ZSL Conservation Programmes

LIVING CONSERVATION

PIGS, PALMS, PEOPLE AND TIGERS

SURVIVAL OF THE SUMATRAN TIGER IN A COMMERCIAL LANDSCAPE

REPORT 2002-2004

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SUMMARY

A key strategy for ensuring the survival of the Sumatran tiger is to work on their survival outside the protected area system. Non-protected areas represent a far larger area of land, do not exclude people and therefore reduce the potential for land use conflict, and can provide connectivity between the core protected areas.

In 2002 LIPI issued a research permit to Tom Maddox on behalf of the Zoological Society of London to begin researching how tigers can survive outside protected areas. Potential for coexistence between tigers and commercial land use had already been shown in an oil palm plantation, PT Asiatic Persada (AP), in Sumatra. A combination of the plantation's readiness to adopt a management system sympathetic to tiger conservation and the Zoological Society of London (ZSL)'s belief in the importance of engagement with industry for conservation has resulted in the formation of the Jambi Tiger Project, a unique partnership between a conservation NGO, LIPI, and a commercial agricultural company that aims to establish how tigers survive with oil palm and what can be done to ensure the situation persists in a sustainable manner. Between 2001-2 the plantation created a 15 man conservation team which demonstrated without doubt the existence of at least four adult and breeding tigers on site as well as a large variety of other species. In late 2002 the project expanded, with ZSL receiving funding from the Save the Tiger Fund (STF), 21st Century Tiger, Tufton Charitable Trust and employing permanent field staff. 2004 saw repeat funding from all organisations and the addition of Rhino and Tiger Conservation Fund money for developing the plantation conservation team. Onsite infrastructure was thus established and programmes for monitoring species presence, relative abundance and any immediate threats were expanded. A total of 20 hard working and enthusiastic staff are now in place dedicated to tiger conservation and research. The ZSL and Asiatic staff share the workload, assisting each other with the patrols and scientific survey efforts as necessary. Co-operation has been fostered with the Jambi branch of the KSDA and the adjacent logging concession PT Asialog (which is also used by the tigers), both of whom are keen to find a solution to conflict between industry and conservation. The project combines a core monitoring / protection team run jointly by the plantation and ZSL with a research team that now employs three Indonesian scientists, one British researcher and one Indonesian mechanic. Research objectives for 2003-4 targeted understanding the relationship between tigers, their probable main prey (wild pigs, *Sus scrofa*) and their role of prey species as pests on the plantation.

The results show more than 40 medium and large sized mammals using the oil palm concession and borders, with other mammals of conservation interest including tiger (*Panthera* tigris) dhole (*Cuon alpinus)*, sun bear (*Helarctos malayanus),* Malayan tapir (*Tapirus indicus)*, clouded leopard (*Neofelis nebulosa)* and fishing cat (*Prionailurus viverrinus)* with little difference between the plantation concession and the more intact forest concession. However, use of the oil palm crop itself is limited and almost all species are restricted to the unplanted habitats bordering the oil palm or the Asialog forest concession. However, the degraded scrub habitats showed higher presence of many species than the apparently less degraded forest concession, including the Sumatran tiger.

Prey studies were based on night transects and randomly placed camera trap surveys. These confirmed wild pigs (*Sus scrofa*) to be the dominant ungulate and likely tiger prey present, with abundance far outweighing any other species, although at least 19 potential tiger prey species exist on site. Line transects estimated density within the oil palm and scrub habitats to be around 2.5 pigs/km^2 and agreed with camera trapping studies that densities in the forest were negligible in comparison. These densities are comparable to other pig studies but much lower than the only other oil palm study where predators were absent. Pigs were also one of the few species to show higher abundance inside the oil palm crop compared to outside in the scrub. However, studies of abundance were not as complete as hoped with the failure of capture mark recapture studies following unsuccessful trapping attempts. Line transects are

thought to be underestimating true densities and further work estimating absolute density is also required for calibrating camera trap results. Consequently, these estimates are only considered to be preliminary results. As a result of problems capturing pigs, other aspects of the prey study were also delayed and planned assessments of pig impact on the plantation are still underway.

Prey movements were investigated with two radio collared wild pig (*Sus* scrofa) and one tapir (*Tapirus indicus*). Wild pig do not wear collars well, the first releasing itself after two weeks and the second, thanks to a modified harness attachment, lasted two months. Data may not be complete, but indicate range use of approximately 5-6 km^2, both focussing on scrub / oil palm border areas. The tapir continues to be tracked well and shows a surprisingly small range of about 6 km^2, based entirely in the plantation scrub and not in the forest.

Research on the tigers based on density calculations from camera trapping rates and individual recognition of camera trap photos show that a minimum of nine and possibly even sixteen tigers have used the plantation concession and bordering areas within the last three years, suggesting densities comparable to many protected areas. At least four of the tigers were breeding residents living within the plantation concession. However, camera trap rates fell sharply in 2003-4 despite prey species and other large mammals apparently remaining stable and based on recent data the tiger population looks to be in severe trouble. Various avenues still need to be explored before conclusions drawn (for example an expanded survey is needed into the forest concession) but it appears likely that illegal land clearance is looking the most likely cause.

Tiger movements were also assessed by camera traps and all appeared to use both the plantation and forest concessions. One tiger was also successfully captured and radio collared, the first ever in Sumatra. Despite some complications receiving the signal in certain habitats, data were collected for 7 months before the tiger slipped out of the collar. During this time the tiger spent most of its time in plantation scrub, apparently never venturing into the oil palm. However, estimates of tiger ranges were not particularly improved by the radio tracking data.

INTRODUCTION

THE IMPORTANCE OF UNPROTECTED AREAS

Whilst much attention is rightly placed on species in protected areas, very little is placed on their survival outside reserves, despite the vast majority of land being unprotected and the obvious limitations on increasing protected land (Western 1989). For large carnivores in particular, it is clear that protected areas in isolation will never be sufficient for long-term conservation needs, both because of size limitations and because of the "edge" effects (Woodroffe & Ginsberg 1998) which cause surrounding areas without any wildlife management to act as a "sink" for the "source" inside the park. Undoubtedly, human-dominated landscapes have highly detrimental effects on a range of species; however, in many cases coexistence of even the most unlikely species is possible (Maddox 2002). In Indonesia, massive habitat losses are occurring outside protected areas. Forest cover has fallen from 162 million hectares to 98 million hectares between 1950 and 2000 with the current loss rate at 2-2.4 million hectares per year, a rate that should wipe out lowland diptocarp forest in Sumatra by 2005 (Glastra *et al*. 2002). In its place remains a patchwork of production forests, plantations and human habitations, now becoming the dominant landscape type in Sumatra.

THE IMPORTANCE OF OIL PALM

Of the many land uses found outside protected areas in South East Asia, of particular importance is the rapidly expanding oil palm sector. Oil palm (*Elaeis guineensis*) is a palm native to West Africa, producing fruit rich in oil from which food and non-foodstuffs can be manufactured. Land used for oil palm is important for conservation for three primary reasons.

Firstly, oil palm represents a major direct threat to many conservation interests. Initially this is by driving forest clearance. Oil palm plantations require high rainfall, relatively flat land and an altitude of below 200m - the exact same conditions as tropical lowland diptocarp forest. Consequently, most oil palm production is directly or indirectly responsible for forest clearance and consequent species loss. Furthermore, due to the rapid degeneration of the fruit, oil palm fruit cannot be transported easily and is generally produced in association with a mill. The economics of this result in large areas (several thousand hectares) of monoculture rather than small holdings of crops interspersed with other vegetation. Such large patches of monoculture are far less compatible with conservation interests that many other agricultural production methods and consequently the local impact of oil palm production is generally severe with very few other species surviving in the production areas. Finally, oil palm production also has an impact on the environment through various production methods, most notably fires used for land clearance (oil palm concessions have been blamed for many of the destructive forest fires that have blighted Indonesia in recent years) but also through chemical runoff and other local pollutants.

Secondly, oil palm crop already covers a major proportion of the South East Asian and in particular Indonesian landscape and it is expected to increase. Since the first plantation in 1911 oil palm has spread, primarily in the last ten years, to over 3 million hectares currently planted in Indonesia with Sumatra being one of the main producers (Potter & Lee 1999), (Wakker 1999). Furthermore, oil palm coverage is set to increase. Between 1975 and 1995 output of crude palm oil increased ten times, whilst consumption increases between 1990 and 1996 were higher than any other edible oil (Potter & Lee 1999). Global demand for palm oil is already at 22.5 million tonnes per year and this is predicted to rise nearly 100% in 20 years, to 40 million by 2020 with Indonesia and particularly Sumatra expected to provide at least 50% of the increase (Glastra *et al*. 2002). Consequently, 8.7 million hectares are already allocated for oil palm in Indonesia and a further 32 million hectares were under application in 1999

(Wakker 1999). By 2012 “Oilworld” predicts oil palm will become the leading vegetable oil source (Casson 1999).

Thirdly oil palm is a vital part of the Indonesian economy, bringing in 1.4 billion US$ of foreign exchange in 1997 and accounting for 31% of agricultural exports (Casson 1999) with the recent increases in demand have made it one of the fastest growing sections of the Indonesian economy (Potter & Lee 1999), Oil palm crop therefore has severe impacts on conservation, already covers much of the Indonesian landscape and is increasing rapidly and its economic importance mean that it is here to stay whether conservationists agree or not.

Consequently various conservation groups are looking at how to reduce or minimise the impacts of oil palm production on conservation. Already there is mounting political pressure on the oil palm industry and governments, both through groups concerned primarily conservation implications as well as groups more concerned with the social impacts. For example, large, politically powerful groups such as the Worldwide Fund for Nature (WWF) and Friends of the Earth are already working hard both to limit future forest losses to new oil palm by encouraging new plantations to be established on low conservation priority land and also by trying to force environmental responsibility into production through the Round Table on Sustainable Oil Palm, buyer lobbying and other methods. However, solutions are also required for existing plantations. Oil palm concessions are not good for conservation but neither are they entirely incompatible. For plantations wishing to reduce their environmental impact, or for plantations forced to reduce their impact through market forces, basic field data are required on what and how plantations can be managed to maximise their compatibility with certain conservation goals. The potential for coexistence with conservation does not apply to all species, but for some of even the most endangered species there is hope.

TIGERS AND OIL PALM

Tigers are currently facing a variety of threats throughout their range and many predictions for the future make grim reading, even in their core protected areas. For example, the Sumatran tiger (*Panthera tigris sumatrae*) is listed as “Critical” by the IUCN and is on CITES Appendix I and is the last remaining subspecies in Indonesia following the shooting of the last Balinese tiger in 1937 and the extinction of the Javan in the early late 1970s / early 1980s (Seidensticker & Suyono 1980). The number thought to remain in the wild is about 400 in protected areas, with a further 100 estimated in other forested areas (Franklin *et al*. 1999). However, whilst many populations in protected areas are monitored, almost no research has been carried out in areas outside protected areas and the accuracy of these figures is unknown. Inside the National Parks, tigers face a daily risk of habitat loss, prey depletion and direct poaching and are surrounded by a sea of agricultural plantations, increasing human populations and decreasing forest coverage. On first appearances the future looks bleak. However, tigers are a surprisingly adaptable species (Sunquist *et al*. 1999) and apparently inhospitable cleared or agricultural land does not necessarily represent a barrier to tigers (Seidensticker 1987). Tigers therefore can and do survive in even the most unlikely environments, including an oil palm-forest matrix (Zoological Society of London 2003a). However, how tigers survive in such a landscape and to what extent is still largely unknown. If the future of Indonesia’s last tiger subspecies is to be ensured, its survival in the unprotected matrix of commercial forests, plantations and inhabited areas that already dominate its last refuges must be understood. If the conditions that allow their survival can be identified and their persistence ensured, the fragile populations in protected areas may suddenly look more hopeful as they are interlinked by their little understood cousins in Sumatra’s commercial landscapes.

THE NEED FOR CONSERVATION ACTION IN COMMERCIAL LANDSCAPES

NGOs need to take a lead in the development of conservation in commercial landscapes in Indonesia for three reasons. Firstly the development of commercial landscapes is a problem for the Indonesian government, torn between the need to earn revenue and develop a country still suffering from the impact of the economic crash in the late 1990s and concern about loss of natural resources and international opinion. The resulting dilemma means the future of the patchwork of forest and agriculture that covers Sumatra is still very much in the balance and the government is actively looking for viable solutions, although few are available. Second, the key government organisation responsible for wildlife protection in such areas (the KSDA) is seriously under-funded and frequently overlooked in favour of their higher profile colleagues working in better known reserves and National Parks. Whilst tiger areas in Sumatra such as Kerinci-Seblat National Park and Leuser National Park have been the focus of multi-million dollar funding programmes, the less glamorous KSDA struggles to operate on a minimal budget despite operating in a far larger and possibly more difficult area. Thirdly, an understandable hesitancy on the part of conservation organisations to engage with commercial organisations is restricting the search for solutions and despite the importance of understanding how tigers and other species survive outside protected areas this field is still relatively unexplored. Consequently there is little experience and few guidelines on how to develop the conditions that enable coexistence between wildlife and human interests and this forms a clear management void. It is therefore essential to raise the profile of wildlife in commercial landscapes through such projects as this, demonstrating that the two are not completely incompatible and developing guidelines for other areas to follow.

PROJECT BACKGROUND

THE ZOOLOGICAL SOCIETY OF LONDON

The Zoological Society of London is a registered British charity with three primary areas of interest:

1. Zoological collections (London Zoo, Whipsnade Safari Park)
2. Scientific research and education (Institute of Zoology)
3. Field conservation (Conservation Programmes)

The Jambi Tiger Project represents all three aspects of the society; in the zoo, members of the public can see Sumatran tigers, with gate revenues contributing to core funds that allow the society to support research and conservation. The Institute of Zoology is an internationally renowned centre for research, with specialists in large carnivore ecology, conservation macroecology, genetics and many other disciplines. Conservation Programmes then links the zoo and research aspects whilst also bringing in external funding to form a number of science-based conservation programmes based *in situ* around the world.

PT ASIATIC PERSADA

PT Asiatic Persada (AP) is an oil palm plantation company originally formed in 1979 under the name of PT Bangun Desa Utama, (PT BDU). It subsequently acquired two subsidiaries, PT Maju Perkasa Sawit (MPS) and PT Jammer Tulen (JT) which were added in 1985 and 1986 respectively, taking the total concession size to 27,000 hectares after which the company changed its name to Asiatic Persada in 1988. Initial oil palm plantings took place in the same year with the final plantings in 1996. In 1994 a central processing mill was placed on site and production started in 1997. Pacific Rim Palm Oil Limited, (PRPOL), acquired a majority holding of 51% in AP in early 2000 and took over management in February 2000. Major forest fires in 1997, destruction of young plantings by wild pigs and poor maintenance of plantings during the economic crisis reduced the original area of cultivated land to approximately 9000ha. PRPOL's initial work has been to concentrate on the rehabilitation of existing areas prior to extending plantings. However, the plantation plans to increase production in the coming years from 45,000 tonnes of crude palm oil (CPO) to 63,000 tonnes in 2004. Between 2002-6 the area under cultivation is expected to rise to a final planted area of 22,953 ha (85% of the concession). It is within the context of this expansion that developing management practices conducive to conservation are so important.

AP and PRPOL have already demonstrated a commitment to environmental issues. AP operates under ISO 9000 and was recently awarded ISO 14000. As a company, PRPOL are committed not to develop natural forest with the ability to regenerate, specialised ecosystems or vegetation that serves important environmental functions. They also aim to promote forest regeneration, genetic diversity and intend to create a series of interlinking conservation areas constituting 15% of the concession with unplanted buffer zones along all rivers. Furthermore, PRPOL have stated they intend to reduce hunting and trapping and implement specific management schemes for endangered species (PRPOL 2003).

COLLABORATION BETWEEN PT ASIATIC PERSADA AND ZSL

In 2000 an environmental audit conducted for PRPOL by LTS International Ltd. identified 30 species of conservation concern likely to be present on site including tigers, clouded leopards, sun bears, Malay tapirs and crested firebacks. AP then actively approached the conservation community for help and advice specifically for the tiger issue and the options of translocation, compensation or in situ conservation were discussed. Chris Carbone of the Zoological Society of London (ZSL) then visited the site in 2001 and a policy of in situ conservation was established. Initially a team of Indonesian conservation scouts was recruited on site and joined by a British volunteer consultant, Robert Gordon. Together they conducted low level camera trapping, funded by AP and ZSL, which confirmed the existence of at least four adult tigers within the concession and began an anti-poaching programme, removing snares and patrolling tiger habitats.

RESEARCH PROGRAMME 2002-2004

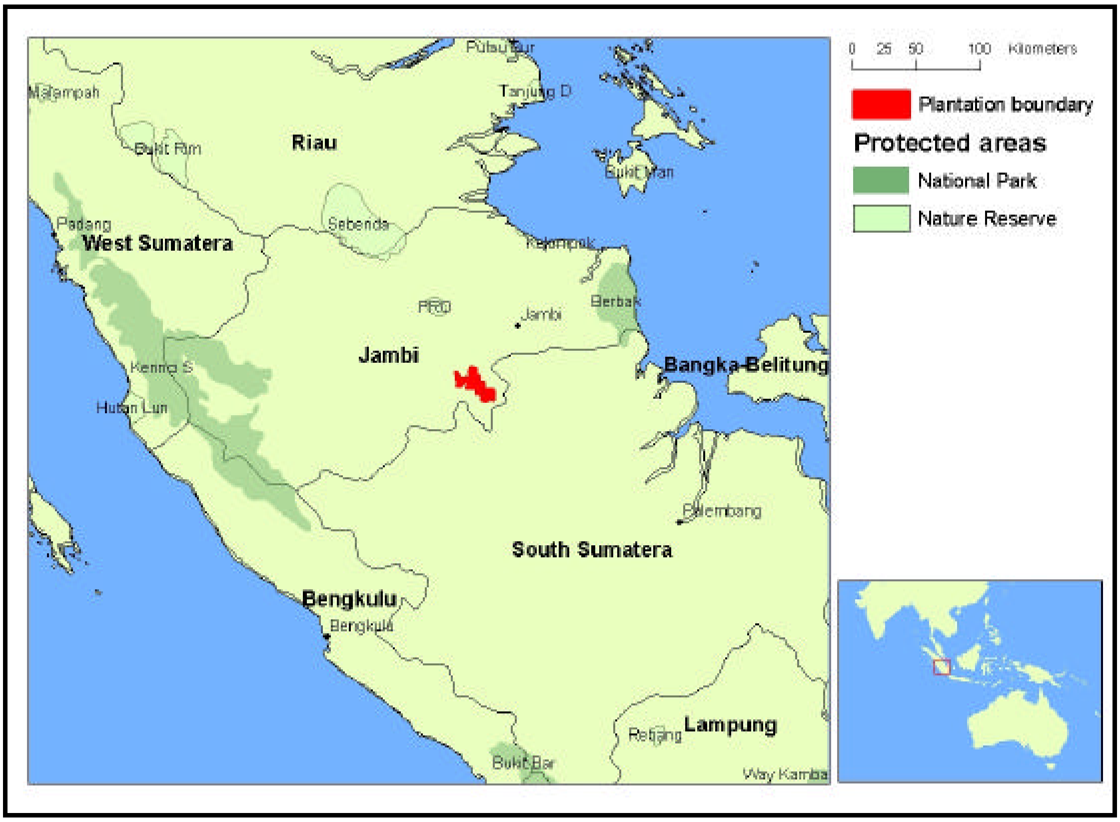
The initial results convinced ZSL both of Asiatic's commitment to the project and of its importance for tiger conservation and led in 2002 to an application to LIPI to carry out research on tigers at Asiatic Persada. LIPI granted a permit for one year (later extended for two six month periods to two years) and ZSL recruited a full time field conservation manager, obtained funds from external funding bodies and brought the project into the ZSL Carnivores and People Programme. The ZSL / Asiatic Jambi Tiger Project now has in place a total of 20 hard working and enthusiastic staff dedicated to tiger conservation. The ZSL and Asiatic staff share the workload, assisting each other with the patrols and scientific survey efforts as necessary. The managerial and infrastructural support provided by PT Asiatic Persada is invaluable to the project as a whole, providing an environment where fieldwork can be carried out efficiently and safely, with accommodation, access to telephone and email communications, and accounting, secretarial and personnel services all provided. In return, ZSL has invested heavily in the project, bringing in core funding as well as grants from external funders. Together we form an almost unique conservation-industry partnership that is collecting some of the first vital data on for tiger conservation outside protected areas in Sumatra whilst rapidly gaining the attention of the national and international communities and providing a glimmer of hope for the tiger in Indonesia.

PROJECT SITE

LOCATION

The study is located within and around the 27,000 hectare oil palm concession owned by AP in Jambi Province on the island of Sumatra, Indonesia, approximately 90 km from the city of Jambi. The nearest protected areas are Berbak National Park (119km) and Kerinci-Seblat National Park (170 km).

Figure 1 - Location of study site within Sumatra



HABITAT TYPES

Not all of the AP concession is covered by oil palm crop. At time of writing, oil palm covered about 10,000 ha, or approximately 40% of the concession. The remaining 60% consists of two main habitat classes:

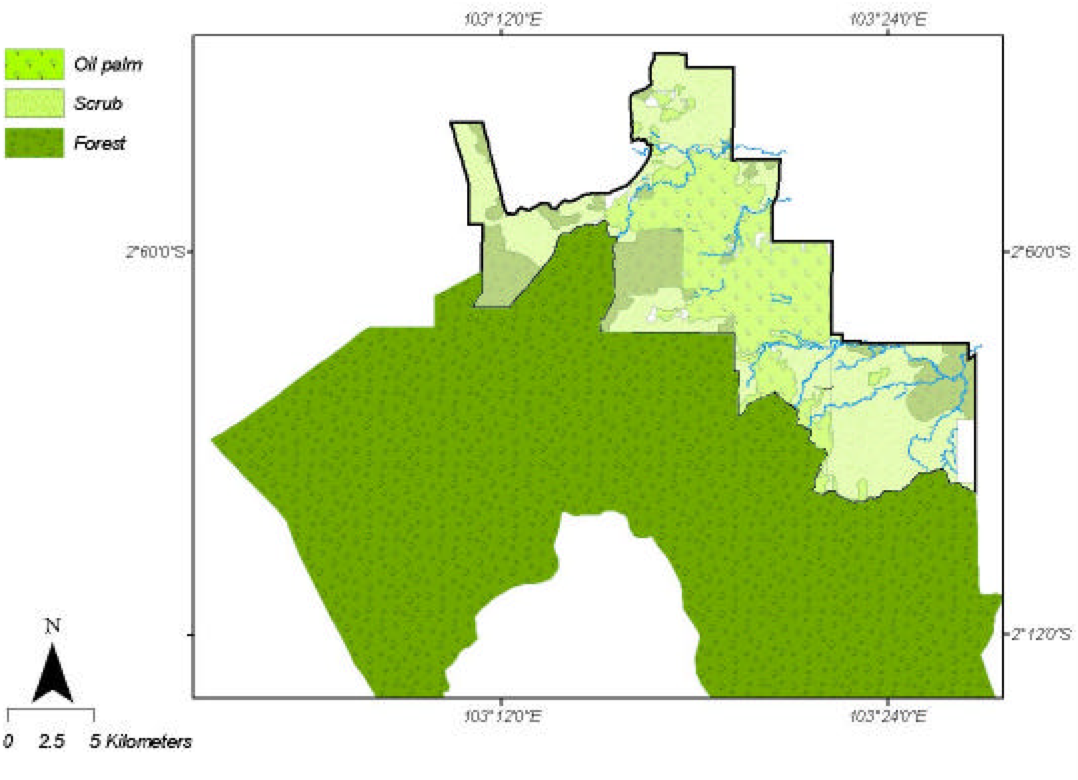
- "Degraded secondary forest" – areas previously belonging to a logging concession and since unused. These areas are a macaranga-dominated low canopy with a thick under story of gingers, bamboos and palms

- "Scrub" - areas cleared in the past for planting, but since re-covered in thick, bamboo-dominated scrub

Figure 2 - Broad habitat types within the study area: from top; oil palm crop, secondary forest, scrub re-growth

Most of the non-oil palm habitat is concentrated in two of the five estates; Jammer Tulen and Bungin (see Figure 3). The current tiger research is based in these two estates, although reports of tiger activity have also been made in Tanjung Johor estate. The Asialog concession consists of secondary forest, with a relatively thick undergrowth and broken canopy, but the height of the canopy is noticeably different from areas within the plantation.

Figure 3 - PT Asiatic Persada and adjoining forest concession showing the five estates and broad habitat types



PROJECT GOALS AND OBJECTIVES

PROJECT VISION

The project takes the assumptions explained in the introduction that:

- Successful conservation cannot be conducted in isolation from economic development
- Successful conservation requires an effective, coordinated strategy in both protected AND non protected areas
- Commercial landscapes are a key form of unprotected area, representing both a major potential threat to many conservation interests as well as a vital component in economic development. However, they also have the potential and ability to improve coexistence with conservation concerns.

The vision of the project is therefore to use good science and good field data to aid the development of conservation understanding and management in unprotected areas in particular, allowing the formulation of an integrated conservation strategy that covers both traditional protected conservation areas as well as sub-optimal commercial and other unprotected areas.

Initially the project is focusing upon the particular issues of tiger conservation and oil palm production. The first objectives therefore focus on trying to understand how and why tigers are surviving in commercial landscapes and what can be done to ensure this situation persists whilst conflict remains at a minimum.

