should therefore be redefined to realistically reflect, and protect, the needs of the breeding population. The highest abundance of elephants was found in the area adjacent to and partly surrounded by the WS (the red zone in the map above). This area is ecologically contiguous with the interior of the sanctuary, and the abundance of elephants there, including breeding herds, indicates not only that this is optimal elephant habitat but also that it is still customary elephant habitat. To fulfil its role as a wildlife sanctuary, and to avoid increasing levels of human-elephant conflict in future, Salakpra needs to incorporate as much optimal habitat, including optimal elephant habitat, as possible. This area should be added to the sanctuary before it is too late.

b) The southern core of Salakpra is exposed and vulnerable to human encroachment

Because it is a well-watered, lowland basin, Thung Salakpra is the southern heartland of the sanctuary and is especially favoured by elephants and other large herbivores. However, the current sanctuary boundary follows a dry stream bed which cuts through this core zone exposing its eastern side and making it extremely vulnerable to human incursions and degradation. The survey zone closest to Thung Salakpra has the highest density of elephants and is therefore the highest priority for protection (red hatched zone in Map 16 above). Adding this area into the Salakpra Wildlife Sanctuary would not only improve the conservation integrity of Thung Salakpra and the southern half of the sanctuary, it would also provide a natural barrier that is easier to demarcate and protect. Unless habitat degradation and other damaging human activities on the unprotected, eastern side of Thung Salakpra are arrested before they reach a critical threshold, it is likely that elephants will be extirpated from this area and the whole of lowland basin will become vulnerable to edge effects. If this were to happen, it would greatly undermine the conservation integrity of Salakpra and the security of the sanctuary's elephant population. The east side of the southern core area of Thung Salakpra should be protected because it is an ecologically valuable, but unprotected, part of the sanctuary and because the hills that bound the eastern rim would serve as a natural buffer.

c) The whole survey area is important for wildlife

Although the survey area closest to Salakpra is the most important part from the elephants' perspective, the whole survey area is ecologically contiguous with the heartland of southern Salakpra and is important for the other wildlife species found there. Apart from elephants, these include several species listed in IUCN's Red List, CITES Appendices I and II, and Thailand's Wild Animal Reservation and Protection Act. The most significant species recorded were the Sumatran serow (*Capricornis sumatraensis*), sambar deer (*Rusa unicolor*) and Sunda pangolin (*Manis javanica*). The unregulated hunting recorded during the survey area poses a threat to all the wildlife there, particularly the more vulnerable and endangered species (see Figure 37).

Figure 37: White-rumped sharma (*Copsychus malabaricus*) caught in a hunter's mist net. This species is exploited for the songbird trade. While this activity is illegal, wildlife protection is poorly enforced outside protected areas.

d) Land-use conversion and human activities will escalate human-elephant conflict

Widespread human activities, most significantly active land clearance, in the survey area confirm that habitat loss and degradation pose a real threat. The survey shows that zones 1 and 3 have the most overlap between human activities and elephant distribution. Crop-raiding is already occurring in and around these two zones and is likely to become a much bigger problem if clearance for agriculture is not halted and, if possible, reversed. Crop-raiding already occurs in areas recently converted to agriculture and conflict will become more severe unless land clearance is stopped. If more people are move into areas where crop-raiding already occurs, not only will conflict in that location increase, but crop-raiding may increase in adjacent areas as elephants are displaced from formerly secure habitat. Ground and aerial observations indicate that the survey area is in transition from an area that was/is predominantly forest to one that is a human-dominated land use mosaic. The habitual presence of elephants near sites of regular crop-raiding suggests that HEC will escalate if the area is not protected from further encroachment.

Figure 38: Agricultural activities east of Salakpra: (a) cassava fields and eucalyptus plantations; (b) sugar cane farming abuts the forest near Khao Singto; (c) large scale sugar cane cultivation at Khao Daeng

7. Recommendations

We recommend that the survey area adjoining the south-eastern boundary of Salakpra be incorporated into the wildlife sanctuary in order to:

- improve the ecological integrity of Thung Salakpra, the sanctuary's southern core;
- protect the surviving forest habitat in the survey area from further degradation;
- reduce &/or prevent human-elephant conflict caused by agricultural encroachment.