INITIAL OBJECTIVES

The initial objectives as stated in the original proposal to LIPI were:

1. Obtain measures of the size, distribution and mobility of wild pig / tiger prey populations
2. Monitor pig diet
3. Measure pig crop damage
4. Estimate financial costs of keeping pigs
5. Understand tiger population, feeding and ranging ecology
6. Inform plantation workers on tiger safety
7. Develop recommendations on pig control
8. Understand the impacts of pig culling for tiger conservation in Sumatra
9. Strengthen the capacity of the Indonesian research / conservation team

MODIFIED OBJECTIVES

As time progressed and the project developed, it became clear that these objectives were rather optimistic for the initial one year time period or even the two years following extensions. In addition, as the project developed and the situation was better understood, new research angles not considered in the original proposal became more important and following discussion with LIPI certain aspects of the original proposal were altered (for example a radio tracking component became a central objective in mid 2003). For the purpose of this report the above objectives have therefore been re-grouped into four main objectives which are then covered by the results in this report. These objectives are:

Objective 1: Establish the infrastructure, foundations and base data for a long-term tiger research project (covering initial objectives 6 and 9)

Establishment of the Jambi Tiger Project was formed by the collaboration of two organisations with very different objectives that had never worked together before and in an area where almost nothing was known from previous literature. This objective therefore laid the foundations for all further research through four main aims:

1. Establishment of a joint research / conservation programme between ZSL and Asiatic

2. Establishment and development of a research team on site

3. Establishment and development of a permanent monitoring / patrolling team on site

4. Establishment of communication and information channels between conservation and the plantation

Objective 2: Provision of a basic ecological picture of the conservation status of the study site (not in initial objectives)

As well as a lack of experience in NGO-commercial company collaboration, there is almost no information on the basic ecological condition of oil palm habitats. This objective therefore aimed to establish basic information on:

1. Species diversity

2. Species distribution

3. Threats to conservation

4. Relative abundance

Objective 3: Understand tiger prey ecology and interactions on the site (covering initial objectives 1,2,3)

Prey availability has been shown to be one of the key factors in determining tiger success (Karanth & Stith 1999) with a close relationship between prey and tiger density (Sunquist *et al*. 1999). Initial data from 2001 suggested that the oil palm supports a particularly high density of wild pig (*Sus scrofa*) which benefit from eating both fallen fruit and sapling trees (Ickes 2001). Since wild pig are a common prey item for tigers in other studies it has been hypothesised that their high density around oil palm is key to the survival of tigers in this study area. However, pigs are also a key species because they are perceived as a major pest for the plantation who consequently would like to see their numbers as low as possible. This may lead to conflict between tiger requirements and commercial requirements. Prey studies are therefore being concentrated on the pig population, trying to determine population size and extent of damage to the plantation. Assessment of tiger prey status is covered with three main aims:

1 Calculate the abundance of pigs and other potential tiger prey using the plantation habitat

2 Understand the impacts pigs and other species have on oil palm production

3 Produce guidelines on the likely impacts of pig-control on tiger populations together with recommendations for the reduction of conflict.

Objective 3: Understand tiger ecology in and around an oil palm concession (covering initial objective 5)

Determining the basic population parameters of a tiger population is clearly an essential first step when beginning a tiger study. However, we are also particularly interested in *how* the tigers are surviving in a commercial landscape. Such information is key if we are to ensure their survival is continued. The fourth objective therefore attempts to estimate the number of tigers using the area and also to trap, radio-collar and track a subsection of the population to determine how they use the oil palm and surrounding habitats.

1 Estimation of the number of tigers using the plantation

2 Investigate ranging patterns and habitat use.

Remaining objectives:

Objectives 4,7 and 8 could not be attempted at this time. These are long term objectives that will require the collection of several years more data before sensible recommendations and quantifications can be made.

PROJECT FUNDING AND SUPPORT

During the two years of research, the Jambi Tiger Project has received numerous backing:

- The project is sponsored in Indonesia by LIPI-Biology and was run under a research permit issued by LIPI (the Indonesian Institute of Sciences).
- The project is hosted by PT Asiatic Persada who provide some of the infrastructure on site.
- Support has also been given by the PHKA and BKSDA Jambi, with specific permission for radio collaring granted by the PHKA in Jakarta whilst the Jambi BKSDA are continually involved in the research, seconding two members of staff to the project.
- Core funding for salaries and some equipment is provided by ZSL
- Funding for prey research for 2003 and prey research and tiger ranging studies in 2004 was granted by the Save the Tiger Fund
- Funding for tiger ranging research for 2003 and 2004 was granted by 21st Century Tiger
- Funding for development and training of an anti-poaching and monitoring team in 2004 was granted by the Rhino and Tiger Conservation Fund (RTCF)
- Funding for veterinary and trapping consultants to join the project in 2003 and 2004 was granted by the Tufton Charitable Trust.
- Additional funding and support was granted by BSI Travel, the International Zoo Veterinary Group and Chessington Zoo.

GENERAL METHODS

CAMERA TRAPPING

Camera trapping is an increasingly widely used technique used for monitoring elusive prey in habitats where visibility is poor, based on cameras that can be left in the field and are triggered to take a photograph when passed by an animal. The resulting photographs can either give a rough indication of relative abundance (Carbone *et al*. 2001), an estimate of minimum population size based on individual recognition or sophisticated estimates of density based on capture mark recapture if data are sufficient (Karanth 1995). Cameras are already in use for tiger research *e.g.* (Karanth & Nichols 1998) but are also used for a variety of other species including bears (Mace *et al*. 1994), small carnivores (Moruzzi *et al*. 2002) and ungulates (O'Brien *et al*. 2003). In this study, 44 "Camtrakker" cameras were used with passive sensors (*i.e.* they are triggered by a combination of heat and movement). However, due to various problems with the cameras (see *Problems with "Camtrakker" camera traps* p.90) there were rarely 44 in cameras in operation simultaneously. The results from the cameras were used to help achieve all of the project objectives.

Cameras were set up in one of two ways. Some cameras, referred to in the text as "Tiger cameras" were used to target tigers and were set up on tracks with known tiger activity, particularly at junctions to maximise the chances of a tiger passing. Ideally such cameras should be set up in pairs to allow both sides of recognisable animals to be photographed (Karanth & Nichols 2002); however, the tiger cameras were primarily set up to keep track of already known tigers rather than to survey new areas, therefore cameras were set up singly but over a larger area. Other cameras, referred to as "Prey" or "random" cameras were set up randomly so as to minimise bias in the species targeted or the chances of photographing individuals. These cameras were set up in grids of sixteen cameras in a 4x4 configuration, with 500m spacing between cameras. The grids were then placed in target areas along UTM gridlines. The actual camera position was flexible within 100m of the randomly chosen point to avoid placing cameras in positions with almost no chance of any photographs (for example in the middle of a thick bush) and cameras were placed on animal trails, tracks, watering holes or crossing points within this leeway. In general, cameras placed within the oil palm could almost always be placed at the exact random point due to the openness of the habitat, whereas cameras in the thicker scrub often had to be placed away from the pre-chosen point due to accessibility.

Figure 4 - Map of study area showing randomly placed camera grids (blue) and non random tiger cameras (black).

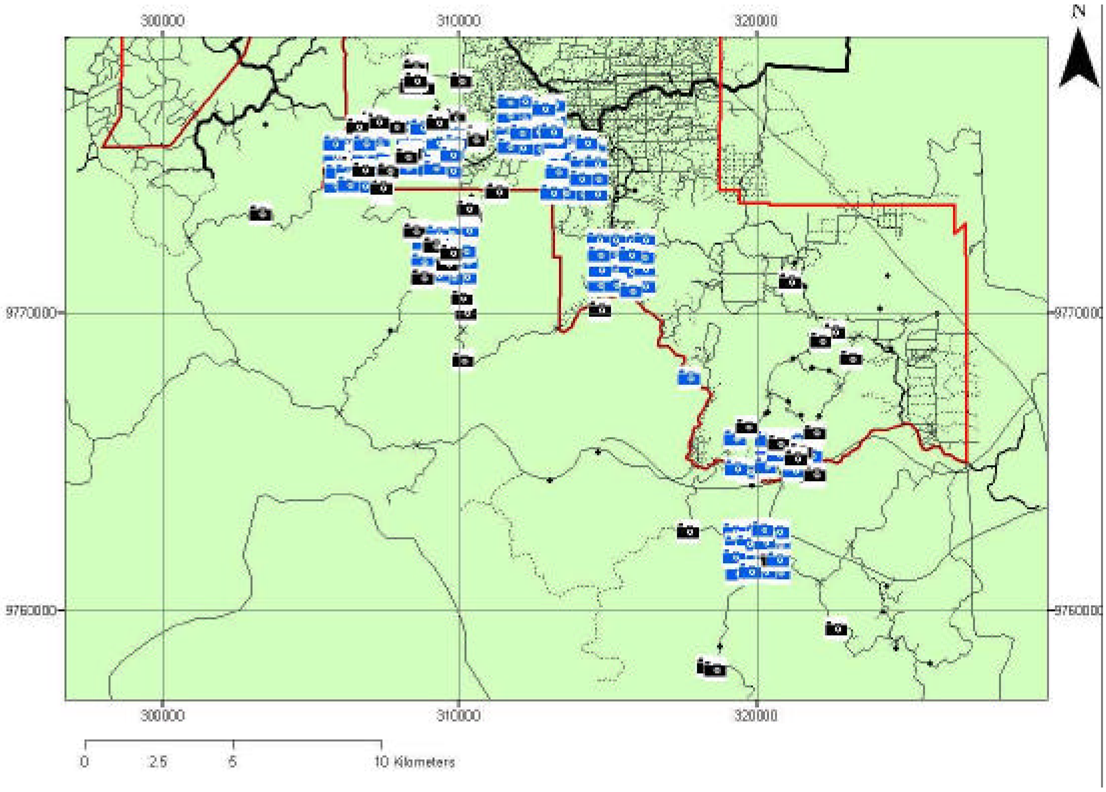


Figure 5 - The two types of camera used on the project: Camtrakkers (left)and Trailmaster Photoscouts. Following persistent theft and vandalism some cameras are now set up in metal cages, sunk into concrete bases (right).

In almost all cases, cameras were attached to trees about 1-2m from the expected path of the animal and generally about 30-70cm above the ground (depending on vegetation length). Cameras were aimed at an animal the size of a crawling or crouching human.

Details on the date of installation, film name and location were recorded, the camera secured against theft with a chain and a polite notice requesting finders not to disturb was nailed above the camera. Cameras were generally left 1-2 weeks before checking on the film and battery status, although this varied for cameras expected to run out sooner. In total, "Prey" cameras were left in position for one month, giving a maximum of 496 trap nights (16x31), if every camera worked for every night. "Tiger" cameras were more permanent and left indefinitely when a successful location was identified.

Once films were finished they were developed in Jambi and the negatives scanned into a central database. Details of every *individual* on each photograph are entered into the database and all records linked with the scanned image.

The number of camera trap nights and trapping rates could then be calculated in two ways. Firstly, a simple count of the number of 24 hour periods each camera was left in the field can be used. However, on many occasions a camera will have run out of film, or batteries, or had stopped working whilst still in the field. Therefore using the actual number of trap nights overestimates the amount of time cameras were actually operational in the field. The *effective* number of trap nights is therefore calculated as the time when the camera was definitely working (see Table 1). Use of a test card when checking cameras is therefore particularly important since if a camera is taken down without checking it is still working, all of the trap nights between the last photo and the date taken down have to be discarded as we cannot be confident the camera was working during this period. All referrals to trap nights in this report refer to effective trap nights unless stated otherwise.

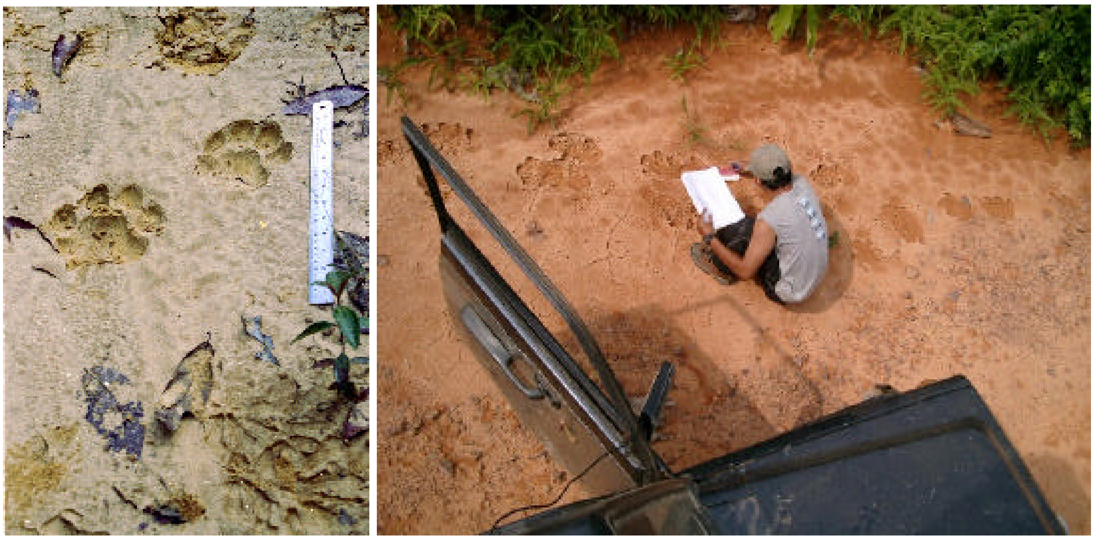
Table 1 - Calculation of effective camera trap nights

Day	Event	Negative number	Trap nights
1	Camera set up and tested with test card	1	7 effective trap nights
2	Animal passes	2	
4	Animal passes	3	
7	Animal passes	4	
8	Batteries die		
9	Animal passes		
10	Camera checked, batteries replaced and camera tested with test card	5	10 effective trap nights
12	Animal passes	6	
14	Animal passes	7	
15	Animal passes	8	
16	Animal passes	9	
20	Animal photo, film ends	10	
21	Animal passes		
24	Animal passes		
25	Camera checked, film replaced, camera tested with test card	1	6 effective trap nights
27	Animal passes	2	
29	Animal passes		
31	Camera checked, tested with test card and taken in		
Actual trap nights			31
Effective trap nights			23

SECONDARY SIGN SURVEYS

Secondary signs (footprints, faeces, scrapes *etc.*) of wildlife are recorded whilst walking known distances along man-made tracks. Footprints are identified using a collection of mammal footprint ID guides and all tracks are measured to allow later checking for false identifications. Records are also classed according to confidence, with 1 being a positive identification and 3 being a guess.

Figure 6 - Recording tiger tracks (left) and tapir tracks (right)



LINE TRANSECTS

A group of methods commonly used for estimating wildlife density and abundance are quadrat-based methods, such as strip transects or point transects, whereby all individuals within a set distance from a transect line or point are counted and densities estimated by dividing the total count by the area surveyed (*e.g.* see Caro 1999 or Bergstrom & Skarpe 1999). However, such methods assume that all individuals within the surveyed area are recorded, an assumption rarely met and impossible to test using the survey data (Thomas *et al*. 200). Furthermore, such methods are wasteful since to increase the probability of recording all individuals the surveyed area has to be very small, thereby discarding up to 60-80% of observations (Anderson *et al*. 2001). An extension of quadrat-based methods are line and point transects in which the perpendicular distance to the sighting is recorded (Buckland *et al*. 1993). Assuming that objects are spaced randomly with respect to the transect and that detection probability at distance 0 is 100%, the increasing number of missed sightings with increasing distance can be modelled using a detection function and thus the proportion of missed sightings estimated. In this study, line transects were primarily used for the prey biology objective, since they have been previously used to determine a pig population index in Australia (Choquenot *et al*. 1993) and to estimate pig density in lowland rainforest in Malaysia (Ickes 2001). However, spotlight transects were also useful for monitoring overall biodiversity around the plantation.

Transects in this study were all conducted by road since large distances needed to be covered to obtain any sightings but also because animals are frequently less concerned by vehicles compared to humans on foot. Ideally, in order to meet the assumption sightings are distributed independently from the transect, transects should not be conducted by road since many animals move away from roads (and a few move towards roads) (Buckland *et al*. 1993). However, random transects were not an option even in the relatively open oil palm so man made tracks had to be used. The use of small tracks has been shown not to give significantly different density estimates in other studies (Maddox, *in prep.*). Since pigs appeared to be primarily active at night, transects were driven in the dark both in the evening and early in the morning. Each transect was driven at a speed of about 15kph with two observers on the vehicle roof with one 1.5 million candle power spotlight each. For each transect, the distance driven, time and habitat type were recorded and the perpendicular distance from the transect to each sighting group noted (Buckland *et al*. 1993). Distance estimation was made by eye.

Ideally, transects would be placed in the same areas as alternative survey methods such as the 2x2 km trapping areas used for random camera traps (above) and CMR (below). However, these areas were too small to allow transects to be conducted completely within them therefore transect surveys were conducted at a larger scale and driven throughout the plantation in oil palm, scrub and forest habitats. Placement of transects was heavily biased to oil palm habitats since few roadworthy tracks were available in other habitats. The line transects are therefore used primarily to support and calibrate other survey methods used in the oil palm, although some comparisons of densities in other habitats could also be drawn. Data from transects were entered into a database and analysed using *Distance* software (Laake *et al*. 1998).

WILDLIFE CAPTURES

EXPERTISE

All wildlife captures have been carried out under the supervision of either the Jambi KSDA, Bart Schleyer (a professional wildlife trapper originally from WCS Russia) or Dr. John Lewis (a veterinarian from the International Zoo Veterinary Group specialising in large mammal anaesthesia). For some captures all three were in attendance.

Figure 7 - Bart Schleyer, wildlife trapping consultant (left) and John Lewis, veterinarian consultant (right)

TRAINING

Bart and John provided intensive training to both the research team and the KSDA on wildlife trapping techniques, darting and the use of anaesthesia. Initial training was provided in March 2003 at the Veterinary Training for Wildlife Professionals Workshop in Jambi jointly organised with FFI Indonesia where lectures were given by John, Bart and veterinarians from Taman Safari with practical demonstrations on zoo animals. Attendees included the Jambi KSDA, PolHut from various National Parks, government veterinarians from Jambi and members of the Jambi Tiger Project and FFI Tiger teams. John then provided further training on dart gun use for the Jambi KSDA at Asiatic Persada whilst Bart and John spent a total of 4 months intensively training the ZSL team. Tom Maddox also attended further training in the UK with John, assisting with various anaesthetisations at zoos in the UK. As a result the team is now competent at capturing, anaesthetising, handling, processing and releasing large mammals.

Figure 8 - John Lewis of the IZVG demonstrating tiger anaesthesia at the "Veterinary Training for Wildlife Professionals" workshop in Jambi 2003

Figure 9 - Dart gun training with the Jambi KSDA

REMOTE DART GUN

Two capture methods were attempted in 2003. The first was a remote-controlled video dart-gun, developed by KORA (a Swiss group dealing with the conservation and management of carnivores in Switzerland) who kindly provided one on loan. This device consists of a modified dart gun complete with a motion sensor, video monitor, aiming controls and infra-red light, and reduces the stress experienced by the animal during capture to a minimum. The apparatus is controlled from a hide approximately 200 metres away by a hidden operator. If any animal walks in front of the device, the motion sensor alerts the operator who can then fire the dart using the video camera and remote controls to adjust the aim. Experience in Switzerland has shown that the darted animal, unaware of a human presence, quickly falls asleep, usually within metres of the target site.

The remote dart gun was set up between 18:00 and 8:00 the following morning on a total of 14 nights with three to four people monitoring the gun area from the hide using the video monitor. It was first tested in the Jammer Tulen part of the plantation, then moved to Asialog. To attract tigers to the site, the team tried a variety of baiting methods including non-living bait (variously fresh meat, offal, fish and durian fruit), live bait (a young wild pig in a tiger-proof crate), bait trails (1 km blood trails) and an audio predator caller playing recordings of a piglet and a distressed adult pig.

LEG-HOLD TRAPS

The second method used was the humane leg-hold trap; the most widely used and successful capture method in radio-telemetry studies of tigers in Russia. These consist of a loop of cushioned heavy-duty wire laid over a hole in the ground and attached to a tree, with tension provided by a small spring. They are triggered when weight is placed on a trigger in the middle of the loop. Triggering the leg-hold was not painful and was usually tested on a human foot.

To minimise stress in any capture, the leg-holds were modified, firstly by padding the foot-loop with plastic tubing and secondly by attaching a weight between the loop and the tree. The weight then acted as a shock absorber, ensuring that any tiger caught could not jar its weight against the tree. Most importantly, all leg-holds were also fitted with trap transmitters. These gave off a signal when the trap was triggered and ensured the capture team could respond as quickly as possible and minimise the time the tiger spent in the trap. All leg-holds were also modified so that although any animal could trigger one, only something with a paw the size of a tiger would be caught.

Up to thirteen leg-holds were set at any one time, remaining open for up to 24 hours a day. All were placed in the Jammer Tulen area of the plantation on small tracks. Monitoring of the trap transmitter signals was carried out 24 hours a day by at least two people from a hill that provided coverage of all transmitters. No attempts were made to attract tigers to the leg-hold traps (although “cat lure” scent was used at some leg-hold sites in the hope that it might interest a passing tiger). Instead, leg-holds were placed on tracks known through track records to be used by tigers, and branches were used as makeshift road barriers to guide the tigers over the trap site.

Figure 10 – Remote dart gun (left) and Bart Schleyer training ZSL and KSDA in the setting of a leg hold trap (right, below)

LIVE BAITING

Live baiting both increases the chances of a capture and decreases the effort required by trappers, thus making monitoring easier and a response to a trapped animal faster. It generally works on the basis that a tiger almost always returns to a large kill. Therefore, by setting traps around a freshly killed animal the chances of trapping a returning tiger were extremely high. A bait animal too large to be consumed in one sitting therefore has to be used. This is tethered in an area with good visibility and access to maximise the chance of a tiger detecting it and then left with the only visits being to check, feed and water the prey animal. Once the animal has been killed by a tiger, a boma (enclosure) is set up around the carcass, with obvious entrance points around which several leg hold traps and trap transmitters are set. Tigers almost always returned the following night after the kill and thus the capture team can be constantly monitoring the trap transmitter signal with the capture kit ready for an immediate response.

Initially, live baiting was not considered due to the ethical considerations and because a tiger had been caught the previous year without live bait. However, in 2003 621 trap nights were required for one tiger. In 2004 we had trapped three times this effort and still had no success therefore in the final week of the trapping period live bait trapping was tried. Firstly a natural prey species was considered, such as a wild pig. However, the only pigs that we captured would not have been at all manageable – they were large, strong and very aggressive which would have made daily feeding and especially transportation to the bait site extremely problematic. Since the concerns about using domestic bait were considered to be less important in this particular site since domestic cows are not kept in the area, a young, castrated, male cow being fattened for slaughter was purchased. The cow was extremely placid and was easily taken and tethered to a site in Jammer Tulen. The site (Simpang Harimau) was chosen for the high level of shade combined with being the meeting point of three known tiger trails.

Around the cow (but out of its range) several trap sites were set up in a circular configuration, with areas between the traps blocked off with brushwood, forming a boma with traps at the entrances. Some of the traps were set on the off-chance that they would catch an incoming tiger, but the advice from Bart was that an incoming tiger would generally creep as close as possible to the prey before rushing it thus making it unlikely to get caught in a trap, even if it triggered it. Instead, the expectation was that a capture was most likely on a returning tiger therefore after a kill the remaining traps would be set in preparation. As with all leg hold traps, each was fitted with a trap transmitter.

The cow was then supervised by scouts throughout the day who collected food for it whilst a water bucket (sunk into the ground to avoid it being accidentally tipped over) was replenished twice a day. At night the cow was left alone to maximise the chance of a tiger coming, but fitted with a radio collar in case it was stolen or managed to free itself. Trap transmitters around the boma were monitored throughout the night. The cow was left for 6 trap nights with no trapping success. A small group of dhole (wild dog) approached during the day but these ran away when they saw the scouts guarding the cow. It is not known whether they were attracted by the cow or were simply moving down the path (where they have been frequently photographed in the past). The cow has since been sold on.

In addition to ZSL's trial with live bait, the Asiatic scouts also set a goat as live bait in a different area. In this case the goat was simply tethered in a shaded area near existing traps in the hope it would increase capture chances. It was observed, fed and watered throughout the day in the same manner as the cow. However, due to the illness of the scout who ran this operation the goat was only in the field for three trap nights with no trapping success.

Figure 11 - Live bait

PANEL TRAPS

The third capture method used was a panel trap method (Sweitzer *et al*. 1997) whereby large pen traps are used, capable of trapping more than one pig in each trap. Four of the traps were placed in the 2x2 trapping sites at sites thought to maximise captures and a variety of baits were used including fruit and vegetables, fish, peanut butter and scraps from the plantation canteen. When captured, pigs can be isolated one at a time in the trap "neck" and anaesthetised before marking and releasing.

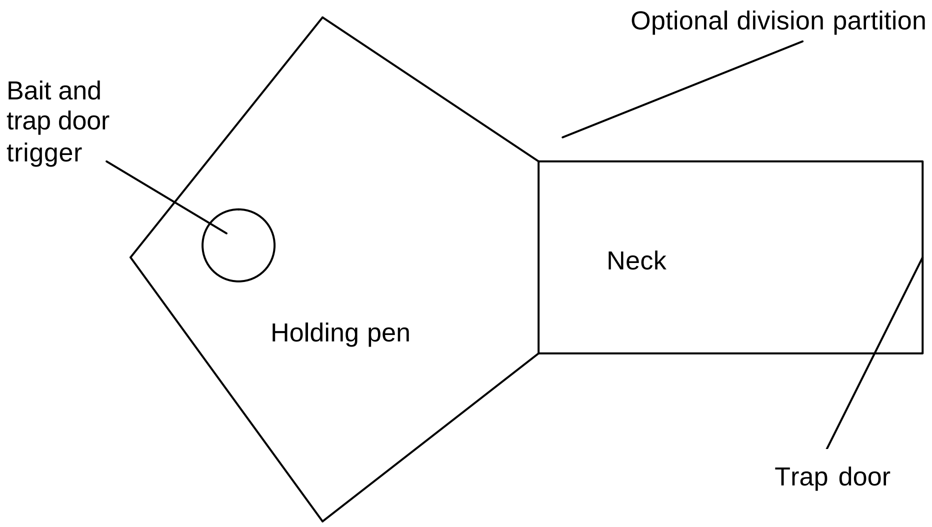


Figure 12 – Completed panel pig trap (without door)

ANAESTHETICS AND MEDICAL DRUGS

A comprehensive anaesthetic, animal health and drug manual was written for the Jambi Tiger Project by John Lewis with a page devoted to each species as well as detailed advice on emergency drugs (to stimulate breathing, heart etc.), antibiotics and painkillers. Funding from the Tufton Charitable Trust allowed provision of a range of anaesthetics and drugs as well as a comprehensive capture and animal health kit. In general, injectable drugs used were "Zolatil" (tiletamine/zolazepam) or "Zolatil" and Medetomadine for most species, ketamine and Medetomadine for tigers and other cat species. Zolatil has wide safety margins although gives a slow recovery, medatomadine is a muscle relaxant with a reversal agent that speeds up induction and makes recovery quicker. Ketamine and Medetomadine is one of the safest drug combinations to use for cats since it does not cause fitting as often, a common side effect of other commonly used drugs (such as xylazine), and can be used in very low volumes which is much easier to administer.

In addition, John Lewis provided a self designed air-based gas anaesthesia kit (Lewis, 2004). Running on isoflurane and air, this kit (Figure 13) allowed anaesthesia to be prolonged if necessary and also increased safety (animals could be quickly fitted with a mask more easily and effectively than injected with more anaesthetic) and also made recovery smoother since gas anaesthetics leave the system almost immediately. Additional important kit include a rectal thermometer and pulseoximeter to monitor core temperature, blood oxygen levels and pulse (also pictured below), laryngoscope, endotracheal tubes and surgical stitching kits.

Figure 13 - Field anaesthesia kit (left) and in use on a juvenile wild pig (right)

RADIO TRACKING

Radio tracking is carried out using a Telonics receiver and Yagi (directional) antennae. Two antennae are available; a hand held antennae and a large extendable antennae from Televilt. Animal locations are determined by recording two or more bearings on the signal. Bearings are generally taken from raised areas, rotating the antennae until the direction of the strongest signal is obtained. The bearing of the signal is recorded along with the grid reference of the location the bearing was taken from. Multiple bearings from different locations are taken and "triangulated" using LOCATE software. If two bearings are taken, the intersect shows the approximate location of the signal. If three or more bearings are taken LOCATE calculates a 95% confidence ellipse representing the accuracy of the fix. When calculating a range from fixes, the top 5% outliers are removed and a Minimum Convex Polygons drawn around the remaining fixes using the Animal Movement extension of ArcView 3.2.

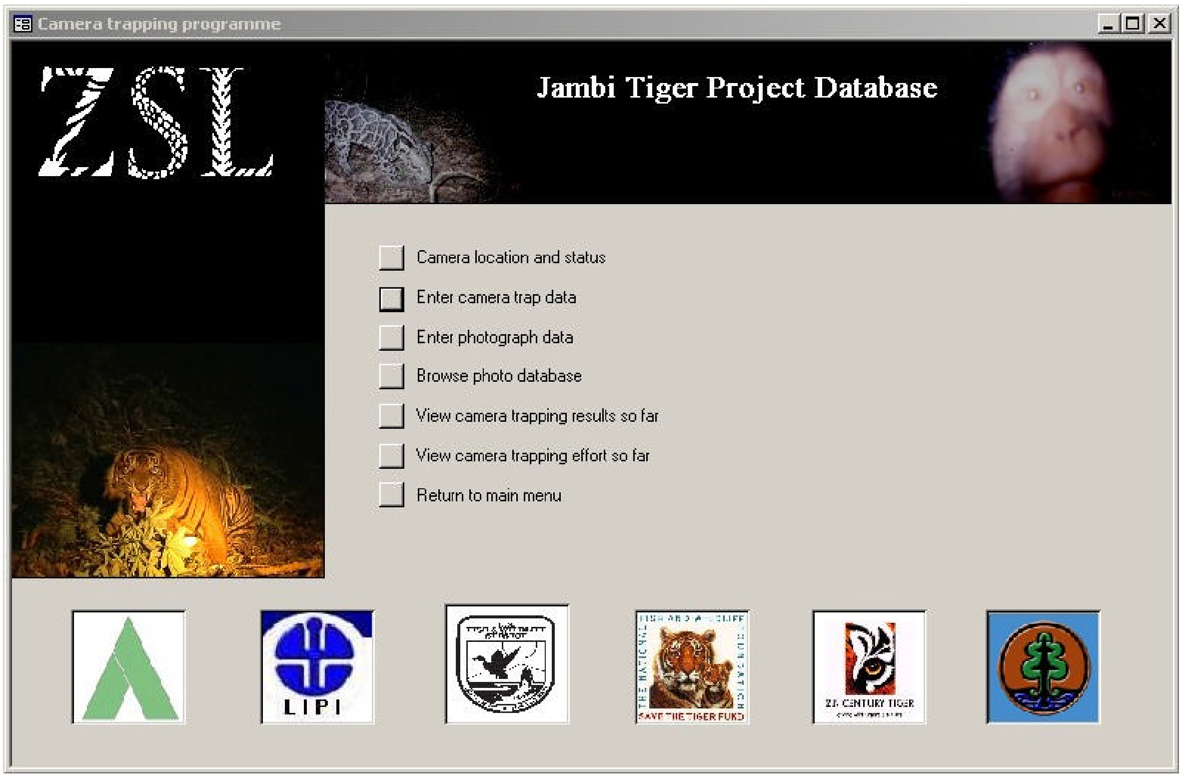
Figure 14 - Radio tracking using the extendable antennae (left) and taking a bearing (right)

DATA HANDLING – PROJECT DATABASE

OVERVIEW

A central component of the project is the central database, an Access-based database which holds all of the project data. The database is accessed through a central switchboard menu which allows users to press a button to enter data, view monthly results etc. All data are backed up weekly onto an external hard disk and is also replicated on three computers.

Figure 15 - Main menu for the database



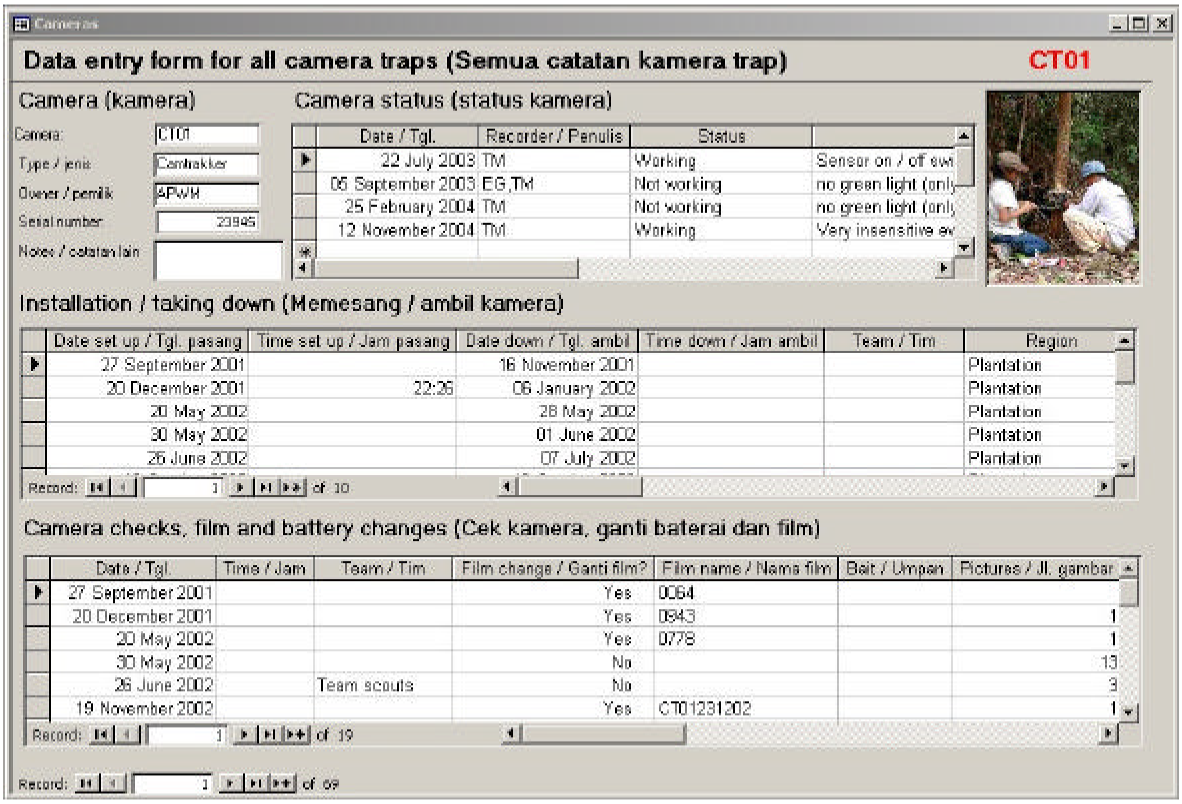
DATABASE FUNCTIONS

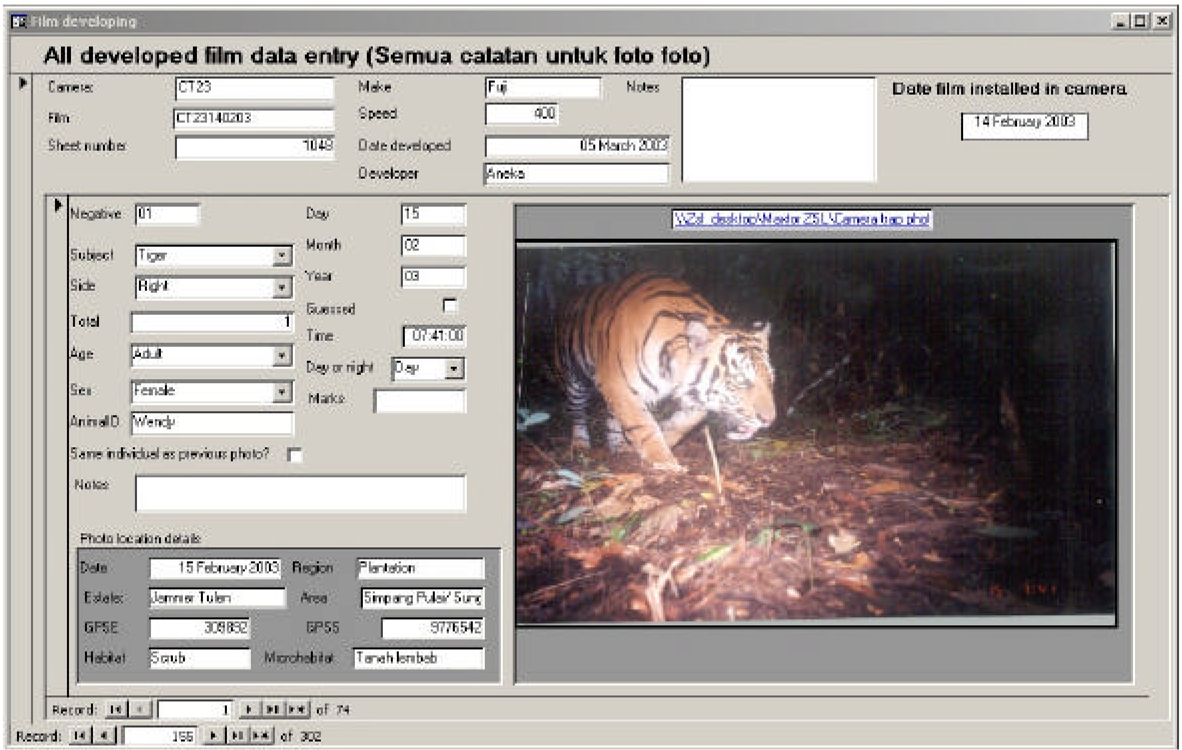
The database has three functions:

1. Data storage
2. Facilitation of daily project running
3. Results production

The primary function is to be the central information store for the project. Almost every class of information collected during the project is stored both on paper datasheets and within the database. All data entry is conducted through forms, which means data entry points can be written in Indonesian whilst the data actually remains in English (see Figure 16 for an example of camera trap and photo data entry forms).

Figure 16 - Data entry forms for camera trap running and photograph entry. The forms are in two languages and each feeds into multiple tables

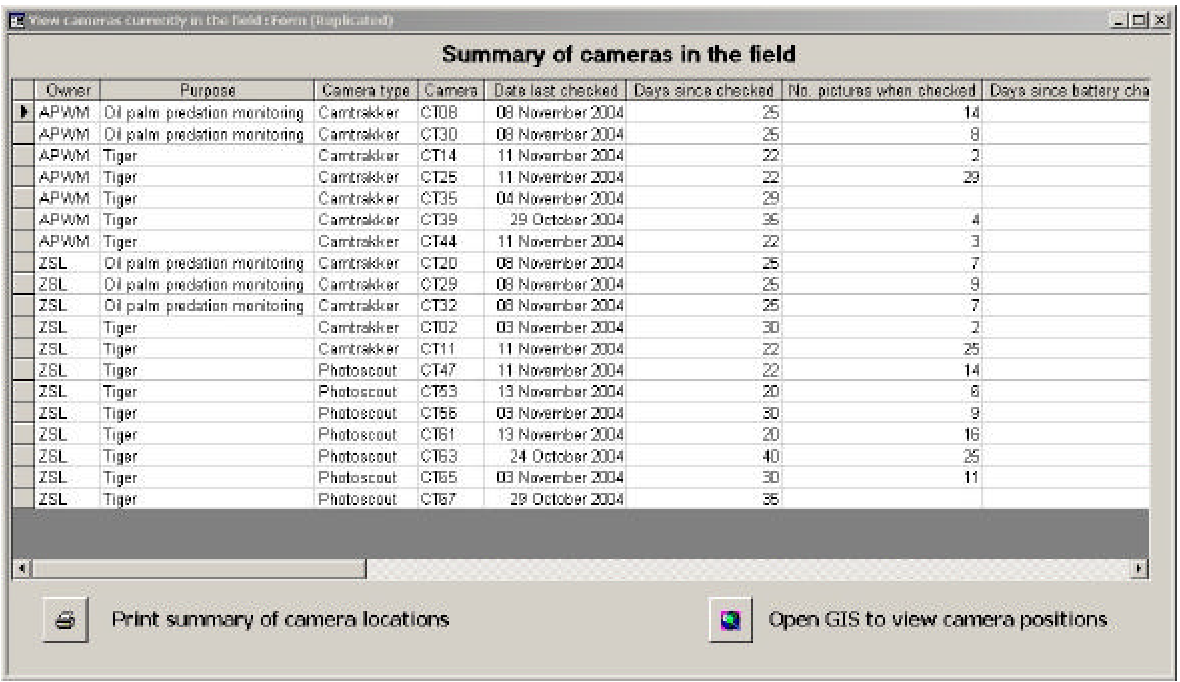




The second function is carried out using queries and reports to provide the project workers with up to date information. For example, the database will currently provide:

- Summary of the current positions of all cameras, calculating the number of days since they were checked, batteries were changed, films changed *etc.* (Figure 17).
- Photo-database browser, linking photographs to information in the database therefore allowing users to browse through all photographs by species *etc.*
- Summary of transects not yet completed this month as well as which transects were least recently patrolled.
- Summary of all wildlife sign from the previous month, allowing project workers to keep up to date on the latest tiger evidence etc. without personally talking to every scout or checking every datasheet.
- Last location calculated for each radio tracked animal allowing trackers to head straight to the last known position before beginning a new search.
- Summary of current locations of all wildlife traps if in use

Figure 17 - Summary of cameras currently in the field with options to print the report or view a linked map



Summary of cameras in the field

Owner	Purpose	Camera type	Camera	Date last checked	Days since checked	No. pictures when checked	Days since battery cha
APWM	Oil palm predation monitoring	Camtrakker	CT08	08 November 2004	25	14	
APWM	Oil palm predation monitoring	Camtrakker	CT30	08 November 2004	25	8	
APWM	Tiger	Camtrakker	CT14	11 November 2004	22	2	
APWM	Tiger	Camtrakker	CT25	11 November 2004	22	29	
APWM	Tiger	Camtrakker	CT35	04 November 2004	29		
APWM	Tiger	Camtrakker	CT39	29 October 2004	35	4	
APWM	Tiger	Camtrakker	CT44	11 November 2004	22	3	
ZSL	Oil palm predation monitoring	Camtrakker	CT20	08 November 2004	25	7	
ZSL	Oil palm predation monitoring	Camtrakker	CT29	08 November 2004	25	9	
ZSL	Oil palm predation monitoring	Camtrakker	CT32	08 November 2004	25	7	
ZSL	Tiger	Camtrakker	CT02	03 November 2004	30	2	
ZSL	Tiger	Camtrakker	CT11	11 November 2004	22	25	
ZSL	Tiger	Photoscout	CT47	11 November 2004	22	14	
ZSL	Tiger	Photoscout	CT53	13 November 2004	20	6	
ZSL	Tiger	Photoscout	CT56	03 November 2004	30	9	
ZSL	Tiger	Photoscout	CT61	13 November 2004	20	16	
ZSL	Tiger	Photoscout	CT63	24 October 2004	40	25	
ZSL	Tiger	Photoscout	CT65	03 November 2004	30	11	
ZSL	Tiger	Photoscout	CT67	29 October 2004	35		

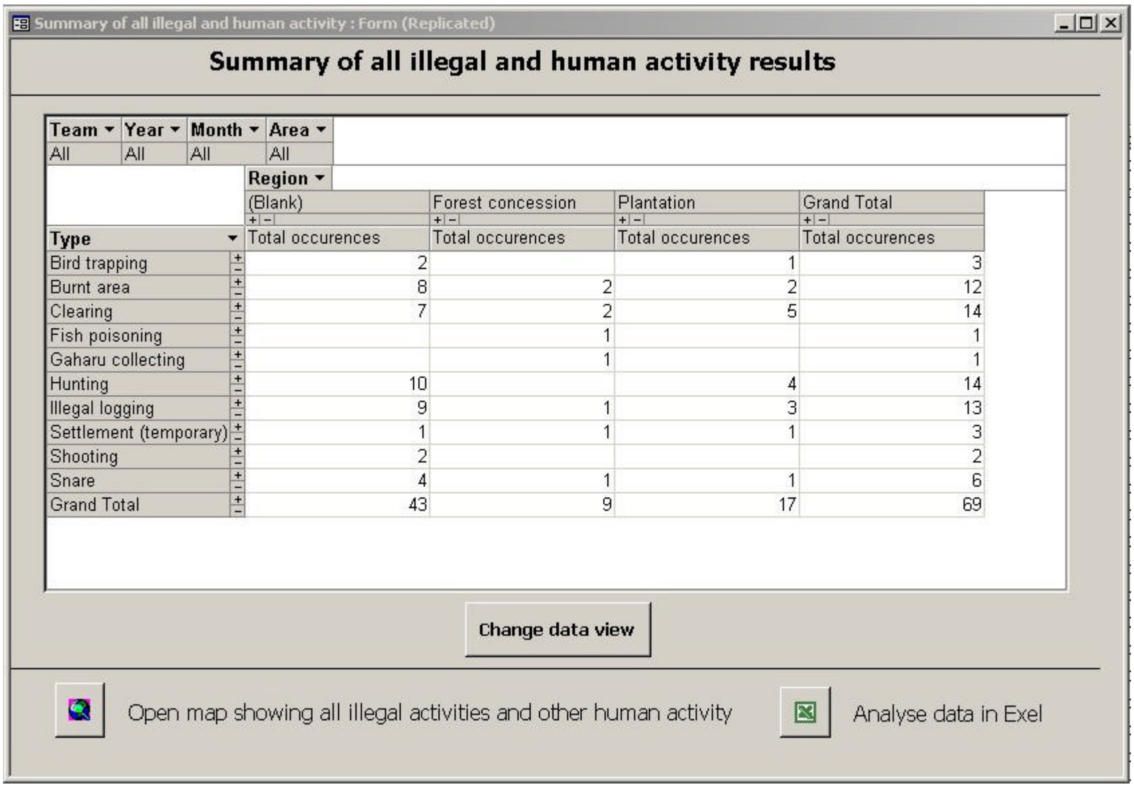
Print summary of camera locations

Open GIS to view camera positions

The third function is to produce up to date results at the touch of a button, allowing for faster and more efficient report production. This is the last feature to be developed and is still under construction, but current outputs include:

- Summaries of all survey effort (kms of transects patrolled, number of photographs taken, number of radio tracking fixes collected, number of animals captured *etc.*)
- The number of species recorded by camera traps over time
- An up-to-date species list based on all survey methods together with distribution map
- An up-to-date summary of all illegal activity recorded together with a distribution map
- Encounter rates of animal sign and illegal activity over time
- Camera trapping rates for every species over time
- Up-to-date ranges for radio tracked animals
- Summary of wildlife captures

Figure 18 – Database results page summarising all illegal activity recorded to date



Summary of all illegal and human activity : Form (Replicated)

Summary of all illegal and human activity results

Team	Year	Month	Area
All	All	All	All

Region

Type	(Blank) Total occurences	Forest concession Total occurences	Plantation Total occurences	Grand Total Total occurences
Bird trapping	2		1	3
Burnt area	8	2	2	12
Clearing	7	2	5	14
Fish poisoning		1		1
Gaharu collecting		1		1
Hunting	10		4	14
Illegal logging	9	1	3	13
Settlement (temporary)	1	1	1	3
Shooting	2			2
Snare	4	1	1	6
Grand Total	43	9	17	69

Change data view

Open map showing all illegal activities and other human activity

Analyse data in Exel

SURVEY EFFORT

CAMERA TRAPPING

CAMERA RESOURCES AVA ILABLE

Table 2- Summary of current camera resources

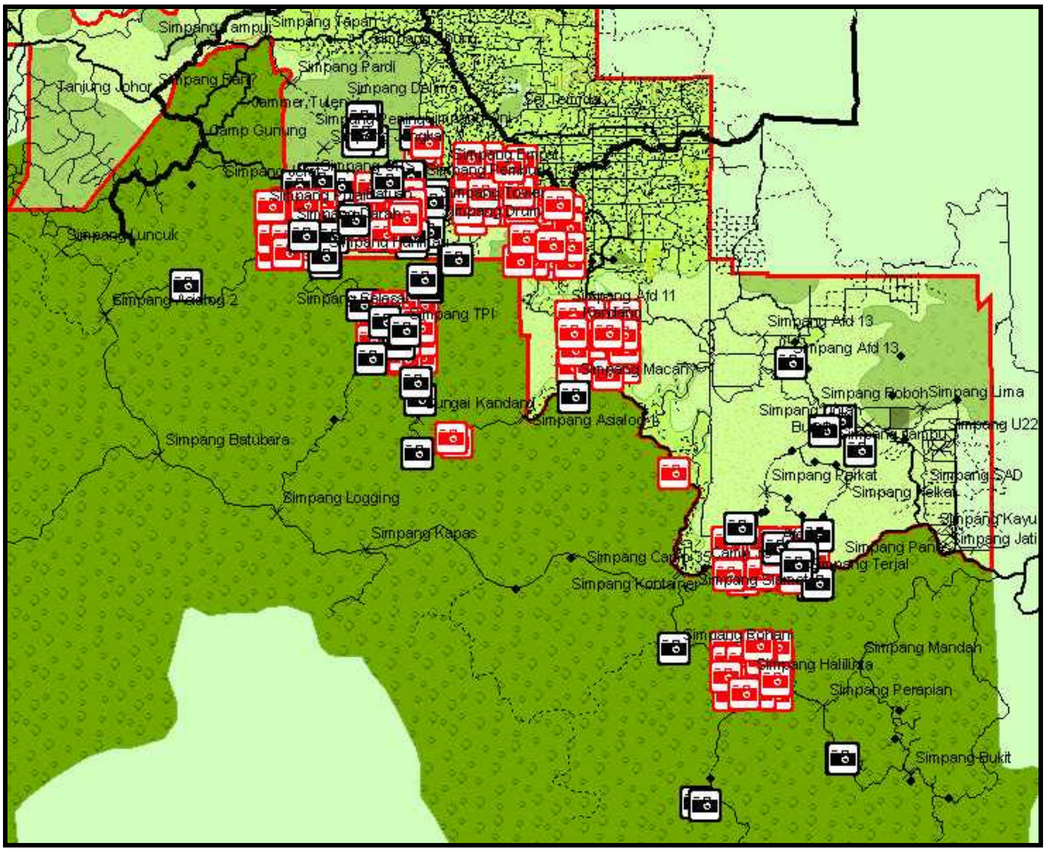
Owner	Camera type	Status	Number of cameras
APWM	Camtrakker	Working	12
ZSL	Camtrakker	Working	4
ZSL	Camtrakker	Sometimes working	8
ZSL	Camtrakker	Not Working	11
ZSL	Camtrakker	Stolen	10
ZSL	Photoscout	Working	21
ZSL	Photoscout	Stolen	1

There are currently 37 working cameras on the project, 12 of which are permanently stationed at known tiger locations around the plantation and run by the scout team. The remaining cameras are used in various locations as a survey tool. No camera will work 100% reliably however there are also 8 cameras that work so irregularly that they cannot be used for survey work. These are generally just placed in likely tiger areas in the hope they will be occasionally triggered when something passes.

CAMERA LOCATIONS

Overall, 298 camera locations have been used over the course of the study. Most effort has been concentrated in the areas set aside for conservation and the bordering forest habitats (Figure 19).

Figure 19 - Map of all positions used for camera trapping. Red cameras denote randomly chosen locations, black were non random.