At the very least, this area should be given effective official protection to prevent the eastern side of Thung Salakpra being exposed to human impacts. By giving this target area full protected area status, the government would add over 100km^2 of prime wildlife habitat to Salakpra - increasing the size of the sanctuary by around 10% – which would greatly enhance the ecological integrity and conservation value of Salakpra by protecting the whole basin – a natural 'theatre' - of Thung Salakpra, and add a natural topographical buffer between the settled human zone and the sanctuary's southern heartland.

a) Improve the ecological & conservation integrity of Salakpra

Being long and narrow, Salakpra is not the optimal shape for a conservation area. Plus its east, west and southern sides are surrounded by expanding human settlements. It is thus highly vulnerable to the damaging 'edge effects' of human activity near its boundaries. Worse, the southern heartland of the sanctuary, *Thung Salakpra*, is only partially protected because Salakpra's current boundary cuts off a third of it on the eastern side. This ecologically impractical boundary does not recognise the fact that Thung Salakpra has a natural topographic boundary in the ridge of hills that ring this lowland basin. Incorporating those hills – and the whole of *Thung Salakpra* – into the sanctuary would greatly improve the ecological integrity of Salakpra as a conservation area for elephants and other wildlife. This would do much more than simply add around 100km2 of land to the sanctuary. It would have the value-added effect of securing Salakpra's southern core. The multiplier effect of this, in conservation terms, would be immeasurable.

b) Prevent further degradation of prime elephant habitat in traditional home range

This study found that the outer reaches of the survey area are being heavily exploited for forest products, and are now being cleared for agriculture and settlement. In spite of being a military controlled area, this land is not being protected from encroachment or degradation. And yet all of it is important for wildlife, including elephants. By adding this area to Salakpra, the government would incorporate valuable habitat into the sanctuary as well as a natural buffer-zone. Elsewhere in Thailand, the Royal Thai Army is involved with conservation and the management of protected areas (IUCN, 2010). It has also been instrumental in helping to improve the conservation value of Kuiburi National Park. We recommend that the Army be asked to transfer land in the survey area to DNP so that it can be legally incorporated into the Salakpra Wildlife Sanctuary. Thereafter it would be helpful to work with the Kanchanaburi-based 9th Army to help improve the area's protection.

d) Reduce &/or prevent further escalation of human-elephant conflict

Human-elephant conflict hurts people and elephants, both directly and indirectly. In order to prevent and/or reduce HEC in the survey area, we recommend:

- ***Halt and, where possible, reverse land clearance:*** our ground and aerial surveys show that clearance is occurring on land that is part of the Salakpra elephants' traditional home-range. Habitat degradation and fragmentation is the primary driver of HEC so unless land clearance is halted and reversed, we can predict that HEC will escalate.

- ***Promote pragmatic land use planning:*** where farms are already established, crops that attract elephants, such as sugarcane, should not be planted within 1km of the wildlife sanctuary boundary, especially in known crop-raiding areas.

- ***Consider elephant needs and behaviour:*** Negative sentiment towards elephants is detrimental to the elephants and to wildlife conservation. This can be addressed by giving priority to community outreach to better understand attitudes, foster collaboration, and support the local communities through targeted human-elephant co-existence programmes.

Figure 39: Elephants by a pond in Thung Salakpra, the core area of the sanctuary for this and other lowland species.

Figure 40: View over Thung Salakpra; this lowland basin is optimal elephant habitat, but it is unprotected and needlessly exposed on its eastern side, making it extremely vulnerable to harmful human activities.

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Appendices

Appendix I – Data Collection Sample Sheet

Date: Survey ID: Transect ID:	Sheet No. of Transect Length: Survey Zone:	Surveyors: Navigator: Data recorder:

1. WPT no.	2. UTM Ref.	3. Habitat Type	4. Observation	5. Distance from transect line	6. Dung Class	8. a) Diameter of bolus (cm), b) Circumference of bolus (cm), c) Number of boli, d) Number of intact boli, e) Dung condition, f) Circumference of footprint	9. Notes	10. Photo ref. number

Guide for filling in data sheet

Column 1 – Waypoint number: from GPS

Column 2 – UTM Ref.: from GPS

Column 3 – Habitat type: based on dominant vegetation type

MD	Mixed deciduous forest with bamboo
MBo	Bamboo dominated mixed deciduous forest
DD	Dry dipterocarp forest
DE	Dry evergreen forest
HE	Hill evergreen forest
ME	Moist evergreen forest
P	Pine forest
G	Grassland
Sav	Savanna forest
2	Secondary forest
Sc	Scrub/degraded vegetation
B	Bamboo – almost entirely
AA	Eucalyptus plantation
Ag	Agriculture (note: what type of agriculture)

Column 4 – Observation type: mark waypoint in GPS

E	Elephant
H	Human activity
N	Natural feature
WL	Wildlife sign (notes: species, details i.e. footprint, dung, carcass)

Column 5 – Observation type detail

Type of elephant (E) evidence

D	Elephant dung
FP	Elephant footprint (notes: direction of travel, length of trail)
O	Other (notes: sightings, feeding sign, rubbing mark etc..)

Type of human (H) presence

Hu	Hunting (notes: sound, cartridges, old camp, people)
BC	Bamboo cutting (notes: bamboo type)
L	Logging (notes: big/small trees, hard/soft wood, old/new)
C	Cattle (notes: animals, tracks, dung, people)
R	Human rubbish
F	Fire
P	People doing other things (note: activity e.g. mining)

Type of human (H) presence (continued)

NTFP	Non-timber forest product (note: what collected)
TVN	Vehicle tracks new
TVO	Vehicle tracks old
TBC	Bamboo cutter trail
TF	Foot trail

Type of natural (N) feature

WRS	Running stream
WSS	Stagnant stream
WSD	Dry stream
WPW	Pond with water
WPD	Dry pond
WS	Spring
MLW	Mineral lick wet
MLD	Mineral lick dry
NF	Natural fire

Column 6 – Distance from transect: distance of the feature from the centre line of the transect (m)

Column 7 – Dung Class

D1	Fresh dung still intact, smells, mucous coating, may have insects, likely dropped in last 24 hours
D2	All dung intact but dry, no mucous and no smell, likely dropped within 2-3 days
D3	More than 50% of dung boli intact, still moist and 'sticky'
D4	More than 50% of dung boli broken, little moisture or substance
D5	Dung is dry, each bolus is disintegrating, still has some substance but no moisture
D6	Sign of dung pile but no substance or structure/shape

Column 8 a-f – Details of (E) elephant sign

a	diameter of bolus (cm) – take measurements from 3 boli and average if possible
b	circumference of bolus (cm) – take measurements from 3 boli and average if possible
c	number of boli – estimate if not all intact
d	number of intact boli
e	dung condition – notes: e.g. disturbed, broken, eaten by dung beetles
f	circumference of footprint – measure front footprint

Column 9 - Notes

Appendix II – Elephant Dung Classification

(i) ECN dung stage classification

Stage	Description
D1	Fresh Dung still intact, smalls, mucous coating, may have insects (likely dropped within last 24 hours)
D2	All dung intact but dry, no mucous and no smell (likely dropped within 2-3 days)
D3	More than 50% of dung boli intact, still moist and 'sticky'
D4	More than 50% of dung boli broken, little moisture or substance
D5	Dung is dry, each bolus is disintegrating, still has some substance but no moisture
D6	Sign of dung pile but no substance or structure/shape

(ii) Dung size/age classification

(Jachmann & Bell, 1984; Hedges & Tyson, 2002; Pollard, et al., 2008)

Bolus Circumference	Age Class
≤ 20 cm	Calf (<1 year)
20 – 30 cm	Juvenile (1-5)
30 – 42 cm	Sub-adult (5-15)
≥ 42 cm	Adult (15+)