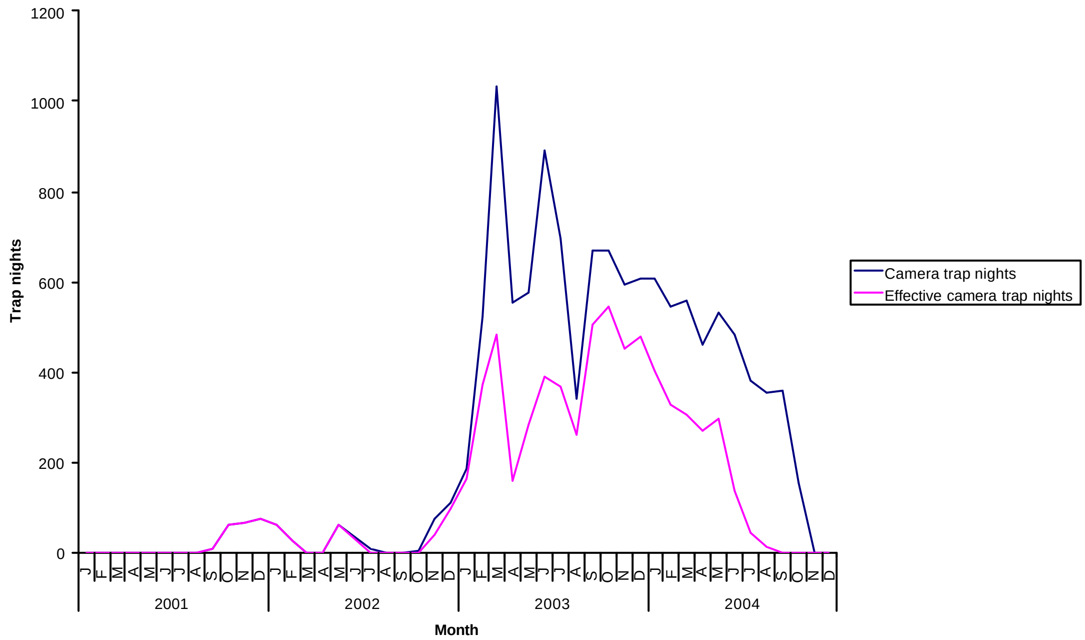
CAMERA TRAPPING EFFORT

Within these locations, 7625 effective camera trap nights have been carried out (although cameras were in the field for over 12000 trap nights), with most effort concentrated in 2003 and 2004 when more camera resources were available (Table 3 and Figure 20).

Table 3 - Camera trapping effort

	Forest concession			Plantation			
Year	Non random	Random	Total	Non random	Random	Total	Grand Total
2001	59	0	59	155		155	214
2002	16	0	16	235	59	294	310
2003	634	363	997	2066	1400	3466	4463
2004	450	287	737	1364	537	1901	2638
Grand Total	1159	650	1809	3820	1996	5816	7625

Figure 20 - Number of camera trap nights conducted over time



PHOTOGRAPHS OBTAINED

The camera trapping photograph dataset available for analysis consists of two main parts:

- Data from 2001-2002 were collected using 4-6 camera traps on an opportunistic basis, primarily to confirm the presence or absence of tigers. Few details were recorded on camera trap location or dates therefore photographs could not be "geo-referenced" (matched to a location), thereby restricting the use of these data for any detailed analysis (although some could be geo-referenced retrospectively).
- From 2003 funding was used to purchase a further 38 camera traps which arrived in late January. Data were recorded on the positions and dates of use for these cameras allowing photos to be geo-referenced and the calculation of trap rates. These data form the basis for most of the analysis in this report.
- Occasionally more recent photographs are not geo-referenced. This is usually due to a lag in data entry, or due to a minor error in data entry which stops the database matching photographs with location records. We are currently removing these glitches.

At the time of writing 9526 photographs were available for analysis, of which 72% were geo-referenced. Analyses are generally carried out on independent photographs of individuals rather than photographs (for example one photograph may show two different individuals) therefore Table 4 gives a breakdown of all photographs and individuals captured on film. Only the geo-referenced photographs were used for analyses, apart from when looking at species presence / absence or numbers of individual tigers on site. A complete list of every subject photographed can be seen in Appendix II.

Table 4 - Breakdown of photographic results

Total photos taken	9526
Total individuals photographed	11224
Average individuals per photo	1.18
Total geo-referenced photos	6901

Total geo-referenced individual	8269
Overall % photos geo-referenced	72.44

LINE TRANSECTS

So far, data for 76 line transects covering a total of 390.3 km conducted over approximately 40 hours are available for analysis. More transects have been carried out but have not yet been entered into the database. Habitat types for each transect were divided into four habitats rather than three since a large proportion of transects were driven along the forest / oil palm border road.

Table 5 - Summary of line transect effort

Habitat	Distance driven (km)	Number of transects conducted
Forest	15.3	3
Oil Palm	242.5	37
Oil palm/Forest	89.4	18
Scrub	43.1	18
Total	**390.3**	**76**

SECONDARY SIGNS

TRANSECTS WALKED

Records of transects walked have been kept since 2002, however, from May 2004 the transect team was properly equipped using funds from the RTCF and a new system of data entry started. Results presented here therefore only represent transects patrolled since this date. Patrols prior to this date have yet to be analysed.

Between May and October, 2665 kms were patrolled on foot or motorbike within the study site (Table 6)

Table 6 - Patrols conducted between May - October 2004

		Forest concession			Plantation			
Year	Month	Foot	Motorbike	Total	Foot	Motorbike	Total	Total
2004	May	68.5	102.4	170.9	244.3		244.3	415.2
	June	61.8	116.9	178.7	216.3	12.1	228.4	407.1
	July	64.3	201.3	265.6	266.3	28.2	294.5	560.1
	August	61.8	144	205.8	266.8	12.1	278.9	484.7
	September	51.5	124.7	176.2	209.2	12.1	221.3	397.5
	October	48.1	159.2	207.3	180.9	12.1	193	400.3
Total		356	848.5	1204.5	1383.8	76.6	1460.4	2664.9

WILDLIFE SIGNS A ND ILLEGAL ACTIVITY RECORDED

2718 tracks, 3935 faeces, 389 sightings and 69 illegal activity events have been recorded since the project begun. However, analysis of encounter rates is only conducted on records collected during the patrols shown above.

WILDLIFE CAPTURES

TRAP NIGHTS

Trapping effort for leg hold traps was far greater in 2004 than 2003, with 2276 trap nights in three different areas compared to just 621 trap nights in one area in 2003. Pen traps for pigs were opened for 60 trap nights. The remote dart gun was operated for 14 trap nights.

Table 7 – Leg hold trapping effort

Year	Region	Habitat	Total trap nights
2003	Jammer Tulen	Scrub	621
	All		621
2004	Asialog	Forest	744
	Bungin	Scrub	701
	Jammer Tulen	Scrub	831
	All		2276

ENCOUNTER RATES AND CAPTURES

Encounter rates (animals tripping traps) were similar in both years; in 2003 traps were triggered approximately once every 21 trap nights and in 2004 about once every 19 days. The overall capture rate was higher in 2004 with one capture every 380 trap nights compared to once every 621 trap nights in 2003, however, the capture rate for tigers was lower in 2004 with no tigers caught despite 3 near misses and over three times the capture effort.

Table 8 - Summary of trap triggers and captures 2003-2004

Year	Region	Species	Total triggers	Total captures	Encounter rate (Trap nights / trigger)	Trap rate (Trap nights / trigger)
2003	J. Tulen	Binturong	3	0	207	0
		Dog	2	0	311	0
		Human	6	0	104	0
		Leop. Cat	1	0	621	0
		Civet	1	0	621	0
		Mongoose	1	0	621	0
		Pig	5	0	124	0
		Porcupine	4	0	155	0
		Tiger	3	1	207	621
		Unknown	3	0	207	0
		Total	**29**	**1**	**21**	**621**
2004	Asialog	Civet	1	0	677	0
		Pig	5	0	135	0
		Tapir	2	2	339	339
		Tiger	2	0	339	0
		Unknown	21	0	32	0
	Bungin	Bearded Pig	1	1	701	701
		Civet	1	1	701	701
		Pig	22	0	32	0
		Rain	2	1	351	701
		Tapir	1	0	701	0
		Unknown	15	0	47	0
	J. Tulen	Dhole	1	0	831	0
		Domestic dog	1	1	831	831
		Person	2	0	416	0
		Pig	22	0	38	0

Unknown	21	0	40	0
Vehicle	2	0	416	0
Total	**122**	**6**	**19**	**380**

In total, 8 captures were made in 2004; 6 from leg hold traps, one by the pen trap for pigs and one was found alive in a hunters' snare. No tigers were caught by the remote dart gun in 2003, which was almost certainly due to the failure of all the techniques expected to attract a tiger to the site, but one tiger was caught using the leg hold traps after 553 trap nights. This was fairly quick compared to a comparable capture attempts in Russia where tigers were caught once every 2730 trap nights (Goodrich *et al*. 2001) however, by the end of 2004 the trapping rate had fallen to a more comparable 1/2276 trap nights.

Table 9 - Summary of captures in 2003-2004

Year	Date	Species	Name/ID	Sex	Age	Animal weight	Method	Region	Radio collared?	ID marks
2003	02/05/2003	Tiger	Slamet	Male	6-7 years	148	Leg hold	Plantation	Y	
2004	06/07/2004	Pig (wild)	Chrispy Bacon	Male	Young adult	65	Leg hold	Plantation	Y	1 Orange tag on right ear
2004	13/07/2004	Malayan tapir	Stubborn Mole	Female	Adult		Leg hold	Asialog	Y	White ear tag in left ear
2004	18/07/2004	Malayan tapir	Sheryl	Female	Adult		Leg hold	Asialog	N	Yellow ear tag on left ear
2004	24/07/2004	Bearded pig	Bellamy	Male	Young adult	72	Hunter's snare	Plantation	N	Orange ear tag on right ear
2004	27/07/2004	Malayan tapir	Shergar	Female	Young adult		Leg hold	Plantation	Y	Yellow ear tag on right ear
2004	09/08/2004	Bearded pig	Beardy	Male	Young adult	105	Leg hold	Plantation	N	None
2004	27/08/2004	Pig (wild)	Sausage	Male	Young adult	85	Leg hold	Plantation	Y	Orange ear tag in right ear
2004	29/08/2004	Pig (wild)	Midget	Male	Juvenile	20	Cage trap	Plantation	N	Yellow ear tag on right ear with "01"

NOTES ON INJURIES DUE TO FOOT LOOP TRAPS

There is some understandable concern over the use of foot loops in wildlife capture, however, on the advice of the trapping consultant and vet foot loops were still deemed preferable to cage trapping due to the higher chance of capture combined with the possibly more serious risks associated with box trapping (such as tooth breakage). During the two capture periods only one animal showed serious wounds due to the foot cable. This was the bearded pig that subsequently died under anaesthetic. It was thought that this pig suffered injuries because

- The weight that was meant to act as a shock absorber had become jammed and was no longer effective
- The trap transmitters were late arriving. This was one of the traps without a transmitter and thus the response was not as fast as it should have been.

After John's arrival (therefore for all captures except the first wild pig and tapir) we had anti inflammatory, pain killing and long acting antibiotic drugs which were administered to all captures as standard. These would have ensured against any discomfort for the subsequent 24 hours following capture and infection for up to one week. One wild pig had injuries on the foot that warranted a few stitches. It is thought these were primarily inflicted on our approach and darting since the pig was extremely aggressive and repeatedly charged. This pig (Sausage) was successfully radio collared and was active until he slipped his collar in late November.

Further evidence of recovery following capture can be seen by the tapir "Sheryl". Although not radio collared, she has since been seen approximately 2.5 km from the capture site with a scarred but healthy foot (Figure 21)

Figure 21 - The captured and tagged tapir that was not radio collared. The snare scar can be seen on the left front foot.

CASUALTIES

Unfortunately two fatalities occurred during the capture period. The first was a bearded pig (Beardy, 9th August) that did not recover from the anaesthetic despite a vet being present. Throughout the anaesthetic this individual's breathing kept stopping for no obvious reason. Each time a few chest compressions started the breathing again until the final time when chest compressions had no effect. Dopram (a breathing stimulant) had no effect.

In addition, one of the radio collared tapir has since died. On the 22nd August after the signal had been stationary for some time a team went in to the forest to look for the animal on foot. The remains of the carcass were found but were too decomposed to determine a cause of death. Possible causes of death if connected to her capture are:

- According to John, tapirs have complications due to anaesthetic more frequently than other species and many of the complications are not fully understood. One example is the tapir digestive system occasionally fails several days after anaesthetic.
- The tapir was caught just before John Lewis arrived. She was therefore not administered carprofen (anti-inflammatory drug) or antibiotics since neither Bart or the rest of the team had been trained in their use at that time. It is therefore possible that the abrasions caused by the foot snare became infected and led to death. All subsequent captures were given antibiotics.

RADIO TRACKING

Since the beginning of the project, six animals have been radio collared, of which three are still being tracked (Table 7). 280 trips have been undertaken to obtain fixes and of these the tapir (Shergar) has most successful fixes with 65 locations, over half of which have an error of below 200 metres.

Table 7 - Summary of all animals collared during the study

Species	Name	Date caught	**Still collared?**	**Total fixes**	**Total fixes (error <200m)**	**% fixes with error <200m**
Tiger	Slamet	02 May 2003	N	63	20	31.75
Pig (wild)	Chrispy Bacon	06 July 2004	N	21	19	90.48
Malayan tapir	Stubborn Mole	13 July 2004	N	12	11	91.67
Malayan tapir	Shergar	27 July 2004	Y	65	34	52.31
Pig (wild)	Sausage	27 August 2004	Y	56	31	55.36
Sun bear	Arsat	03 December 2004	Y	2	2	100

OBJECTIVE 1: INFRASTRUCTURE AND FOUNDATIONS

ESTABLISHMENT OF COLLABORATIVE CONSERVATION PROGRAMME

COLLABORATIONS AND PARTNERSHIPS

PT Asiatic Persada

The primary collaboration is with PT Asiatic Persada, and in particular with their environmental unit team headed by Volta Bone. The ZSL team is now fully integrated with the Asiatic conservation team, with a daily programme combining both research, monitoring and anti-poaching carried out by both ZSL and Asiatic personnel. Asiatic Persada have shown a strong concern for the tigers that use their concession and their commitment to helping the research has been invaluable.

Central government

Some of the projects most important links have also been formed with the PHKA in Jakarta and the Jambi KSDA. This has included the secondment to two KSDA staff members; one specialising in anti poaching and law enforcement and the other specialising in research. Furthermore, the KSDA had a strong involvement in the capture periods in 2003 and 2004, with several members attending a training workshop held jointly by Flora and Fauna International and ZSL which included specialist training in the use of their capture equipment from Dr. John Lewis of the International Zoo Veterinary Group. KSDA participation continued when the capture period began, with one member usually on site when capture attempts were started.

Figure 22 - KSDA joining in with the capture period in 2004

Figure 23 - Head of KSDA Jambi visits the project in 2004

PT Asialog

Links have also been established with the conservation unit within PT Asialog, the owners of the forest concession neighbouring the plantation. The tigers that use the plantation land frequently move into this forest area. Asialog also have a conservation team and one member of their team was seconded to the ZSL team between October 2002 and mid 2003, contributing to all research activities. Furthermore, with the support of the Asialog conservation manager, ZSL have expanded many of their research activities into Asialog, with regular transect and camera trap surveys carried out in areas bordering the plantation.

Local residents

The term “local residents” could be used to cover a wide range of people inhabiting the area. Presently, ZSL is concentrating on building relationships in particular with the Orang Bathin Sembilan (OBS) people who live and work both within the plantation and also within the forest concession. The OBS are commonly acknowledged as the indigenous community. Several OBS members are presently employed within the conservation team by Asiatic Persada, two of whom work primarily with ZSL. Furthermore, regular trips have been made by one member of the team to OBS dwellings teaching children to read in an attempt to learn more about their lifestyle and needs as preparation for future community conservation plans.

Figure 24 - Suku Anak Dalam / Orang Bathin Sembilan in plantation

Local government

Efforts have also been made to publicise the project with the local government, with meetings with the head of the Jambi Forestry Department followed by a socialisation meeting for members of local government, press and other organisations at the Forestry Offices in 2004

Figure 25 - Socialisation meeting, Jambi

Other organisations

Over the past year ZSL have been building relationships with several other Indonesian and Asian-based conservation organisations. These include Flora and Fauna International with whom a joint veterinary training workshop was held in March 2003 in Jambi, WWF Indonesia and Malaysia (with a visit to the Malaysian WWF tiger-oil palm project in 2002), Conservation International and representatives of the Perbakin hunting club. ZSL has also been in communication with Birdlife Indonesia and Birdlife International who also have interests in the Jambi area.

Vehicles

After purchasing a Daihatsu in 2002 this was sold again in 2004 (as unsuitable for off-road work) and a second hand Toyota Land Cruiser and new Mitsubishi L200 were purchased with money donated by the Rhino and Tiger Conservation Fund, Save the Tiger Fund and 21st CT. In addition, ZSL owns three Honda motorbikes for local travel.

Figure 26 – Project vehicles. The Daihatsu (far left) was sold and the Toyota (centre) purchased instead. The Mitsubishi (right) was funded by STF and 21st CT donations

Accommodation and office

Accommodation and office space was initially provided by PT Asiatic Persada for all project members. However, in late 2003 CDC, the then parent company of PRPOL, donated funds for a new, purpose built office within the plantation, including accommodation for project members and guests, work, storage and social areas. The plantation continues to provide accommodation for three project members elsewhere.

Figure 27 - New purpose built multi-use building and office (centre, below left) and original office (below right)

Other

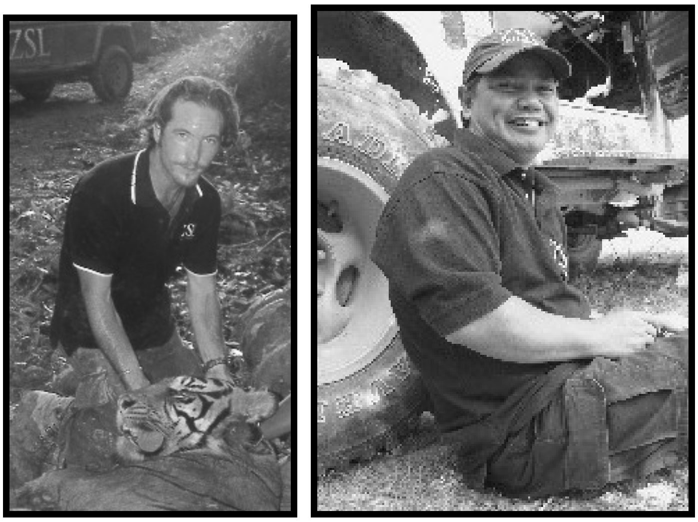
The project is also fully equipped with a VHF radio system, a complete wildlife capture and anaesthesia kit, desktop computer, GPS and various other equipment.

RESEARCH PROGRAMME TEAM

TEAM MEMBERS

Since the beginning of the project in 2001 a number of employees have worked on the project. The project was initiated by Dr. Chris Carbone with field work conducted by Rob Gordon. In 2002 Sarah Christie incorporated the project into the ZSL Carnivores and People Programme of which she is the head. Dr. Tom Maddox was appointed project manager and was initially assisted by Satrio Wijamukti who then left in late 2003. Also in 2003 Elva Gemita and Adnun Salampessy joined the project as research assistants and in 2004 Dolly Priatna was appointed co-project manager and Rio Arman joined as the project mechanic.

Figure 28 – Current ZSL research team. Clockwise from top left; Tom Maddox, Dolly Priatna, Adnun Salampessy, Rio Arman, Elva Gemita



TASKS

The primary tasks of the research team are to complete the objectives of the research programme, therefore they are in charge of most camera trapping, wildlife captures and radio tracking, wildlife surveys, data entry and analysis.

TRAINING

We are attempting to get the research team as much training as possible. Satrio Wijamukti received a three month English course in 2003 and in late 2004 Elva Gemita was accepted onto a conservation course in the UK (starting 2005). Adnun Salampessy attended a field training course with the Sumatran Tiger Conservation Project in Way Kambas in late 2004. All team members have also received intensive training on wildlife trapping, handling and anaesthesia from both a highly experienced tiger trapper and large cat anaesthetist and the research team now forms a capable wildlife handling unit, each member with a specific role.

COLLABORATION

The Jambi KSDA have been invited to second a technician to the research team on a full time basis and funds are available to finance this. Due to other duties a technician has not been available full time but technicians have joined the research team on regular occasions.

ANTI-POACHING AND WILDLIFE MONITORING (APWM) TEAM

STRUCTURE

Figure 29- The APWM team and Wildan, team leader

The Anti Poaching and Wildlife Monitoring (APWM) team consists of 14 staff jointly run by Asiatic Persada and ZSL (Table 8). Staff come jointly from a plantation background and/or come from local Orang Bathin Sembilan communities. Scouts are divided into four teams of three and all teams work on a staggered 4 day week (2 days daylight patrols, 1 night patrol, 1 day off) meaning that at least one team is on patrol every day and night.

Table 8- Management of the APWM scout team

Asiatic	ZSL
Recruitment	Work plan
Salaries	Training
Day to day management	Equipment

TASKS

The work plan and tasks are summarised in a separate document written by ZSL in Bahasa and English. It describes the job titles, responsibilities, timetables and daily work protocol. The primary task of the APWM unit is to conduct daily patrols, both for base monitoring of wildlife in the area and to serve as an anti-poaching / illegal activity unit. The secondary task is to provide backup to the research team and the Asiatic environmental unit when extra staff are required.

Patrols are known as “Patrol transects” as they are a combination of scientific data collection and conservation patrolling and protection. Conducted on a daily basis, with the scout leader giving daily instructions they involve ,Asiatic-employed conservation scouts walking or riding (on motorbike) pre-defined transect routes starting at 7am. Marked routes are patrolled by a single three-man team with each team carrying a patrol pack consisting of datasheets, mammal track guide and a tape measure. The patrol programme was developed by ZSL and the head of the AP scouts, covering almost all non-palm areas within Asiatic Persada and bordering areas of Asialog. The patrol transects cover a network of over 170 km of mapped tracks and paths. Each transect patrol has been classified according to priority, with high priority transects visited every two weeks and low priority transects once per month.

During the transect data are collected on:

- Direct observations of all species of interest (recording species, number in group and perpendicular distance to the centre of the transect line (Buckland *et al*. 1993))

- Animal footprints, faeces or other secondary sign (recording footprint measurements and collecting all carnivore and pig faeces for dietary analysis) (Karanth & Nichols 2002)

- Any signs of illegal activity (such as snares, bird trapping, forest clearance with the relevant authorities informed if necessary). If possible, traps *etc.* are removed immediately.

Night patrols are conducted rather differently with more emphasis on anti-poaching than wildlife data collection. Scouts always use motorbikes at night and patrol a flexible route. Any poaching activities encountered that can be dealt with immediately are done so, however most require the calling of Asiatic security to assist with action.

All data are entered into the project database through one scout dedicated to computer work.

Figure 30 – APWM Scouts on patrol

EQUIPMENT

The team is now operational and fully equipped using funding from the Rhino and Tiger Conservation Fund and some contributions from Asiatic Persada. Each team is now equipped with two motorbikes, a VHF radio, GPS, field clothing and datasheets.

TRAINING

A two week offsite training programme has been booked with the Sumatran Tiger Conservation Project in Way Kambas for December 2004.

COLLABORATION

As with the research team, the Jambi KSDA have been invited to second a PolHut member of staff to the APWM team to assist with authority on patrols. A single ranger has been assigned to the team and is generally present 1-2 days per week.

COMMUNICATION AND INFORMATION

NEWSLETTERS

The main channel of news from the conservation unit to the local communities is through a monthly newsletter. Asiatic Persada already has notice boards set up all over the concession and every month ZSL summarise news on latest wildlife sightings, current activities, guests and other news on a single leaflet that is displayed in all notice boards. The newsletters are also used for advising communities on wildlife conflict. For example, a recent newsletter (Figure 31) tackled the problem of a sun bear that was raiding poultry in one village. The letter gave information about sun bears, what to do if encountered and what the course of action being followed was. ZSL eventually assisted the KSDA to capture the bear and translocate it.

MEETINGS

Close communication is continued with the Asiatic and PRPOL environmental staff, as well as with the Asiatic estates, security and human resources managers. When environmental meetings are held within the company ZSL is always represented.

Figure 31 - Recent newsletter giving information on bear conflict in the plantation


ZSL Conservation Programmes

LIVING CONSERVATION

Pemberitahuan tentang beruang di Bukit Tenera

Beberapa photo beruang hasil kamera

Sekilas info tentang Beruang

Saran untuk masyarakat Bukit Tenera

OBJECTIVE 2: BASE ECOLOGICAL DATA

SPECIES DIVERSITY

SPECIES LIST

Basic monitoring of the diversity of species within the study area is carried out using the results from the camera traps and secondary sign surveys. The results show that despite being a working, commercial landscape, the oil palm / scrub / forest matrix is still able to support a wide range of mammal species including several endangered species including the tiger, clouded leopard, fishing cat and dhole. Overall, 44 mammals have been recorded on the project, with a further two species (flying lemur - *Cynocephalus variegates* and western tarsier - *Tarsius bancanus*) having been recorded on original audit species lists but not yet confirmed by this project. Although no effort has been made to systematically survey other taxa, a few interesting species have been recorded opportunistically, included the crestless fireback (*Lophura erythrophthalma)* which was photographed for the first time ever, as far as we are aware. In general, camera traps were good at recording species presence for medium and large sized mammals, however they failed to record most of the arboreal species which were either picked up by patrol transects or secondary sign surveys. Secondary sign surveys also picked up most species, but could not be used to distinguish between some species (such as the three civet species) and again missed most arboreal species. Direct sightings recorded the fewest species but were useful for adding arboreal, nocturnal species. A summary of all species recorded through these methods is shown in Table 9. At this stage, efforts were only made to record the diversity of larger mammals, however, small mammals recorded have been included whilst non mammalian species are shown in species of reptile and birds recorded during the surveys are included for interest in Table 10.