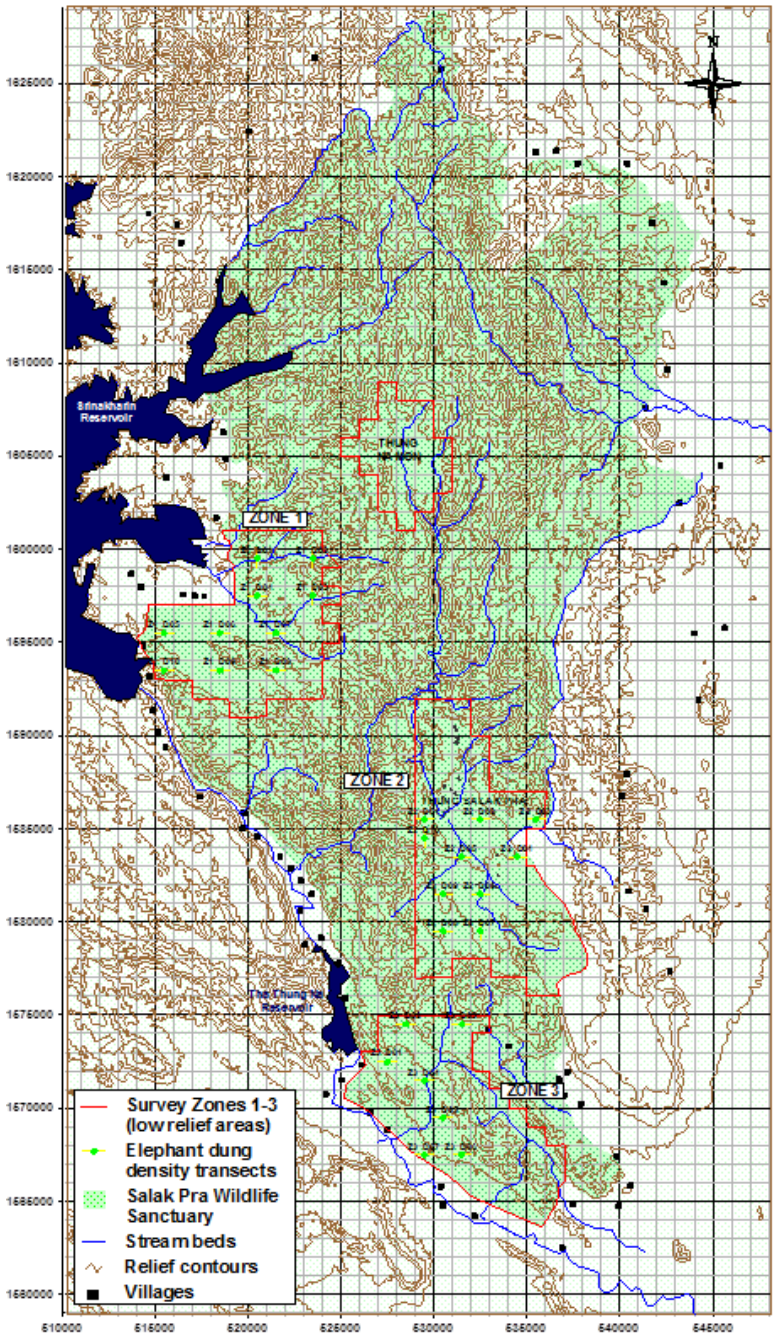
Appendix III – Previous ECN survey data

Elephant dung encounter-rate data previously collected by ECN in and around Salakpra WS:

(i) Salakpra WS forest surveys

Data collected from forest surveys 2006 – 2007 (ECN, 2008a).

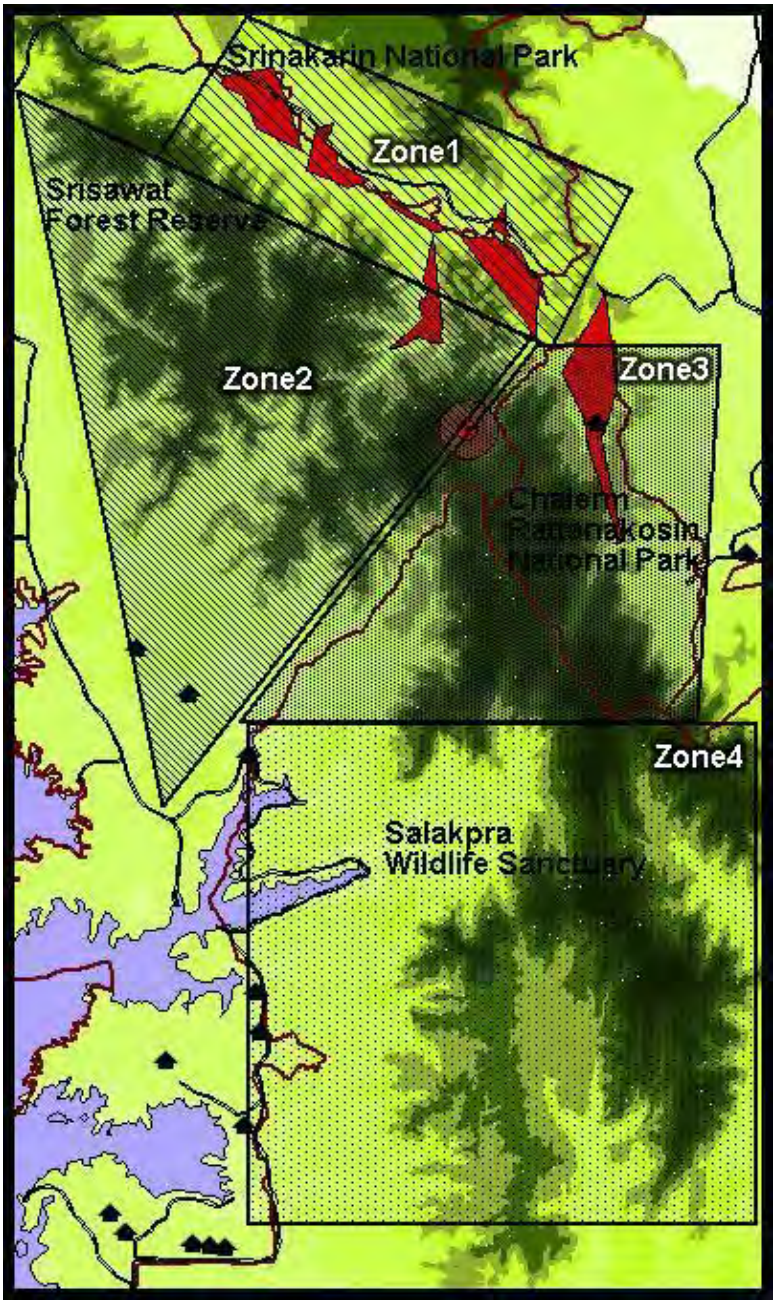
Survey Season	Chongla		Thung Salakpra		Mong Kratae	
	Mean	s.d.	Mean	s.d.	Mean	s.d.
Dry	9.2	6.9	22.4	12.7	17.9	17.9
Wet	17.0	7.7	17.7	13.0	17.3	9.4
Cool	5.7	5.0	23.7	11.8	16.9	11.0



(ii) Srisawat corridor survey data

Data collected from Srisawat corridor survey March – July 2007 (i.e. dry/wet season) (Stewart-Cox, et al., 2007).

Survey zone	Location	Mean encounter rate	Standard deviation	Range
1	Corridor-Srinakarin	0	0	0
2	Srisawat Forest Reserve	5.7	3.3	0.6 – 10.3
3	Chalerm Rattanakosin NP	7.0	3.3	0 – 11.7
4	Salakpra WS	10.0	4.9	3.3 – 16.5
	Total	**7.6**	**4.4**	**0 – 16.5**