Table 9 - Complete list of mammal species recorded since the project started

Order	Common name	Latin name	Photos	Faeces	Footprints	Sightings	Total
Artiodactyla	Bearded pig	*Sus barbatus*	343			5	348
	Greater mouse deer	*Tragulus napu*	12		12	1	25
	Lesser mouse deer	*Tragulus javanicus*	14				14
	Muntjac	*Muntiacus muntjak*	87	16	185	7	295
	Pig (wild)	*Sus scrofa*	1607	391	34	48	2080
	Sambar	*Cervus unicolor*	22	19	467	6	514
Carnivora	Banded palm civet	*Diplogale derbyanus*	2	18			20
	Binturong	*Artictis binturong*			10	1	11
	Clouded leopard	*Neofelis nebulosa*	2	1	10		13
	Common palm civet	*Paradoxurus hermaphroditus*	56	1007	167	46	1276
	Dhole	*Cuon alpinus*	26	2	6	1	35
	Domestic cat	*Felis cattus*	8			34	42
	Domestic dog	*Canis familiaris*	54		5	3	62
	Fishing cat	*Prionailurus viverrinus*				1	1
	Golden cat	*Catopuma temminckii*			1	1	2
	Hairy nosed otter	*Lutra sumatrana*		1	2		3
	Leopard cat	*Prionailurus bengalensis*	199	607	204	88	1098
	Malay Civet	*Vivera tangalunga*	17		3	2	22
	Short tailed mongoose	*Herpestes brachyurus*	24		11	2	37
	Small-clawed otter	*Aonyx cinerea*			1		1

	Smooth otter	*Lutra perspicillata*		3	7	2	12
	Sun bear	*Helarctos malayanus*	27	3	73	3	106
	Tiger	*Panthera tigris*	104	24	159	4	291
	Yellow throated marten	*Martes flavigula*	1			1	2
Insectivora	Moon rat	*Echinosorex gymnurus*			2		2
Perissodactyla	Malayan tapir	*Tapirus indicus*	54	4	344	1	403
Pholidota	Pangolin	*Manis javanica*	3		6	1	10
Primate	Agile gibbon	*Hylobates agilis*				2	2
	Banded langur	*Presbytis melalophos*	1			10	11
	Long tailed macaque	*Macaca fascicularis*	36		6	8	50
	Pig tailed macaque	*Macaca nemestrina*	694	2	12	13	721
	Siamang	*Hylobates syndactylus*				5	5
	Silvered langur	*Presbytis cristata*				1	1
	Slow loris	*Nycticebus coucang*				2	2
Rodentia	Black-eared pigmy squirrel	*Nannosciurus melanotis*			1		1
	East Asian porcupine	*Hystrix brachyura*	135	3	143	6	287
	Long tailed porcupine	*Trichys fascilulata*	1		1		2
	Plantein squirrel	*Calosciurus notatus*	8				8
	Prevost's squirrel	*Calosciurus prevostii*				3	3
	Red giant flying squirrel	*Petaurista petaurista*				1	1
	Red spiny rat	*Maxomys surifer*	1				1
	Three striped ground squirrel	*Lariscus insigins*	4				4
Scandentia	Common tree shrew	*Tupaia glis*	1			3	4
	Large tree shrew	*Tupaia tana*	2				2
Total			3545	2106	1872	312	7835

Figure 32 - Examples of mammalian species recorded by camera trap. From top left; tiger, tapir, dhole, sun bear, clouded leopard, leopard cat, banded palm civet, pangolin

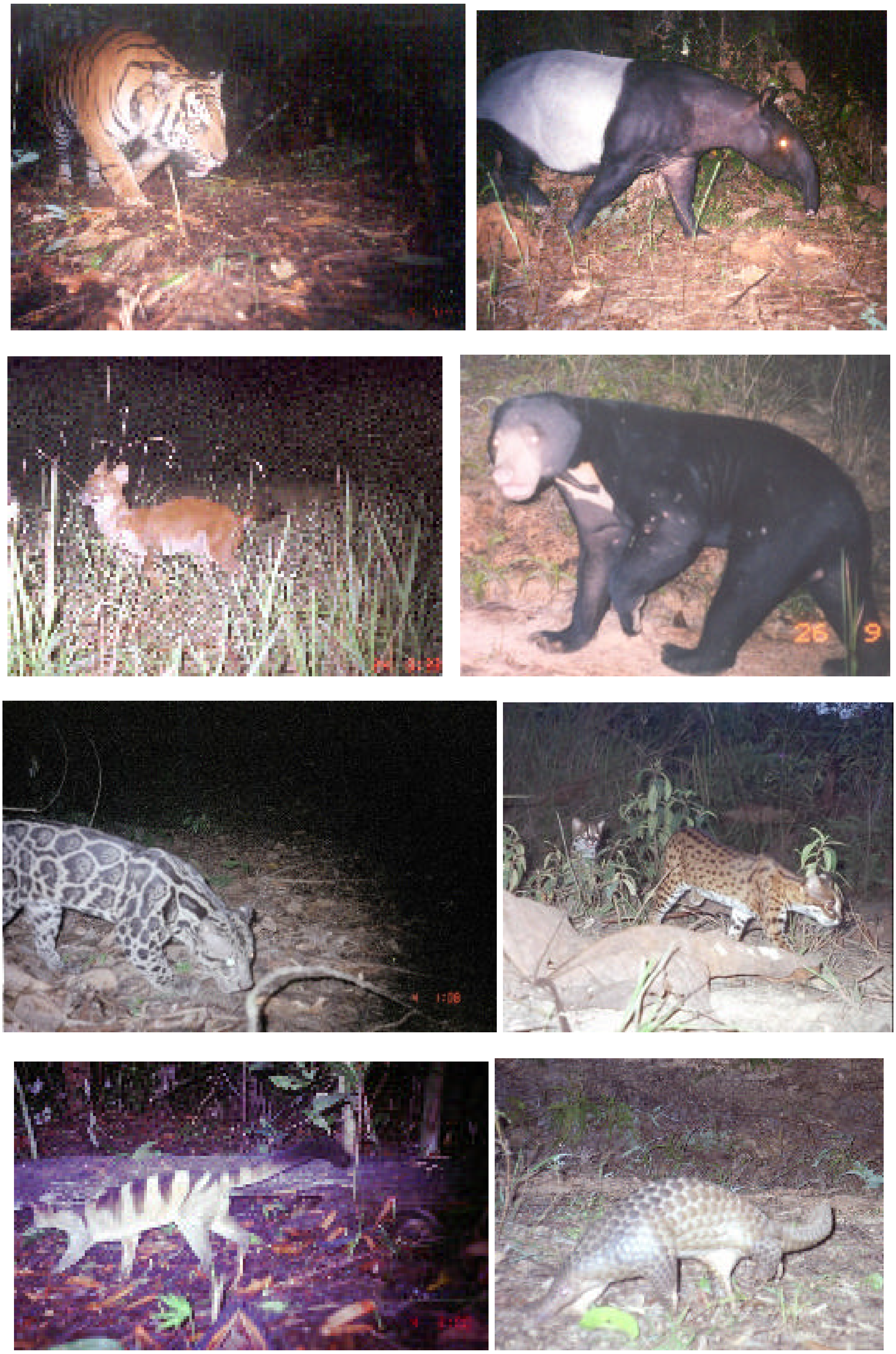


Table 10 - Non mammalian species recorded during the study

Class:	Common name	Latin name	Photos	Faeces	Footprints	Sightings	Total
Birds	Argus pheasant	*Argusianus argus*	5				5
	Black eagle	*Ictinaetus malayensis*				1	1
	Crested partridge	*Rollulus rouloul*	4				4
	Crested serpent eagle	*Spilornis cheela*				1	1
	Crestless Fireback	*Lophura erythrophthalma*	3				3
	Dollar bird	*Eurystomus orientalis*				1	1
	Emerald Dove	*Chalcophaps indica*	4				4
	Greater coucal	*Centropus sinensis*	1				1
	Jungle fowl	*Gallus gallus*	126	1		1	128
	Rhinoceros Hornbill	*Buceros rhinoceros*	2			4	6
	White breasted waterhen	*Amauronis phoenicurus*	13				13
	White throated kingfisher	*Halcyon smyrnensis*				1	1
	Wreathed hornbill	*Aceros undulatus*	1			1	2
Reptiles	Blood python	*Python curtus brongersmai*				1	1
	Monitor lizard	*Varanus salvator*	5	1	10	7	23
	Reticulated python	*Python reticulartis*				1	1
Total			164	2	10	20	196

Figure 33 - Non mammalian species of interest recorded during the study. From left: Argus pheasant, Crestless fireback, monitor lizard

SPECIES IDENTIFICATION RATE

Presenting a list of species also requires some sort of explanation of how complete it is. To check this, the rate of species identification (based on camera trap data only) was examined to look for any levelling off. The results (Figure 34) show that data based on all camera trap records levelled off at just over 40 species at around 6000 trap nights, with no new species recorded for the last 2000 trap nights. This suggests that the species list is fairly comprehensive for species that can be surveyed by camera trap. However, camera placement was important; with non randomly placed cameras levelling off at about 30 species, whilst insufficient effort had been carried out on randomly placed cameras to see a levelling off. Furthermore, although records from the plantation appear to have levelled off, records from the forest may not have levelled off by the end of trapping.

Figure 34 - Rate of species identification with increasing trapping effort

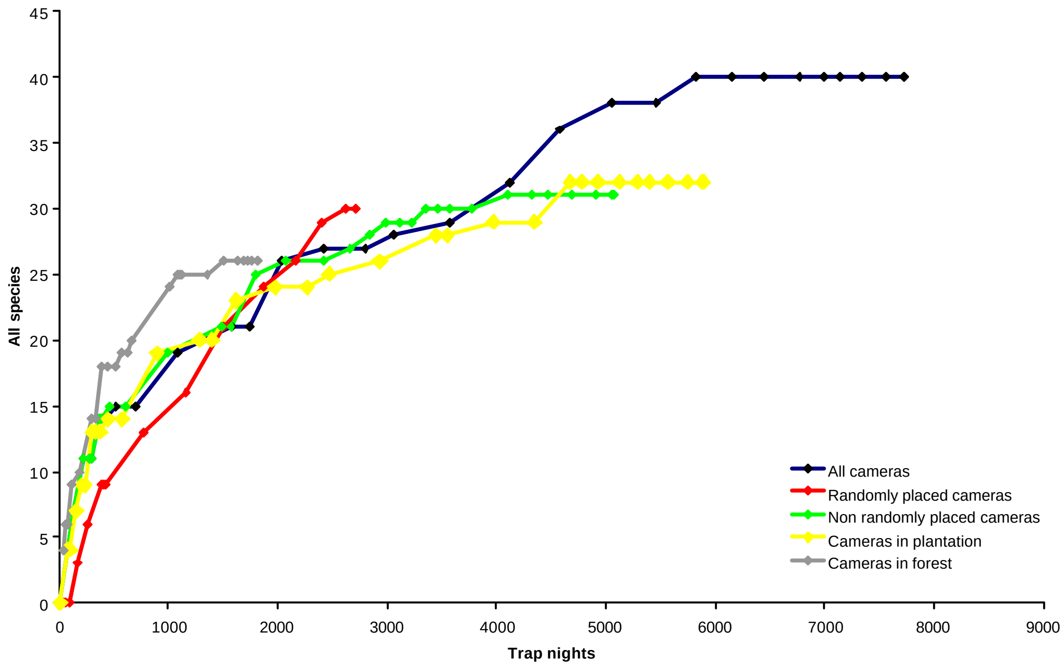


Figure 35 – Long tailed porcupine, the last species to have been picked up by camera trapping after approximately 6000 trap nights

RELATIVE ABUNDANCE

WILDLIFE SIGN ENCOUNTER RATES

Although patrols have been conducted for nearly three years, the patrol team was not equipped or instructed properly until funded with Rhino and Tiger Conservation Fund money in early 2004. Therefore, although data area available for previous months, analysis has thus far only been conducted since May 2004. Encounter rates are therefore fairly low for all wildlife sign, however, tracks are commonly seen and sufficient data are available to show encounter rates for some of the large mammals of primary interest (Figure 36 to Figure 38). In addition, results are presented for faeces collected in recent months

Figure 36 - Encounter rates of tiger tracks 2004

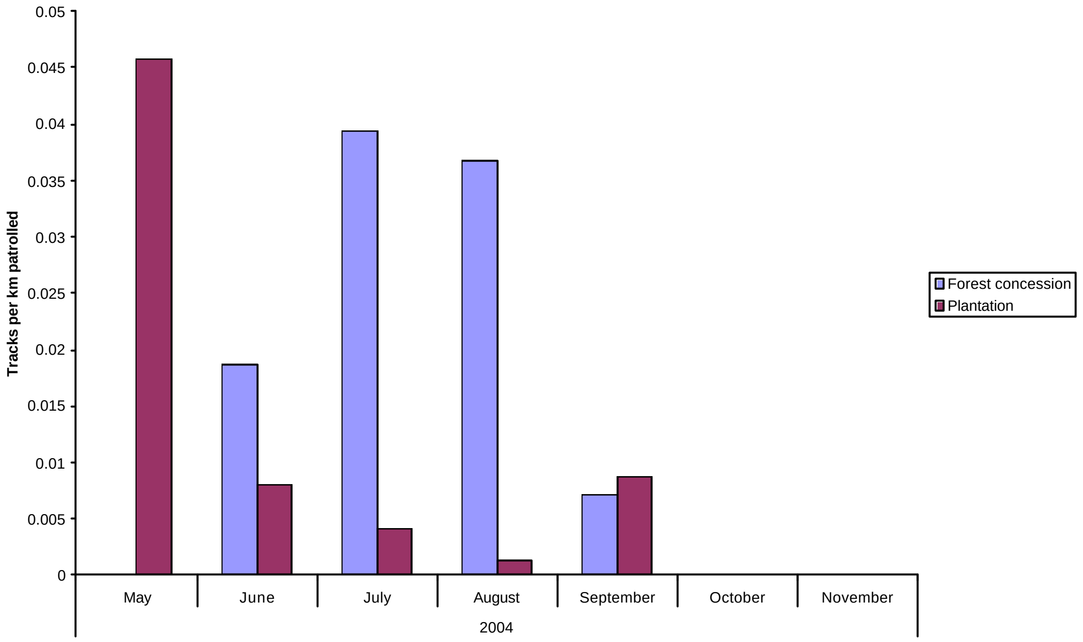


Figure 37 – Encounter rates of Malayan tapir tracks 2004

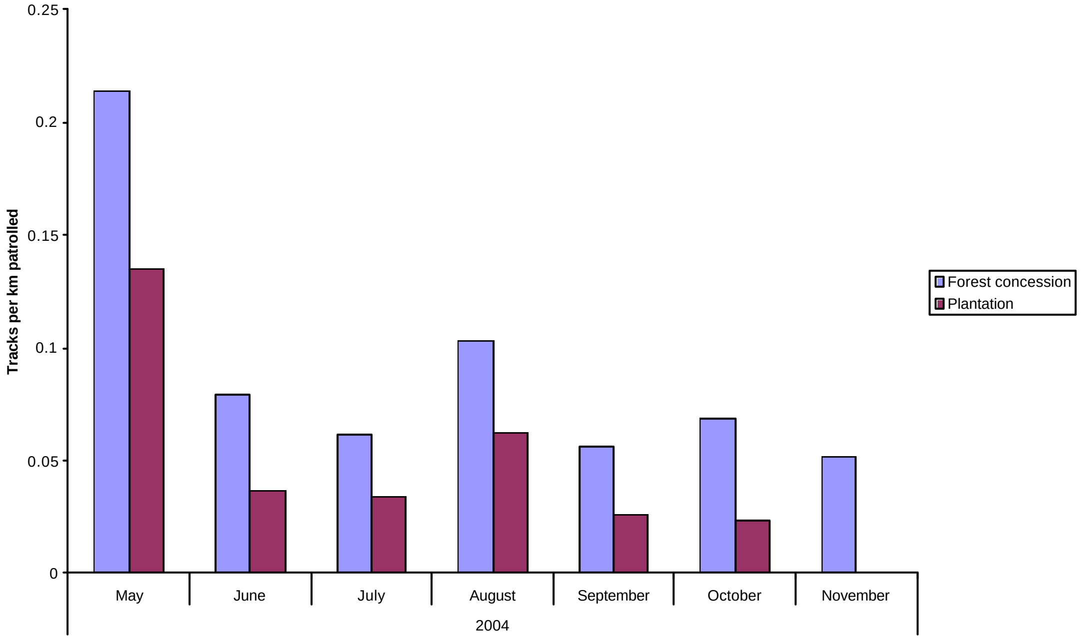


Figure 38 - Encounter rates of Sun Bear tracks 2004

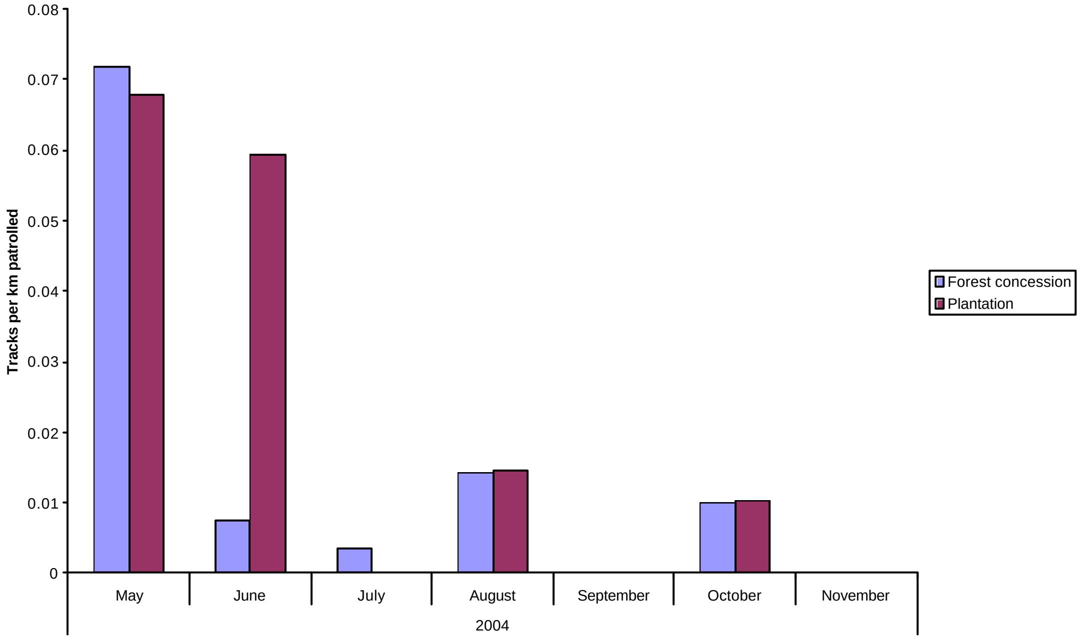


Table 11 - Faeces collected during patrol transects

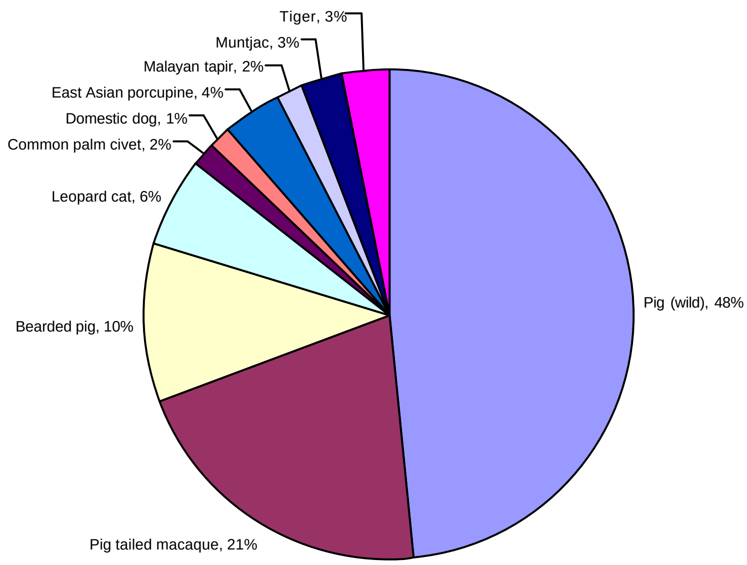
Species	Faeces collected
Clouded leopard	1
Common palm civet	11
Dhole	1
East Asian porcupine	1
Leopard cat	10
Malayan tapir	1
Muntjac	1
Pig (wild)	11
Pig tailed macaque	1
Sambar	3
Tiger	7
Total	48

At this stage wildlife sign data are too sparse for any thorough analysis, however, as patrols continue and data are entered into the database, encounter rates are updated continuously allowing project managers to monitor evidence of various species on a daily basis and by mid 2005 the dataset will be able to be used to analyse variation in abundance over time.

PHOTOGRAPHIC PROPORT IONS

A second analysis of abundance can be carried out by simply looking at the proportions of photographs of each subject. This analysis needs no information on camera locations or time in the field but assumes that the chance of photographing each species is equal relative to its abundance. By restricting the results to the top ten most photographed subjects from all photos (Figure 39) shows that wild pig were the most photographed species, although two endangered species (tiger and tapir) were in the top ten.

Figure 39 - Top ten most photographed mammals (excluding people)



USE OF RANDOM / NON RANDOM CAMERAS

A more robust analysis of abundance requires the calculation of trapping rates (photos / camera / 24 hours). Ideally surveys of abundance would only use randomly placed cameras to minimise bias introduced by selective camera placement (for example, a good place for photographing tigers may be a bad place for photographing pigs). However, random camera trapping was not an effective tool for all species, therefore initial abundance estimates were compared between random and non random cameras. Since random camera trapping has not been carried out at all times on the project, data were restricted to 2003 and 2004 when comparisons could be made. The trap nights available for comparison are summarised in Table 12 whilst Table 13 shows the trapping rates for each of the main species, illustrated by Figure 40.

Table 12 - Trap nights used for comparison of random / random trapping rates

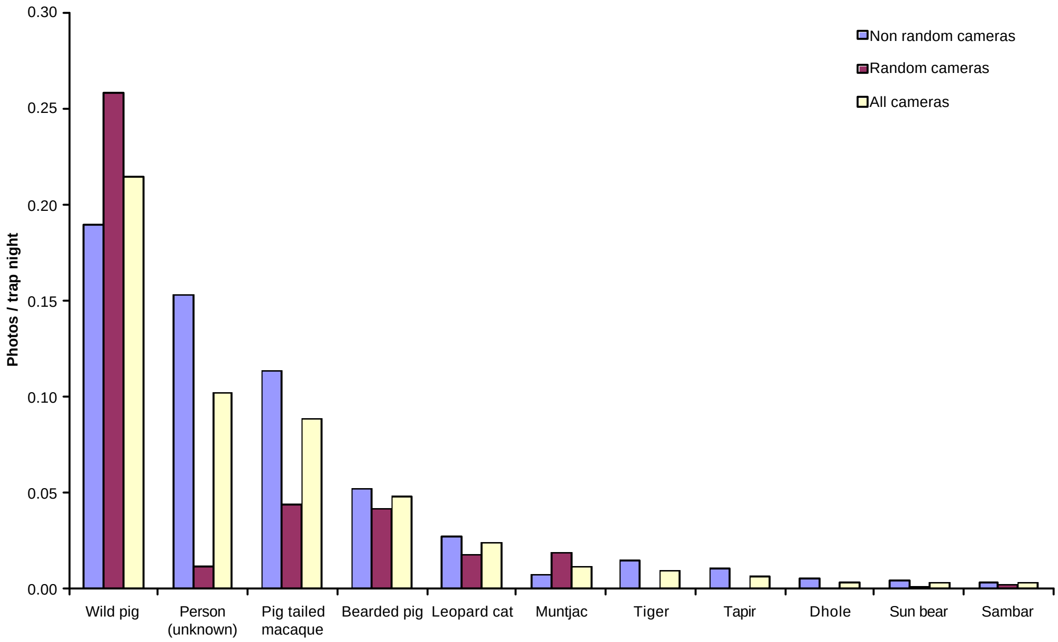
Non random trap nights	4515
Random	2587
Total trap nights	7101

Table 13 - Overall trapping rates from random and non random placed cameras

	Non random cameras		Random cameras		All cameras	
Species	Photos	Photos/trap night	Photos	Photos/trap night	Photos	Photos/trap night
Wild pig	856	0.19	669	0.26	1525	0.215
Person (unknown)	691	0.15	31	0.01	722	0.102
Pig tailed macaque	512	0.11	114	0.04	626	0.088
Bearded pig	235	0.05	108	0.04	343	0.048

Leopard cat	124	0.03	45	0.02	169	0.024
Muntjac	34	0.01	48	0.02	82	0.012
Tiger	68	0.02	0	0.00	68	0.010
Tapir	49	0.01	0	0.00	49	0.007
Dhole	25	0.01	1	0.00	26	0.004
Sun bear	21	0.00	3	0.00	24	0.003
Sambar	16	0.00	5	0.00	21	0.003

Figure 40 - Overall trapping rates from randomly and non-randomly placed cameras 2003-4



These results confirm that wild pig are the most abundant species on site, with bearded pig the next most common likely tiger prey species. The most abundant carnivore was the leopard cat, although tigers were the most abundant endangered species. However, comparison of the random and non-random survey methods show that random cameras are not suitable for all species; people, tigers, tapir and dhole were all either never or rarely photographed by randomly placed cameras, presumably because of a preference for walking on large tracks or roads. However, wild pigs and muntjac were more common on randomly placed cameras, suggesting an aversion to tracks. Unfortunately relying on placed cameras for trapping rates for tigers and other species includes an inherent bias (for example, some people may be better at choosing tiger locations that others) and restricts further comparisons between species surveyed by random cameras, however, since no data were available for species such as tigers from random cameras there was no other choice.

RELATIVE ABUNDANCE OVER TIME

During the project a worrying decrease in the number of tiger photographs has been noted over time. To investigate this further, trapping rates were calculated on a monthly basis for tigers, as well as some of the other large mammals of conservation interest, their likely main prey (pigs) and human activity to investigate whether there really was a decline over time and any possible reasons.

Figure 41 - Variation in overall trapping rate over time for tigers

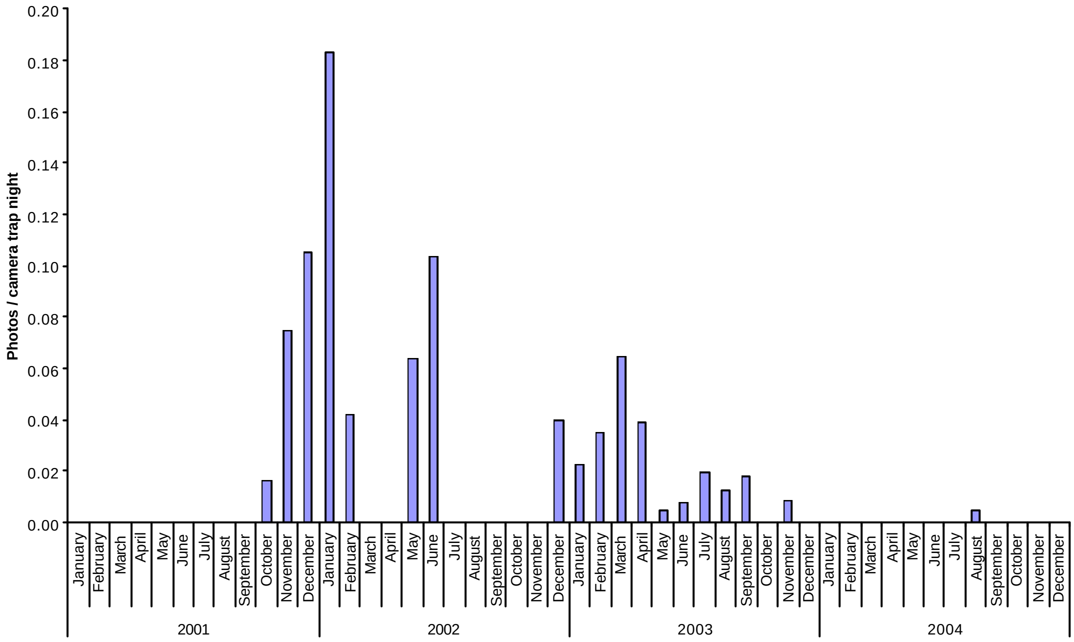


Figure 42 - Variation in overall trapping rate over time for sun bears

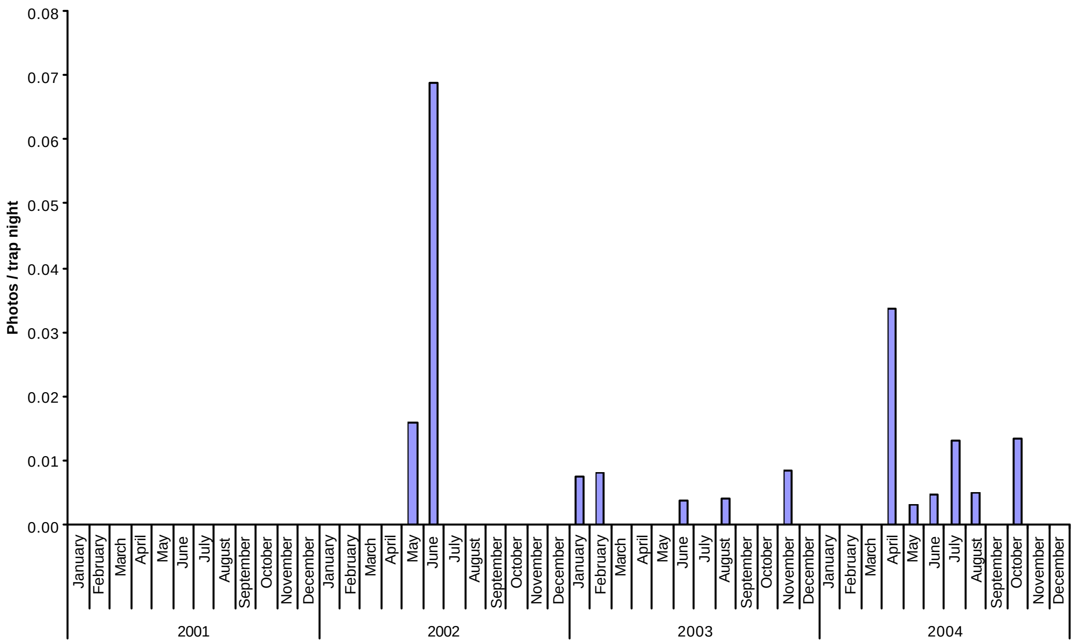


Figure 43 - Variation in overall trapping rate over time for tapirs

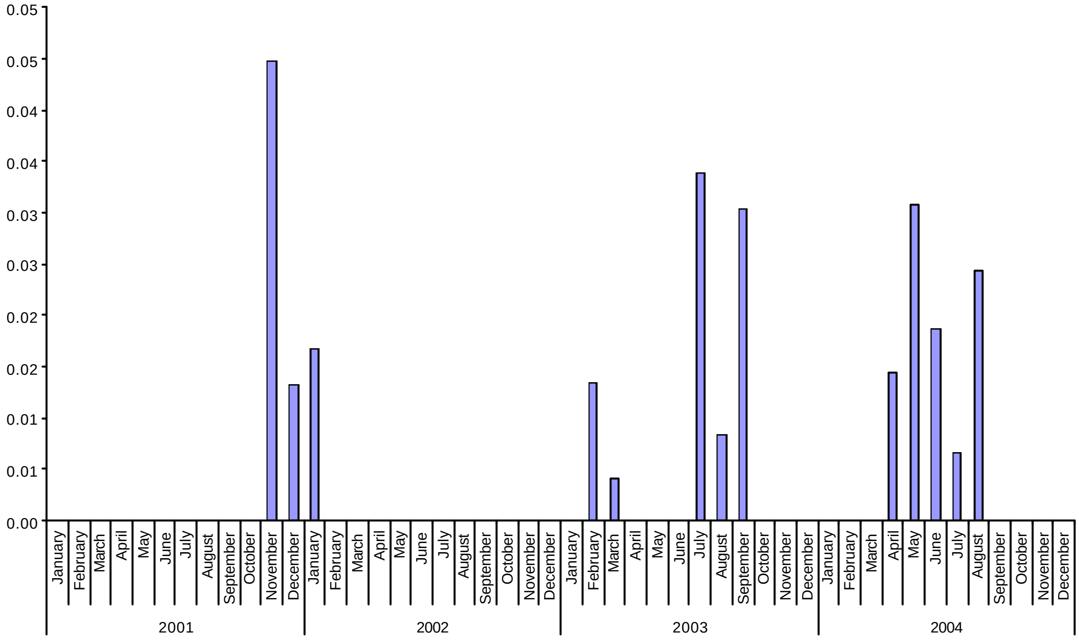


Figure 44 - Variation in overall trapping rate over time for dhole

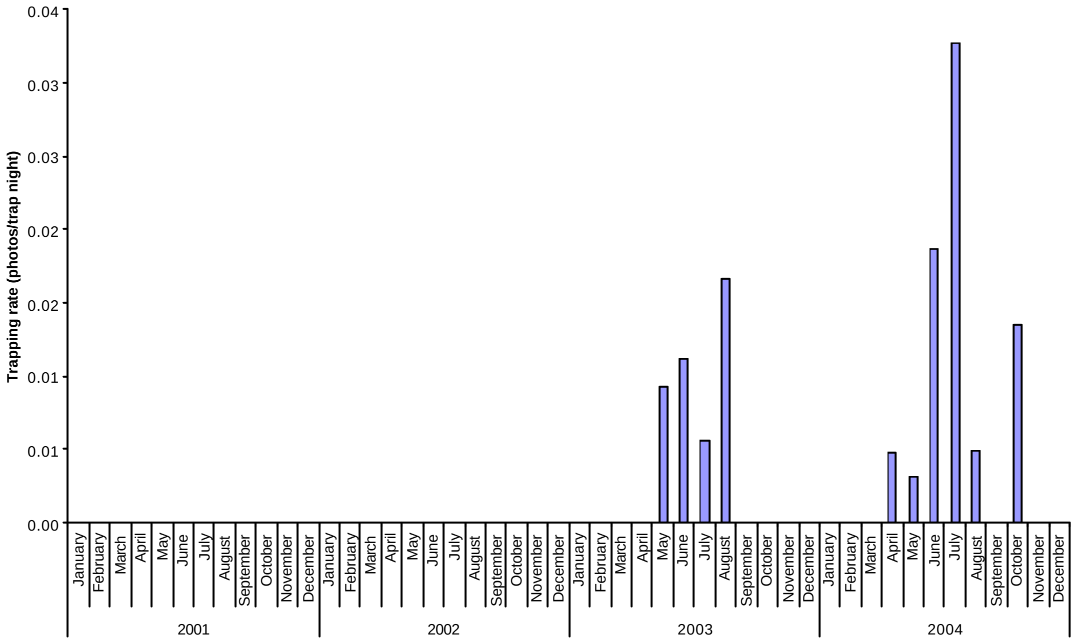


Figure 45 - Variation in trapping rate over time for wild pigs

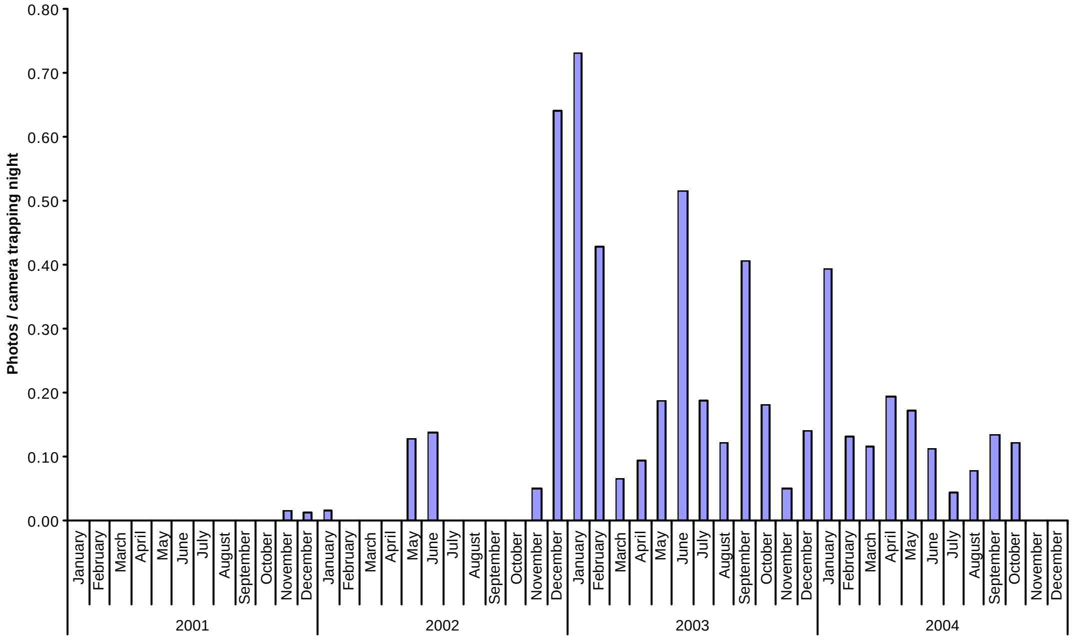


Figure 46 - Variation in trapping rate over time for bearded pigs

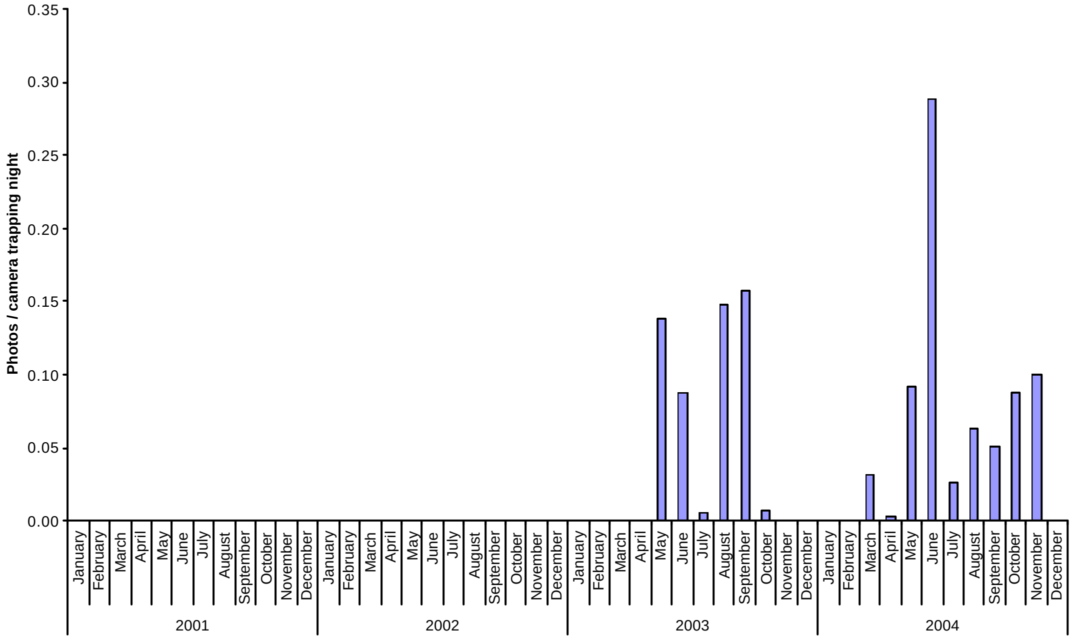


Figure 47 - Variation in trapping rate over time for Sambar

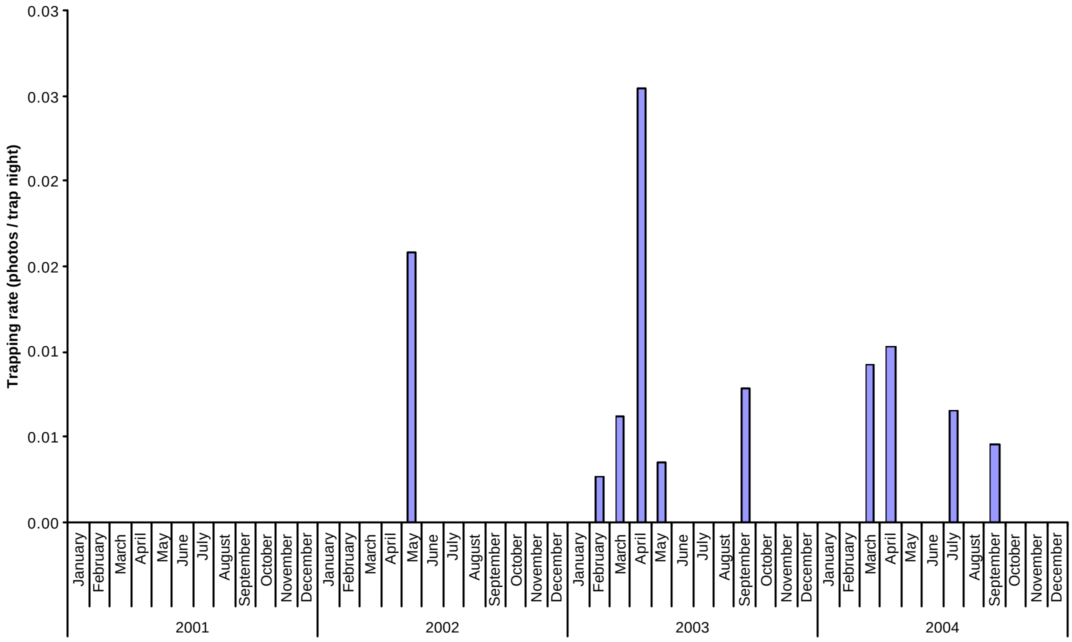
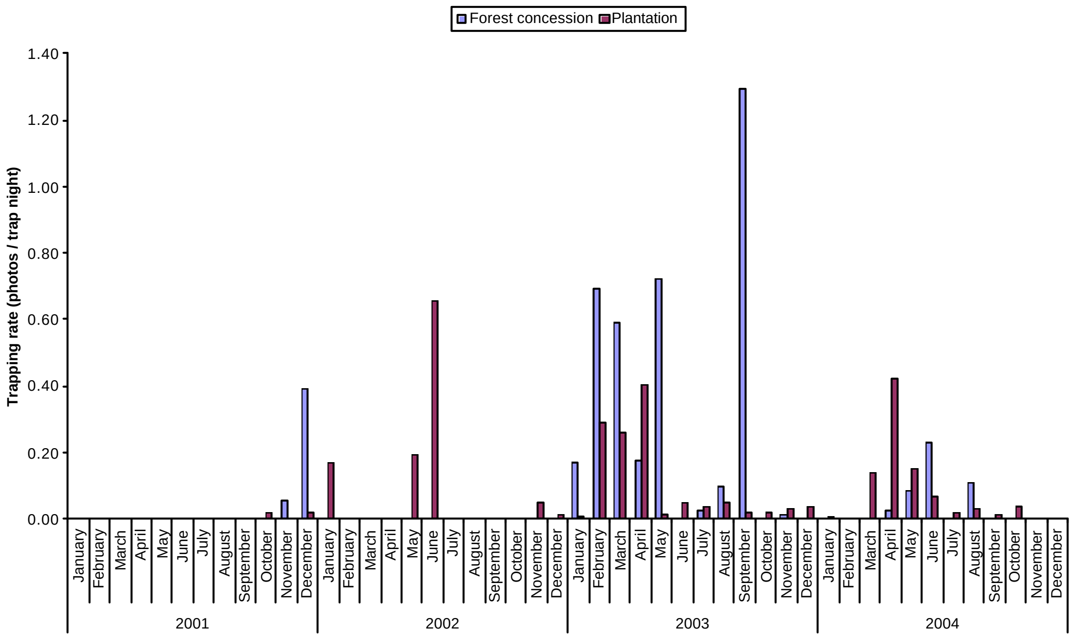


Figure 48 - Variation in trapping rate over time for people (not including conservation / plantation workers)



The results (Figure 41 to Figure 48) appear to confirm that trapping rates of tigers have indeed drastically declined over the course of the project with trapping rates falling almost to zero in 2004. The reasons are not immediately clear. Trapping rates for other large mammals such as tapir and sun bear are intermittent but do not show any downward trend, nor do the likely main prey species, pigs. Data for sambar are poor but again there is no obvious decline. Data for humans are less clear. In 2003 human presence appeared very high, particularly in the forest bordering the plantation. Numbers are lower again in 2004, but with a similar peak of activity around the end of the wet season (April). The data do not show, therefore, a clear correlation between human presence and tiger decline, although the high activity levels in 2003 at the same time tiger trapping rates fell markedly warrant further investigation.

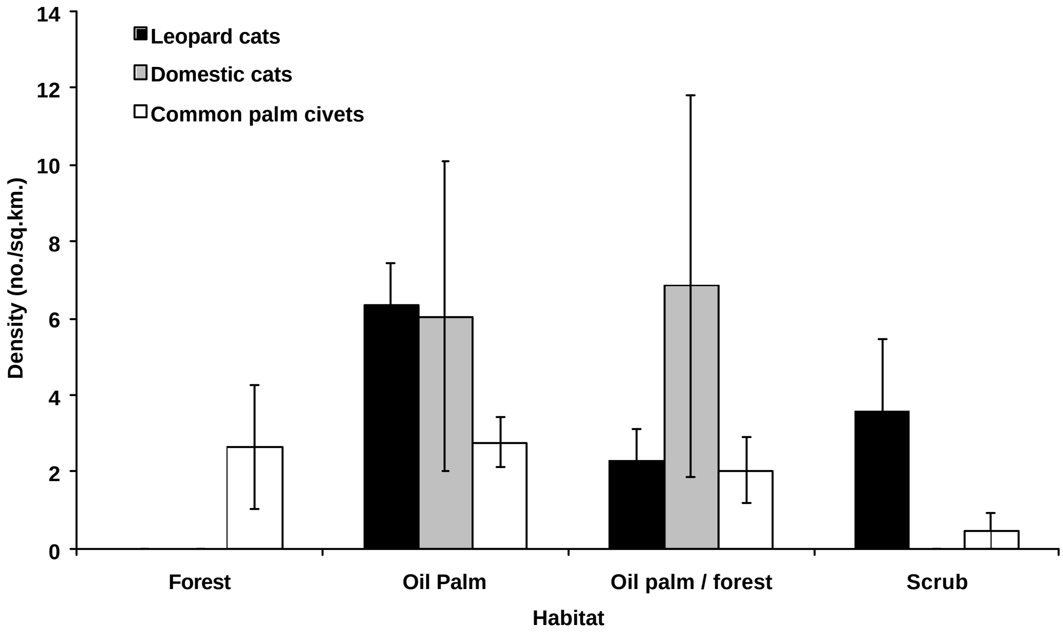
However, although worrying for tiger conservation on site, data from wildlife signs should also be considered. These show that tigers are still present in and around the plantation and have been recorded every month for which data were available (see Figure 36) suggesting that tigers have not completely disappeared from the area. Possible alternative explanations include lower photographic rates for reasons unrelated to density (problems with camera traps, decreased use of trails by tigers) or possibly localised movement of tigers away from previously good camera trapping areas.

An interesting aside is the apparent increase in both dhole and bearded pigs over time. Bearded pigs were not evident in the area at all before 2003, but after this time have been photographed extremely frequently. This may indicate a movement into the area by the pigs, which are known for migratory behaviour. Dhole, as an endangered species, are possibly even more interesting. Also appearing in mid 2003 they have gradually increased in trapping frequency and are now fairly commonly sighted in the two plantation set aside areas (although almost never in the forest concession). This is comparable to similar medium-sized carnivore species elsewhere such as wild dogs in Africa, which also appear to do better in marginal / disturbed habitats and in particular in the absence of larger carnivores. The presence of dhole may well be a direct result of the absence of tiger.

ABSOLUTE DENSITY ESTIMATES FROM LINE TRANSECTS

For a minority of species, actual densities could be calculated from line transects. These could only be calculated for the most commonly sighted species (recommended to be >50 sightings (Buckland *et al*. 1993) but in this report analysis has also been carried out for species with fewer sightings since the results still had fairly low coefficients of variation) were analysed using Distance (Laake *et al*. 1998) to provide actual estimates of density for the most common species. Densities could be calculated for wild pigs, leopard cats, domestic cats and common palm civets. Since pigs are dealt with in a separate section, only the results for the small carnivores are presented here (Figure 49). Interestingly, the results for leopard cats differ from the relative estimates from camera traps, with line transects showing leopard cats to be *most* abundant in the oil palm crop and absent from the forest. This is likely to be a reflection of the difficulty of conducting line transects in forests where perpendicular visibility was almost nil.

Figure 49 - Estimated densities (+/- SE) of small carnivores inside and outside the oil palm crop, calculated from night transect data



SPECIES DISTRIBUTION INSIDE AND OUTSIDE THE PLANTATION

SPECIES PRESENCE / ABSENCE

Contrary to some expectations, many species were recorded within the plantation concession as well as outside in the forest which may be considered more "natural" habitat. Of the mammals, 83% of species recorded in the area were recorded inside the plantation concession. Some species were only recorded inside the plantation, with the forest only housing 88% of species recorded in the area. Species found only outside the plantation concession included clouded leopard, banded palm civet, long tailed porcupine and Argus pheasant, although all of these species were represented by just one or two photographs in total. Percentages for birds and reptiles are also given (Table 14) although few conclusions can be drawn given the survey methods used.

Table 14 - Percentage of total known species in the area recorded inside and outside the plantation concession

	Forest concession	Plantation
Birds	40%	70%
Mammals	88%	83%
Reptiles	50%	100%

Although many species are surviving within the plantation, this is not to say oil palm itself is good for conservation or even comparable to forest habitat. The reason species are surviving in the concession is because there are non oil palm habitats remaining, as shown by Table 15, which shows that of the mammals recorded in the concession, 52% of them were never recorded in oil palm, but only 4% (a single species – the common tree shrew – and not from a taxa comprehensively surveyed) were unique to oil palm. Species occurring within the concession but not within oil palm crop itself include the tiger, tapir, pangolin and dhole. For distribution maps of all the major families, please see Appendix III.

Table 15 - Proportion of species within the plantation concession recorded in the oil palm crop itself and in non oil palm habitats (from camera trap data only)

	Non oil palm	Oil palm
Birds	83%	50%
Mammals	96%	48%
Reptiles	100%	0%

RELATIVE ABUNDANCE INSIDE AND OUTSIDE THE PLANTATION CONCESSION

Camera trapping rates were also used to compare abundance in the plantation concession with the forest concession bordering it. Ideally, only data from the randomly placed cameras would have been used to survey all species to remove the chance of any accidental bias introduced by placing cameras, however examination of random vs. non random cameras (above) showed that some of the larger mammals could not be realistically surveyed using randomly placed cameras. Therefore, trapping rates for comparing between sites were calculated using random cameras only if possible but non random cameras for species that were not sensitive to the random method (Table 17).