Appendix IV – Correlation half matrixes

(i) Correlation half matrix for all human activities separately

MD																							
0.44	MBo																						
-0.31	-0.23	DD																					
-0.18	-0.19	-0.11	G																				
-0.20	-0.32	-0.13	0.28	Sc																			
-0.37	-0.31	0.01	-0.13	-0.19	B																		
-0.32	-0.33	-0.19	0.84	0.21	0.36	Ag																	
0.08	0.32	0.05	-0.08	0.19	-0.14	-0.14	H																
0.06	0.40	0.28	-0.10	-0.30	0.14	-0.09	-0.19	BC															
-0.20	-0.07	0.75	-0.11	-0.07	0.28	-0.01	0.24	0.51	L														
0.40	0.40	-0.18	-0.10	0.33	-0.22	-0.18	0.09	0.11	0.05	C													
0.04	0.23	-0.23	0.33	-0.09	0.31	0.43	-0.28	0.61	0.04	-0.06	R												
-0.18	-0.04	-0.28	-0.14	0.12	0.75	0.31	-0.11	0.09	0.05	0.06	0.46	F											
0.00	0.12	0.08	-0.09	-0.24	-0.14	-0.17	-0.14	0.35	0.10	-0.02	0.15	-0.24	NTFP										
-0.05	0.16	-0.11	0.10	-0.13	0.40	0.26	-0.33	0.47	0.15	0.27	0.68	0.49	0.11	VTN									
-0.14	-0.05	0.36	0.35	-0.09	-0.18	0.17	-0.23	0.17	0.05	-0.41	0.35	-0.22	-0.27	0.02	VTO								
0.21	0.28	0.15	-0.14	0.35	-0.24	-0.25	0.66	-0.05	0.35	0.52	-0.27	-0.16	-0.21	-0.19	-0.12	FT							
-0.17	0.15	-0.12	-0.13	-0.22	-0.09	-0.23	0.07	-0.13	-0.35	-0.05	-0.27	-0.20	-0.05	-0.06	-0.21	-0.13	NF						
0.01	0.16	0.25	0.04	-0.38	-0.18	-0.09	0.06	0.18	-0.04	-0.30	0.10	-0.38	0.42	0.01	0.29	-0.16	0.01	WSD					
-0.18	-0.19	-0.11	-0.06	0.21	-0.07	0.15	-0.08	-0.17	-0.11	-0.08	-0.19	0.13	-0.09	-0.23	-0.16	-0.14	-0.13	-0.21	WPD				
0.58	-0.27	-0.16	-0.08	-0.03	-0.18	-0.14	-0.12	-0.29	-0.27	-0.17	-0.13	-0.21	-0.14	-0.41	0.14	0.01	-0.19	-0.12	-0.08	MLD			
-0.02	0.30	0.05	-0.28	-0.43	-0.22	-0.37	0.02	0.00	-0.27	-0.09	-0.25	-0.37	0.28	-0.19	0.00	0.06	0.55	0.60	-0.11	-0.10	WL		
0.85	0.43	-0.26	-0.16	-0.28	-0.31	-0.29	0.12	-0.19	-0.31	0.14	-0.09	-0.09	-0.28	-0.24	0.06	0.16	-0.14	0.00	-0.16	0.59	0.03	Elephant	

Critical values of *r* with 17 degrees of freedom		
0.05	0.01	0.00
0.46	0.58	0.70

(ii) Correlation half matrix for all human activities as a single index

MD													
0.44	MBo												
-0.31	-0.23	DD											
-0.18	-0.19	-0.11	G										
-0.20	-0.32	-0.13	0.28	Sc									
-0.37	-0.31	0.01	-0.13	-0.19	B								
-0.32	-0.33	-0.19	0.84	0.21	0.36	Ag							
0.11	0.37	0.25	-0.01	0.04	0.17	0.05	H						
-0.17	0.15	-0.12	-0.13	-0.22	-0.09	-0.23	-0.28	NF					
0.01	0.16	0.25	0.04	-0.38	-0.18	-0.09	-0.09	0.01	WSD				
-0.18	-0.19	-0.11	-0.06	0.21	-0.07	0.15	-0.16	-0.13	-0.21	WPD			
0.58	-0.27	-0.16	-0.08	-0.03	-0.18	-0.14	-0.39	-0.19	-0.12	-0.08	MLD		
-0.02	0.30	0.05	-0.28	-0.43	-0.22	-0.37	-0.22	0.55	0.60	-0.11	-0.10	WL	
0.85	0.43	-0.26	-0.16	-0.28	-0.31	-0.29	-0.20	-0.14	0.00	-0.16	0.59	0.03	Elephant

Critical values of *r* with 17 degrees of freedom		
0.05	0.01	0.00
0.46	0.58	0.70

Key: E = elephants, Habitat types: MD = mixed deciduous forest, MBo = bamboo dominated mixed deciduous forest, DD = dry dipterocarp forest, G = grassland, Sc = scrub, B = bamboo forest, Ag = agricultural land. Human activities: Hu = hunting, BC = bamboo cutting, L = logging, C = cattle, R = rubbish, F = human induced fire, NTFP = non-timber forest product, VTN = new vehicle track, VTO = old vehicle track, FT = foot trail. Natural features: NF = natural fire, WSD = dry stream, MLD = dry mineral lick, WL = wildlife