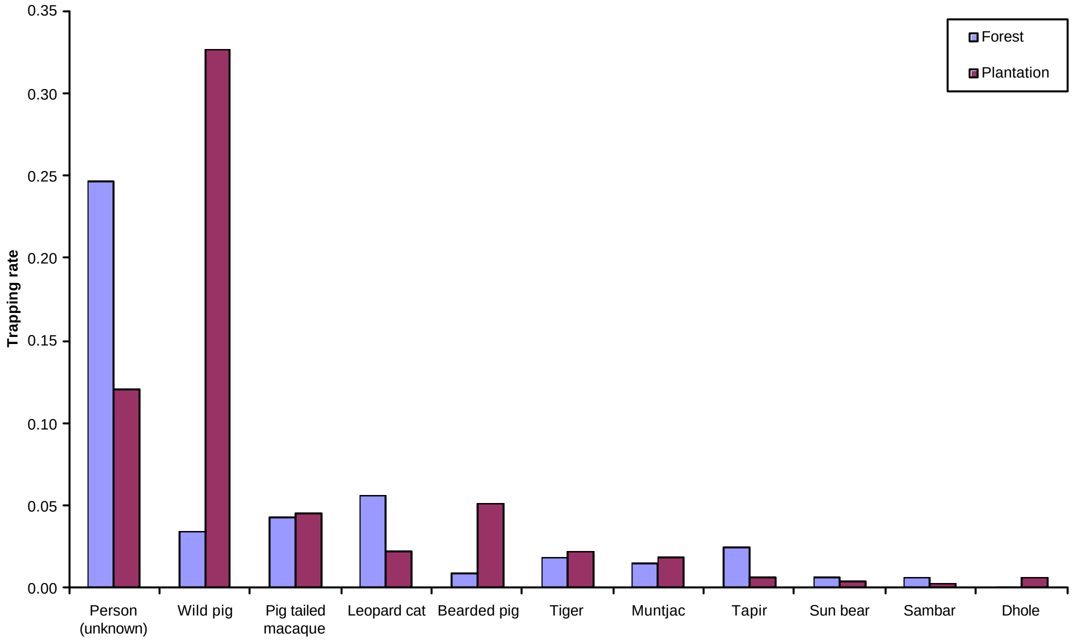
Table 16 - Trapping effort used to investigate differences inside and outside the plantation

	Random	Non random
Forest	650	1159
Plantation	1196	3820

Table 17 - Comparison of trapping rates inside and outside the plantation concession

Species	Forest	Plantation	Survey method
Person (unknown)	0.25	0.12	Non random
Wild pig	0.03	0.33	Random
Pig tailed macaque	0.04	0.05	Random
Leopard cat	0.06	0.02	Random
Bearded pig	0.01	0.05	Random
Tiger	0.02	0.02	Non random
Muntjac	0.02	0.02	Random
Tapir	0.03	0.01	Non random
Sun bear	0.01	0.00	Non random
Sambar	0.01	0.00	Non random
Dhole	0.00	0.01	Non random

Figure 50 - Relative abundance of species inside and outside the plantation concession



Although not yet compared statistically, the results show that patterns are beginning to emerge for some species. Firstly, it is clear that species do *not* in general prefer the more "natural" forest habitat compared to the scrubby plantation habitats. The only species more commonly photographed in the forest were man (primarily Suku Anak Dalam), tapir and leopard cat (although leopard cats were an unusual example – comparing randomly placed camera results showed more cats in the plantation and none in the forest where as the non-random cameras showed more in the forest; presumably leopard cats were just more likely to use paths in the thicker forest). However, several species appear to show a preference for the plantation. Most noticeable is the much higher trapping rates of the pig species inside the plantation compared to the forest concession. But of the species of conservation interest, dhole are also much more commonly photographed in the plantation and tigers were slightly more common inside the plantation too.

THREATS TO CONSERVATION

Since patrols began, illegal activities recorded can be classified into ten broad categories (Table 18) with the main activities encountered being land clearance / burning or direct hunting.

Table 18 - Types of illegal activity recorded in the area

Type	**Number of records**
Bird trapping	3
Burnt area	12
Clearing	14
Fish poisoning	1
Gaharu collecting	1
Hunting	14
Illegal logging	13
Settlement (temporary)	3

Shooting	2
Snare	6
Grand Total	69

Unfortunately, due to a misunderstanding with the Asiatic environmental manager, much of the data on illegal activities has been recorded in a different format and is at present unavailable for analysis. Of the data collected since the patrol team started in earnest, encounter rates of on average 0.004 activities per km patrolled were being recorded. However, it is suspected the real rates are far higher and these will be available when the data have been collated.

Year	Month	Distance patrolled (km)	Total records	Records / km
2004	May	417	6	0.019
	June	407.1	0	0
	July	560.1	2	0.003
	August	484.7	2	0.003
	September	397.5	0	0
	October	400.3	0	0
	Total	2666.7	10	0.004

In general, there are serious problems with illegal activities. Hunting and snaring are generally kept under control by the conservation team, but illegal land clearance is happening daily inside the plantation concession and especially in the conservation set aside areas which probably appear to be unused. Resolution of such issues is beyond either the conservation team or even the plantation security and various attempts are being made to involve the police, military and local government officials in an attempt to resolve the problem.

Figure 51 - Examples of snare wounds seen on tiger (neck) and bear (right front foot) within the plantation

Figure 52 – Conservation team finding a snare (left), and a local hunter photographed in the conservation area

Figure 53 - Examples of illegal land clearance currently happening in the plantation conservation area

OBJECTIVE 3: TIGER PREY ECOLOGY

PREY AVAILABILITY WITHIN THE STUDY AREA

PREY DIVERSITY

Data presented under objective 2 demonstrated that there were a number of potential prey species available to tigers within the study area. Of the species recorded, wild pig, bearded pig, sambar, muntjac, porcupine, macaques, palm civet and even dhole are recorded prey species for tigers (Sunquist *et al*. 1999).

Figure 54 - Possible prey species existing within the study site

Subject	Latin name
Agile gibbon	*Hylobates agilis*
Banded leaf monkey	*Presbytis melalophos*
Banded palm civet	*Diplogale derbyanus*
Bearded pig	*Sus barbatus*
Binturong	*Artictis binturong*
Common palm civet	*Paradoxurus hermaphroditus*
Dhole	*Cuon alpinus*
Domestic cat	*Felis cattus*
Domestic dog	*Canis familiaris*
East Asian porcupine	*Hystrix brachyuran*
Greater mouse deer	*Tragulus napu*
Long tailed macaque	*Macaca fascicularis*
Malay Civet	*Vivera tangalunga*
Malayan tapir	*Tapirus indicus*
Muntjac	*Muntiacus muntjak*
Pangolin	*Manis javanica*
Pig (wild)	*Sus scrofa*
Pig tailed macaque	*Macaca nemestrina*
Sambar	*Cervus unicolor*

PREY ABUNDANCE

Studies of relative abundance have been successful and were presented under objective two, showing that wild pig are the most common likely prey species with bearded pig appearing relatively recently and fast becoming the second major prey candidate. However, studies of absolute prey densities were not entirely successful. In the first plan, local hunters were employed to live capture, mark and release pigs in an attempt to carry out a mark-recapture survey. Attempts to catch pigs with local hunters were carried out between November 2002 and February 2003, using a hunter from Jambi with a team of 5-6 men and fifty wire funnel traps. The traps were then set in lines between the oil palm and forest habitats and on animal trails within scrub habitat. Captured animals were then bound by the trotters before removing from the trap. They were then marked and released. However, despite a huge investment of time and limited capture success, this trapping period was deemed to be unsuccessful and was stopped in early February. There were two primary problems. Firstly and most importantly the methods used by local hunters were found to be less humane than first thought. Although used to capture pigs live for market, the funnel traps were found to be still highly stressful for the pigs and there were serious concerns about the long term impacts of capture and restraint – issues that are not usually considered for pigs due for slaughter at market. The concerns were partly due to the stress incurred by experiencing a capture and handling whilst conscious and partly because the requirement to mark pigs meant they were handled more extensively than pigs caught for market. The second problem was that the funnel capture technique was in fact far more restrictive in where it could be applied. The hunters capture the pigs by channelling them towards the traps. This works well in dense scrub where pig trails can be identified and blocked but in the more open habitats of forest and oil palm the undergrowth was not thick enough to be able to channel pigs towards the traps. Consequently, not all areas of interest could be surveyed using this technique. By February 2003 only six pigs had been caught using the funnel method. Only one adult pig was successfully marked and released and one pig died as a result of being captured (despite being in the trap for less than one hour). The hunters were being offered 200 000 Rp ($20) per pig successfully caught, marked and released but they decided it was not worth the effort or risk and the project in turn decided the method was too harmful to continue.

Following the failure of the first method, a single prototype panel trap was built by the plantation workshop between March and April. The trap was trialled and adjusted in May before being returned for modification and to act as a template for three more. The traps were then set to coincide with the presence of the veterinary consultant in mid 2004. However, again trapping was unsuccessful, with only one capture made. It is suspected that either the choice of bait or pig suspicion was a key limiting factor. Pre-baiting is an essential part of the trapping process (Sweitzer *et al*. 2000) and various baits were trialled for effectiveness. These include fruits (jackfruit, durian, pineapple and banana), fish, maize, cassava, peanut butter and waste food from the plantation canteen. However, no bait achieved obvious success, even when placed outside the trap. This may be a consequence of the high abundance of alternative food (loose oil palm fruit lies on the ground in most areas) or it may simply show the cautiousness of the pigs. The only pig to be caught was a very young juvenile.

However, estimates of abundance were possible from camera traps (see objective 1) and line transects gave some estimates of density. To compare the two, only photographs of potential prey taken by *randomly* placed cameras were used during the time transects were also carried out (Figure 55). These were compared with estimates of actual pig density obtained from night transects (Figure 56). The results show that when using randomly placed cameras only, the difference in abundance between wild pigs and other potential prey species is even larger, possibly because pigs do not use the open tracks favoured by the carnivores. They also show that the estimate of pig abundance in the plantation scrub (the habitat with the highest rate of tiger photos) is higher than if calculated using all cameras, possibly showing that pigs particularly avoid the tracks in these areas. Estimates of relative abundance from cameras are in broad agreement with the line transects (Figure 56), showing low densities in the forest and the high densities in and around the oil palm. However, estimates from scrub habitats do not agree. It is suspected these results are confounded by the low sample sizes and consequent large error margins associated with the line transect data, caused by a lack of driveable tracks in these habitats.

Relatively few studies of pig density in comparable habitats have been published for comparison. However, one study in a topical woodland / agricultural landscape used transects to estimate densities of between 2.2 and 3.5 pigs per square kilometre (Caley 1993), estimates very similar to those in the oil palm and to some extent the scrub in this study. The only other study to look at pigs associated with oil palm also used line transects to calculate estimates of between 27 and 47 pigs per square kilometre across two years in a Malaysian forest / oil palm border (Ickes 2001). However, there were no reported predators in this study site. At this stage, the data from this project are not sufficient to draw too many conclusions from these comparisons, nor can good calibrations of camera trapping data be calculated. It is therefore important that the coming year provides better estimates of absolute density, either through capture mark recapture or by increasing line transect effort and success.

Figure 55 - Relative abundance of potential prey species from randomly placed cameras (plantation forest was not surveyed by this method)

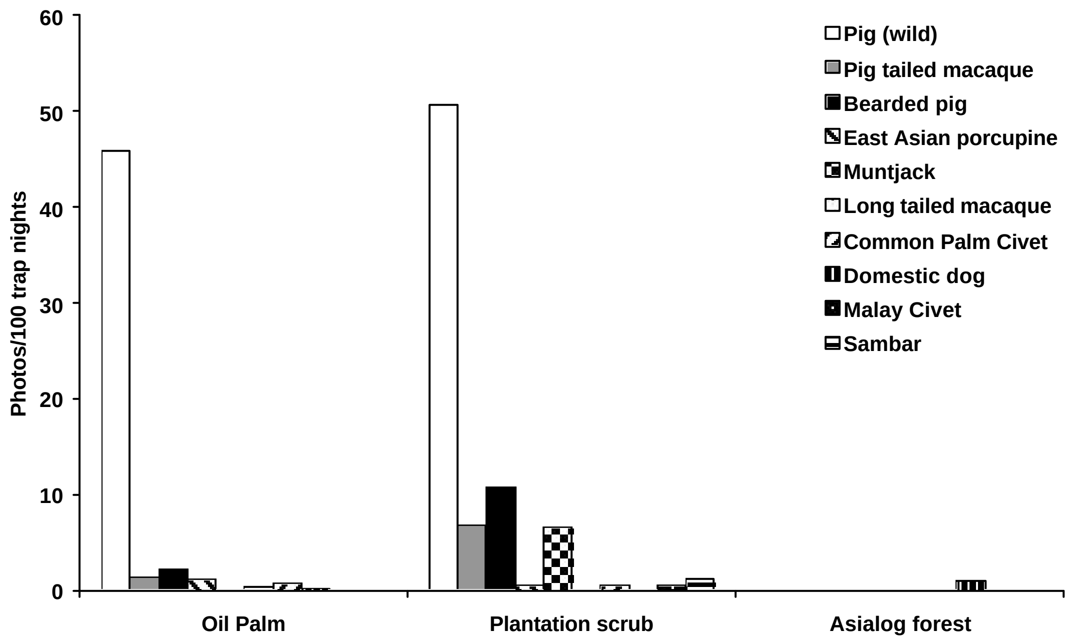
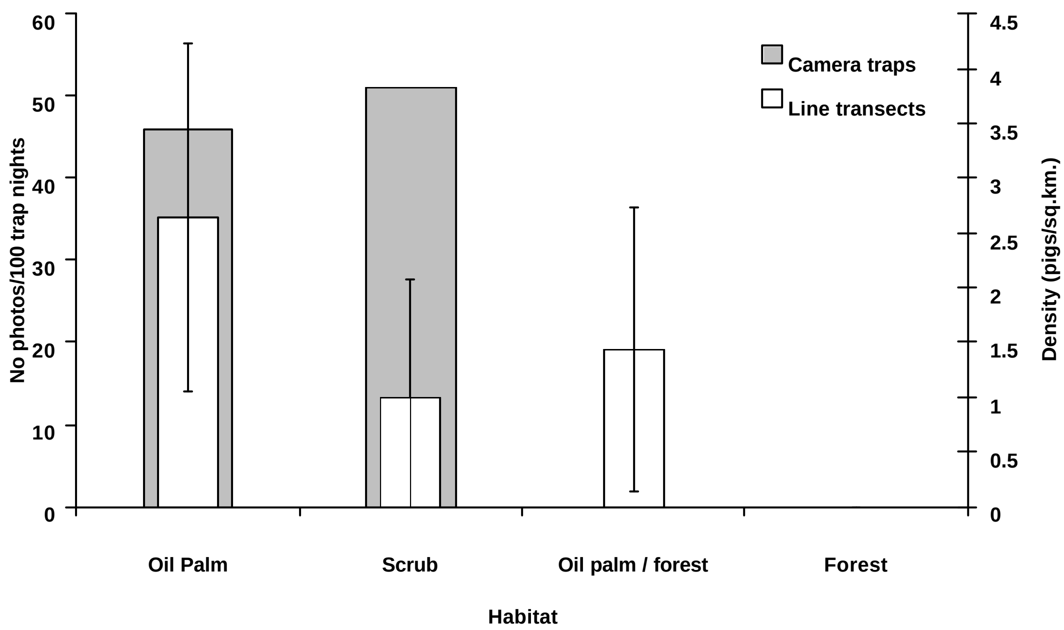


Figure 56 – Comparison of wild pig abundance estimates using night transects (open bars, +/- SE) and camera trap indices (filled bars)



Note: Oil palm / forest boundary habitat was not surveyed by camera traps

DISTRIBUTION OF PREY SPECIES

Distribution of prey species has already been discussed in objective 1 and can be seen in the distribution maps in the appendix. In general, pigs were shown to prefer oil palm habitats or the scrubby set aside areas in the oil palm concession. Densities in the forest did not seem as high.

MOVEMENTS OF PREY SPECIES

Three potential prey species were captured and radio collared. Unfortunately radio collars did not fit pigs properly; bearded pigs could not be collared at all (even slight tightening of the collar caused restriction to breathing, yet the collar could still easily slide off the head) whilst one wild pig was collared for about two weeks before he managed to pull the collar off and another was fitted with a makeshift harness collar which lasted for longer but still the pig managed to free itself within 3 months. Consequently we are not convinced that movement data provided for pigs are necessarily complete. However, the collared tapir has been tracked successfully for 4 months since its capture and we are confident we have mapped most of its range.

Figure 57- Ranges for wild pig (Chrispy Bacon, Sausage) and tapir (Shergar) from radio tracking fixes

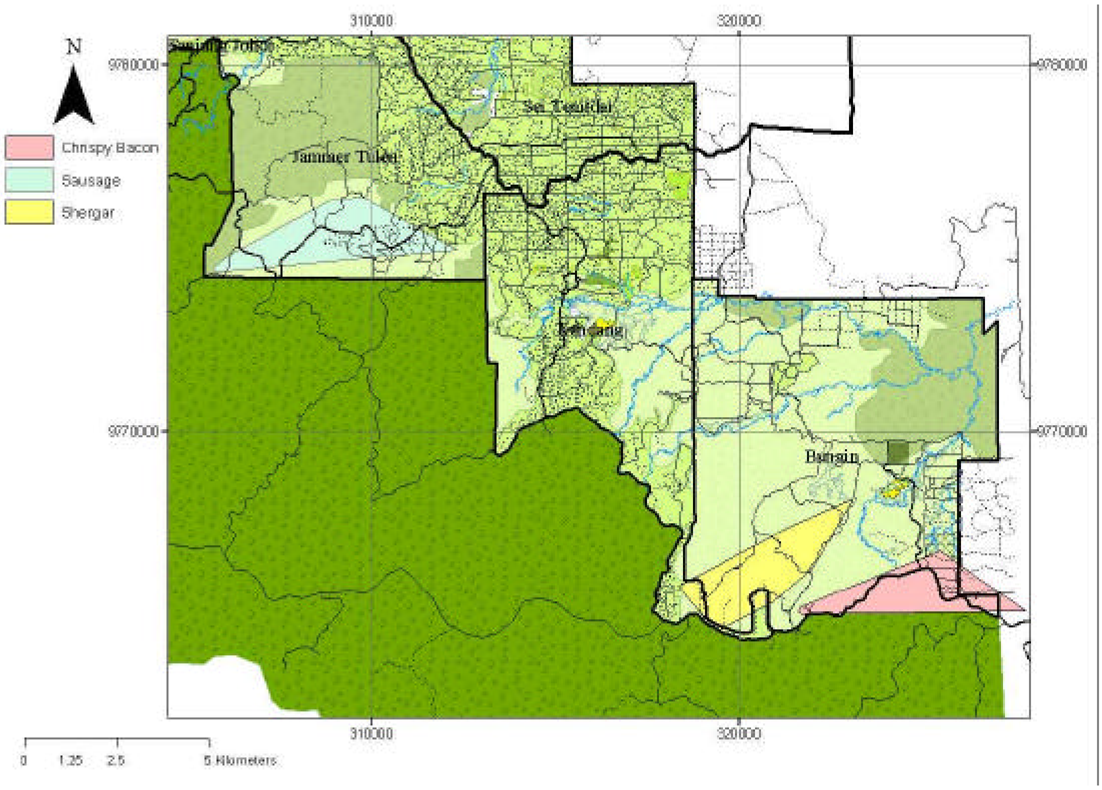


Table 19 - Home ranges (95% MCP) for three tiger prey species from radio tracking data

Species	Name	95% MCP (km^2)
Tapir	Shergar	6.2
Wild pig	Chrispy Bacon	5.4
Wild pig	Sausage	6.6

The prey radio tracking study is far from complete, but preliminary results show that both pigs radio collared stayed fairly close to the forest border but spent almost all of their time in marginal oil palm / scrub habitats. Ranges for both were similar, about 5-6 square kilometres, but data were insufficient to be sure these were final ranges. Both pigs spent some time around the capture site before moving 2-3 kilometres to a new area. Almost no data area available on tapir, but results so far obtained from Shergar show that she appears to have a similar range to the pigs of around six square kilometres. Interestingly she appears to be entirely restricted to the scrubby area of the plantation set aside land and although ranging close to the forest has not yet been recorded inside.

IMPACTS OF PREY SPECIES ON THE PLANTATION

Although a complete programme design has been drawn up and all equipment purchased, studies of plantation losses to pigs have been hampered by the requirement to work closely and continuously with the plantation staff, with both sides also trying to achieve many other objectives.

So far, a detailed plan of the study has been drawn up and translated into Indonesian. A succession of meetings have been held with estate managers and agronomists and all appear agreed on the general approach. There are two main foci; of major concern to the plantation are losses of saplings, trees under two years old that are planted into the field. As a developing plantation, many of the trees are young and managers complain that many are being damaged or killed by pigs. This is a particularly important impact because loss of a young tree means an effective loss of 20-25 years of production from that tree. Replacement of single saplings is time consuming and expensive and also puts individual trees out of synch with neighbouring trees. Crucially, no effective prevention method is known, although several semi-effective measures are employed. The second focus is of more interest to the conservationists. This concentrates on the losses of fallen oil palm fruit to pigs and other species. Although this presents a potentially expensive loss to the plantation, it is comparably much lower than sapling losses and fairly easily resolved by tightening up harvesting practices so is seen as the lesser problem. However, fallen fruit is more likely to be the most valuable food source for pigs and thus represents an important potential conflict.

To look at the sapling losses, plots of trees of different ages and in different locations have been identified in the field. These will be fitted with a range of potential protection measures. Once marked, plantation workers will then begin surveying the palms on a weekly basis to note damage, using damage ID cards drawn up by the company agronomist and ZSL. Factors influencing losses will be analysed using factorial analysis.

Fallen fruit studies will be carried out through exclusion studies. Four electric fences have been purchased, each sufficient to isolate half a block of oil palm (approximately 15 hectares). Fruit will be harvested as usual, but fallen fruit left behind will also be gathered and weighed, enabling comparisons between fenced and non fenced areas.

Due to the difficulties in setting up a collaborative project, a single researcher has been hired to concentrate on losses to pest species in September 2004. Assuming permissions are obtained, the first results should be available later in late 2005.

Figure 58 - Example of serious sapling damage caused by pigs and one method of semi-effective prevention

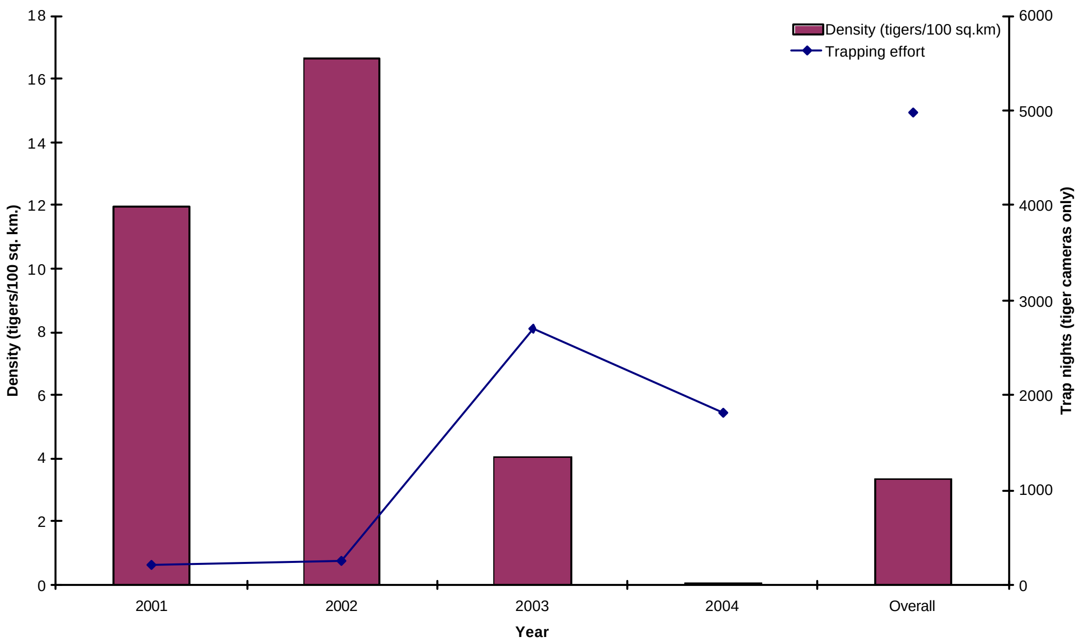
TIGER POPULATION ESTIMATE

Figure 41 in the general monitoring section showed that although tigers were one of the top ten most photographed mammals in the study area, the trapping rates appeared to be falling steadily over time. It is possible to derive an estimate of actual density from trapping rate data (Carbone *et al*, 2001) and although this method has its disadvantages (Jennelle *et al*, 2002) in the absence of sufficient data for mark recapture it can be used to translate trapping rates into some kind of comparable density estimates. Therefore, using the method described by Carbone *et al* trapping rates for each year were translated into densities per square kilometre (Table 20) and plotted together with the camera effort (Figure 59). Initial results from 2001-2 suggested tiger density on site were extremely high, comparable to the densities in the Indian tiger reserves of Nagrahole and Rathambore. However, results from 2003 – 2004 saw a decline in density to almost zero.

Table 20 - Yearly calculated tiger densities based on camera trapping rate

Year	Tiger photos	Trapping effort	Photos/trap night	Trap nights/photo	Density (tigers/100 sq.km)
2001	14	214	0.0700	15	11.98
2002	22	251	0.0700	11	16.66
2003	67	2700	0.0200	40	4.05
2004	1	1814	0.0004	1814	0.06
Overall	104	4979	0.0209	48	3.34

Figure 59 - Tiger density calculated by yearly trapping rates



INDIVIDUAL RECOGNITION

Estimates of tiger abundance can be taken one step further using individual recognition. Using stripes to identify individuals (Franklin *et al*. 1999), eight individuals have been positively identified for each side. These are thought to represent at least nine tigers (since one of the "left only" identifications is almost certainly different from one of the "right only" photos) (Table 21). Four of the tigers are resident, permanent adults (two males, two females) that regularly use land within the oil palm concession and account for the vast majority (78%) of tiger photographs. The others likely form a mixture of dependent cubs from the resident females and rarely sighted independent adults who are suspected to be from previous litters. However, search effort has been restricted to the non-palm plantation habitats (about 15000 ha) and only a small strip of the forest concession bordering these areas. It is therefore probable that several more exist deeper in the forest. Furthermore, with two exceptions, photographs of mothers with cubs have not been obtained, presumably because the cameras cannot be set with less than a 20 second delay, meaning cubs walking close behind their mother are missed. Older cubs (such as "Mambo" and "Eve"), however, walk a few minutes behind their mother and do get photographed. Therefore, based on track records and on scout sightings, several more tigers are known to have used the plantation since the start of the project, but have not been captured on film. In summary, a minimum of eight tigers have been photographed on one given side, but evidence of at least 16 adults and cubs has been collected over the last two years. A summary of all tigers known and their suspected relationships is presented in Table 22.

Table 21 - Composition of tiger photographs taken by camera traps

Tiger	Side photographed		Sex	Age	Last seen	% total
	Left	Right				
Wendy	17	9	F	Adult	12 August 2003	26.53%
Slamet	9	13	M	Adult	19 September 2003	22.45%
Tiga Jari	8	8	F	Adult	11 July 2003	16.33%
Flash	6	6		Adult	16 March 2003	12.24%
Mambo	6	1	U	Young adult	04 April 2003	7.14%
Eve	2	4	U	Young adult	25 March 2003	6.12%
Unidentified	4	0				4.08%
Mo	0	2	F	Adult	30 August 2003	2.04%
Shakira	1	0	F	Adult	08 February 2003	1.02%
Subuh	0	1	F	Young adult	No date	1.02%
Wendy cub A1	1	0	U	Cub	No date	1.02%
Grand Total	54	44				100%

Table 22 - Summary of all known tigers in the Asiatic Persada area in the last two years. Permanent residents within the oil palm are highlighted.

ID	Status	Sex	Age	Area	Notes
Flash	Resident	Male	Adult	Jammer Tulen, NW Asialog	Probably father of Wendy's cubs. Not been photographed since March

					following regular photographs previously.
Wendy	Resident	Female	Adult	Jammer Tulen, palm border, NW Asialog	Bred at least twice. Often near oil palm habitat.
-	Wendy cub A1		Unknown		1st litter present when project began. Photographed once whilst with mother.
-	Wendy cub A2		Unknown		1st litter present when project began. Photographed twice whilst with mother. By Nov 01 looked fully grown but still with mother.
-	Wendy cub B1		Unknown		Second litter born ~ April 2002. Seen by scouts in August 2002 but no camera trap records. Tracks indicate not all three survived?
-	Wendy cub B2				Second litter born ~ April 2002. Seen by scouts in August 2002 but no camera trap records. Tracks indicate not all three survived?
-	Wendy cub B3				Second litter born ~ April 2002. Seen by scouts in August 2002 but no camera trap records. Tracks indicate not all three survived?
Shakira		Female?	Young adult?	NW Asialog	Possibly Wendy cub A1. Definitely not A2. Stripe patterns similar to Wendy
Subuh		Female?	Unknown	Jammer Tulen	Photographed once in 2001. Stripes similar to Wendy and seen in her area. Cub from previous litter?
Unidentified 1		Female	Young adult?	Jammer Tulen	Possibly other side of Shakira – stripes similar
Unidentified 2		Unknown	Unknown	Jammer Tulen	Can't match but poor quality
Slamet		Male	Adult, 6-7 yrs	Bungin, NE Asialog, at least once in Jammer Tulen	Radio collared in May 2003. Lost collar in Dec 2003 / Jan 2004
Tiga Jari	Resident	Female	Adult	Bungin, prob. NE Asialog	Three toes on one foot
Eve	Tiga Jari cub A1	Female	Sub adult	Bungin	Originally seen associated with Tiga Jari in Bungin – probably her cub.
Mambo	Tiga Jari cub A2	Unknown	Sub adult	Bungin, Jammer Tulen	Originally seen associated with Tiga Jari in Bungin – probably her cub. Most recently seen in Jammer Tulen.
Mo	Resident?	Female	Adult?	Asialog, south of Bungin	Never seen inside the plantation. Seen on a camera trap that Slamet also appears on within 24 hours of one another

Therefore, in the initial years of the study at least 4 breeding adults were present in a study area of about 100 km^2 but an estimated 14 individuals have used the area at some point (the approximate area surveyed by cameras not including oil palm crop habitat), which tallies fairly well with the density estimates. However, as with the camera trapping rates, photographs of individual tigers have all but disappeared. In the last year a single photograph has been obtained (Mambo). Track records (Figure 36) show tigers are still present in the area but either they are avoiding camera traps or densities have fallen so low so as to make camera trapping a very rare event.

The potential reasons for this decline are varied and in many cases data are insufficient to prove one way or the other. One possible answer is that tigers have simply shifted activities beyond the study area. It is hoped that a wide ranging survey in 2005 and will answer if this is the case. A common reason for tiger decline is prey shortage, however, camera trapping rates at least do not show any sign of reduction for either pig species (in fact bearded pigs have increased) or for Cervidae species. More likely is the influence of human activities – camera trap rates do not show any major increase in human presence in the tiger areas (apart from a rise when tigers first appeared to disappear) but the huge extent of illegal logging and clearing currently underway in both the forest concession and unplanted plantation areas are likely to be having a strong impact.

RANGING PATTERNS

RANGE CALCULATION

Ranging patterns could be calculated from camera traps for the four most photographed tigers and from radio tracking fixes for Slamet, the radio collared tiger. Combining all available data and using minimum convex polygons to estimate ranges shows the results in Figure 60. These show fairly similar ranges for all tigers (around 12-14 km^2 except for Tiga Jari who was only photographed in a very small area). Camera traps are extremely restricted in their reliability as a range estimate tool since the range is limited by the user's placement of cameras. However, radio tracking data from Slamet gave negligible differences in the estimate of his range (Figure 61) and comparison with the camera distribution (Figure 19) shows that ranges were not just restricted to the area surveyed (in other words, cameras outside this area did not record the tigers) suggesting that the range estimates may be fairly accurate. If so, this would form very low ranges, with other tiger ranges varying from about $30km^2$ for females and $200km^2$ for males in the only other radio tracking study (Chundawat, 1999) whilst in other areas ranges can exceed $1000km^2$. Slamet was monitored until December 2003 when he slipped his collar. Before this he was occasionally sighted on camera traps looking fit, healthy and well fed (Figure 62) but since the collar loss neither Slamet or any other tiger has been photographed in that region.

Figure 60 - Tiger ranges (calculated from camera trap data and radio tracking fixes where available) for the four most photographed individuals

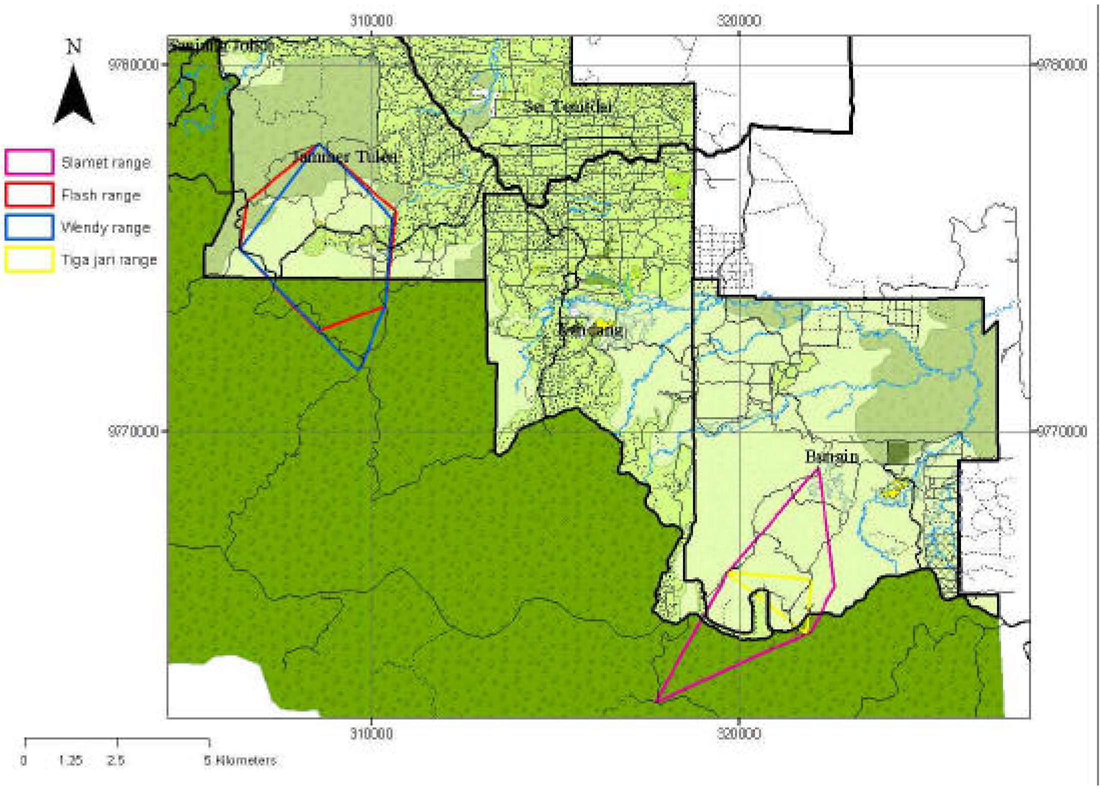


Table 23 – Tiger ranges as calculated from camera traps and radio tracking data where available

Individual	Sex	Area (km^2)
Slamet	Male	12.2
Tiga Jari	Female	1.7
Flash	Male	14.2
Wendy	Female	14.0

Figure 61 - Calculation of Slamet's range from camera traps (cameras) and radio tracking fixes (triangles)

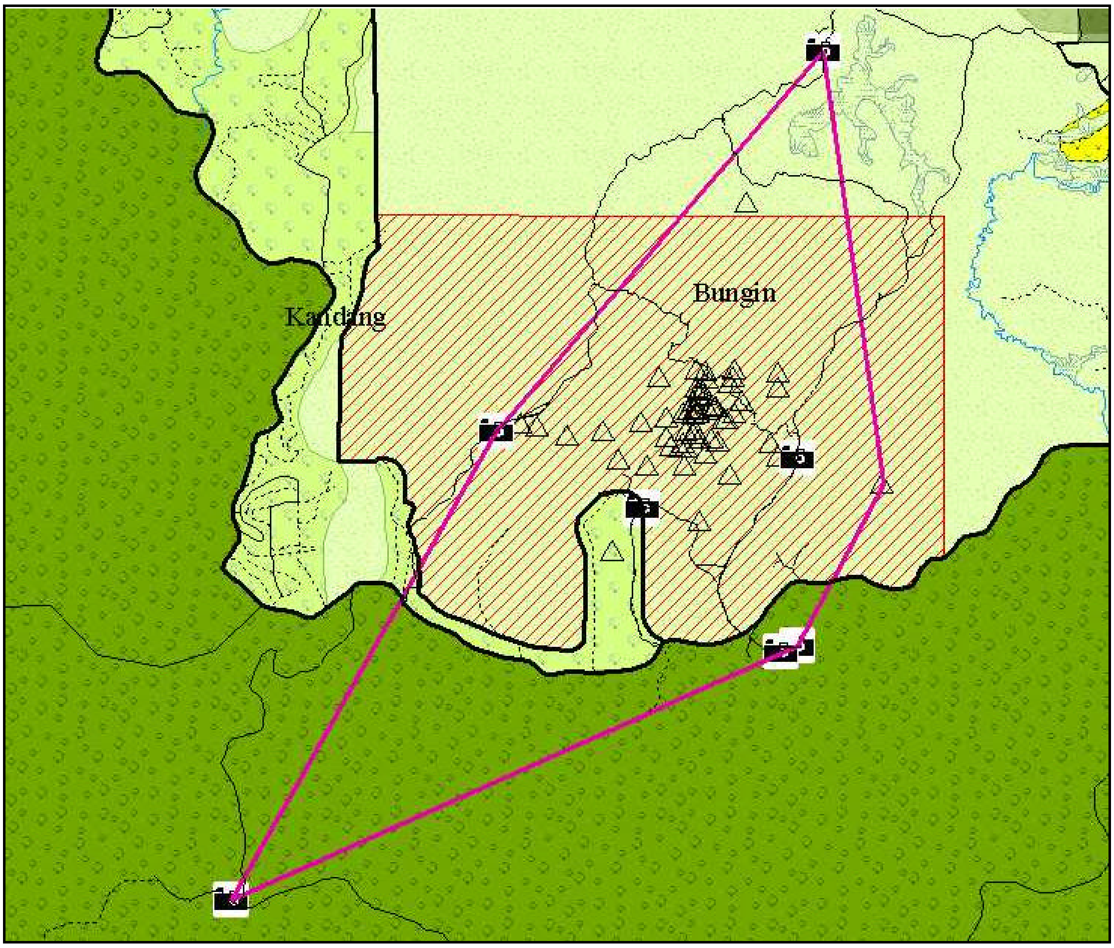


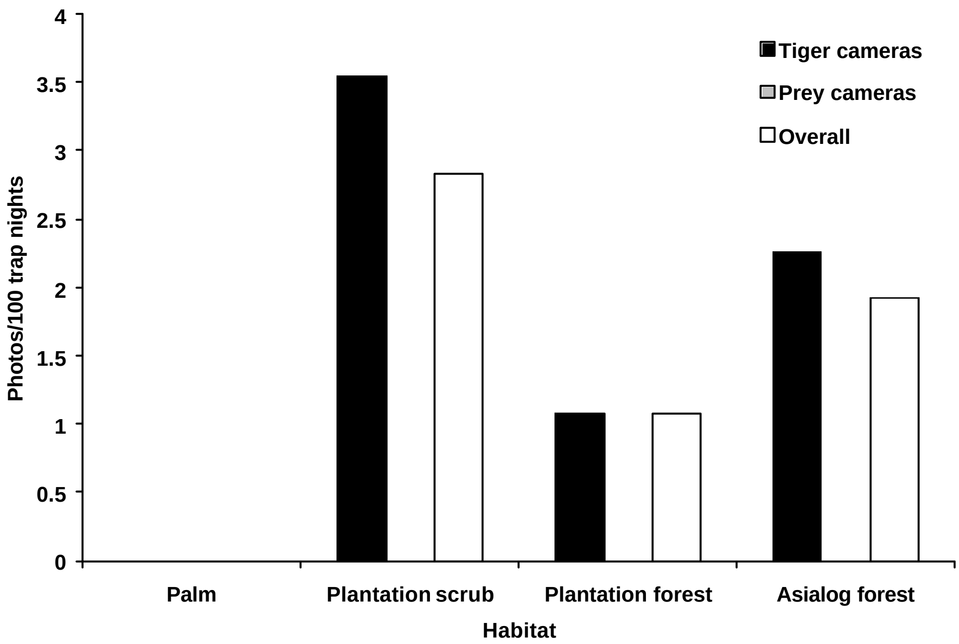
Figure 62 - "Slamet" wearing a radio collar

CAMERA TRAPPING RATES IN DIFFERENT HABITATS

Table 24 - Trapping rates (photos/100 trap nights)for tigers inside and outside the plantation using two camera placement methods

Region	Habitat	Non random cameras	Randomly placed cameras	Overall
Forest concession	Forest	2.26	0.00	1.92
Forest total		2.26	0.00	1.92
Plantation	Forest	1.08		1.08
	Palm		0.00	0.00
	Scrub	3.54	0.00	2.83
Plantation total		3.08	0.00	2.06
Total		2.90	0.00	2.04

Figure 63 - Camera trapping rates in different habitats from "tiger" cameras only



The results show that most tiger photos are taken inside the plantation in the scrub habitats, one of the two habitats with the highest density of pigs. However, tigers were never photographed inside the oil palm crop where pig densities were also high. Furthermore, tigers were never photographed from the randomly placed or "prey" cameras, substantially reducing the number of trap nights from which data were available.

ACTIVITY PATTERNS AS DETERMINED BY CAMERA TRAPS

Tigers around the oil palm are primarily active at night, however there is still significant activity during the day when humans are also active, with 60% of photographs taken at night, 40% in the day. Activity periods have so far been similar between males and females (based on 24 samples), although there is a slight tendency for females to be active earlier in the night and males later. Times for daylight photographs are unrepresented since the date stamp is frequently bleached out from the negative.

Table 25 - Times tigers are photographed

	18:00-22:00	22:00-02:00	02:00-06:00	06:00- 10:00	14:00-18:00	Total
Female	43%	21%	7%	21%	7%	100%
Male	40%	0%	30%	20%	10%	100%
Total	42%	13%	17%	21%	8%	100%

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APPENDICES

PROBLEMS WITH "CAMTRAKKER" CAMERA TRAPS

One of the main problems of 2003 was the reliability of the camera traps chosen for the research. "Camtrakkers" are a well known brand of camera trap. They were selected partly for their increased security compared to other cameras but also because they used by various other conservation bodies in tropical conditions, despite being primarily designed for the American hunting market. Considering they are one of the most expensive models on the market their performance was particularly disappointing. The problems came in three main areas:

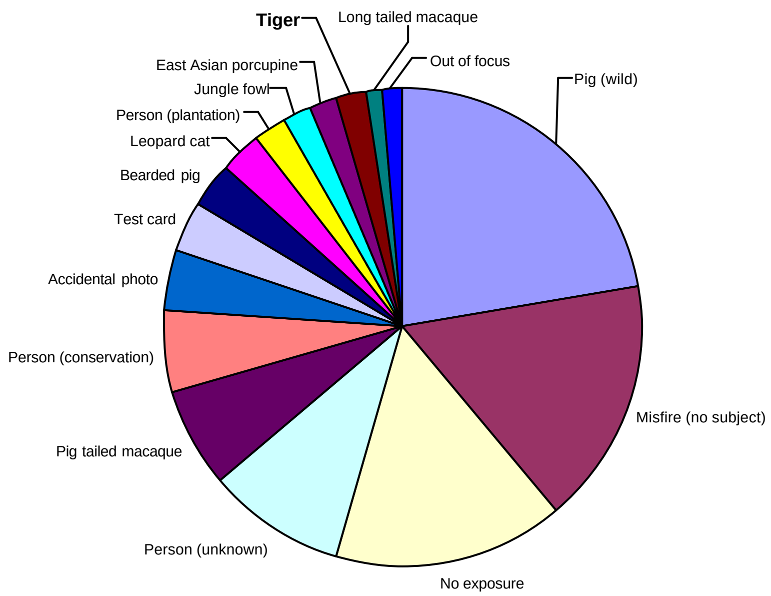
Reliability:

- Of 6 cameras bought in the last two years, 5 of 6 (83%) have broken beyond use. The last camera is extremely insensitive and cannot be triggered deliberately, but occasionally still takes photos in the field..
- From the shipment of 38 cameras that arrived in January 2003, 9 cameras (23%) were not working on arrival.
- One year later, 13 (35%) have now needed to be returned for repair. However, taking into account the fact we have had 8 stolen, the failure rate of the remaining cameras is 43%.
- Of the repaired and returned cameras, a further 1 was not working on arrival.
- Of 38 cameras only 4 have caused no problems within the first year. However, two of these were stolen within a few months. Removing the 8 stolen cameras from the calculation leaves the result that only 2 (6%) of our shipment has worked satisfactorily for one year.
- Of 44 cameras we are left with 16 working in the field and 4 "assumed working" (*i.e.* newly returned but no films yet developed)

"Misfiring":

- On some occasions "misfires" (photographs with no apparent subject) could occur due to vegetation warming and moving in the wind or due to an animal passing by too fast to photograph. However, the former is usually easy to spot whilst the latter is not thought to occur regularly (we frequently photograph motorbikes driving by for example – there can't be many animals moving much faster than this). Most misfires appear to be caused by a camera malfunction, with the camera taking photographs until the film ends at regular or fairly regular intervals. Sometimes entire films are used up within a few hours of set up and on occasion cameras rapidly take a succession of photos (with no delay) whilst being set up despite being turned off! This appears to be an issue with only certain cameras despite some of these being extremely difficult to trigger deliberately.
- 889 of 5113 negatives contain no subject
- This accounts for over 17% of all photographs taken and is our second most common reason for a camera to be triggered (Figure 64)

Figure 64 – Proportion of photographs accounted for by misfires and non-exposures compared to the main other subjects



Time / Date stamp:

- The time/date stamp is our only reference matching photographs to records of where cameras were placed at the time. Without it, the location of most photographs cannot be determined and thus the use of the image for most of our research questions is highly restricted.
- Of films where the date appeared at least once (*i.e.* the time/date stamp was turned on), 1195 of 5113 or 23% of negatives have the time/date stamp bleached out. This does not include photographs for which the date could be worked out based on previous and subsequent photographs.
- Date bleaching most often occurs in photographs taken during the day. 43% of photographs taken in the day have no time/date stamp.
- Bleaching is not dependent on the developer and occurs at developers in the UK and Indonesia equally.

Insensitivity:

- After setting up, cameras are tested by a human holding a sign showing the date and location. If the camera cannot be triggered manually (taking into account the 10 minute "warm up" period mentioned in the instructions) it is recorded as insensitive.
- 12 of 16 cameras (75%) currently working in the field have caused problems when trying to test.
- Insensitivity is of particular importance when comparing "trapping" results from different areas. At present we have no way of knowing whether a relative lack of photographs from one area represents a low density of tigers or whether it simply shows where we put our poorest cameras!

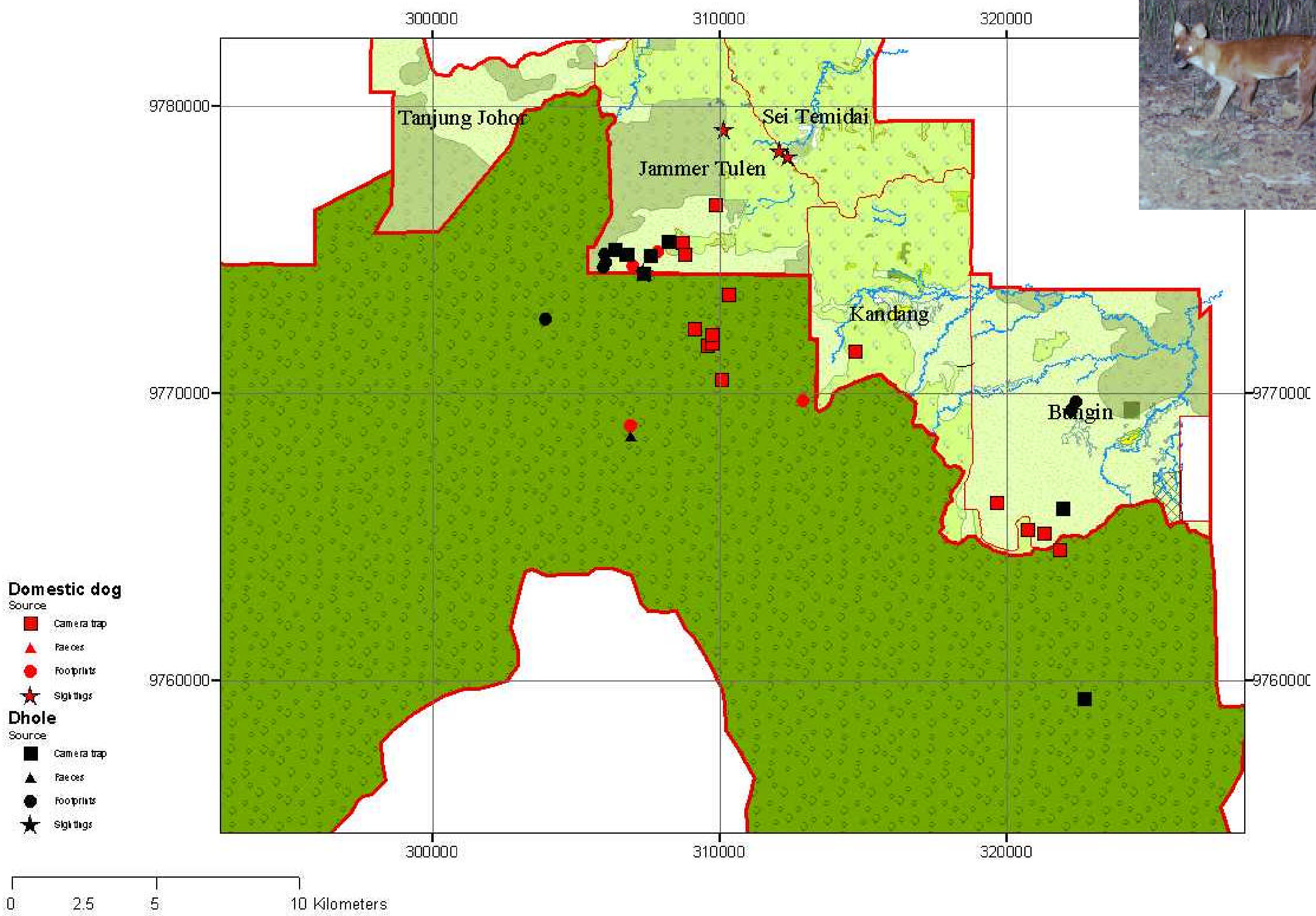
LIST OF ALL SUBJECTS PHOTOGRAPHED

Common name	Latin name	Total photos	Total individuals	Average individuals per photo	Total geo-referenced individuals	% total geo-referenced photos	% total geo-referenced individuals
Accidental photo		334	334	1.00	211	3.06%	2.55%
Misfire (no subject)		2485	2486	1.00	1966	28.49%	23.78%
Motorbike (non-plantation)		13	13	1.00	13	0.19%	0.16%
Motorbike (plantation / conservation)		58	62	1.07	61	0.83%	0.74%
No exposure		1382	1382	1.00	41	0.59%	0.50%
Out of focus		100	100	1.00	82	1.19%	0.99%
Person (conservation)		783	982	1.25	816	9.45%	9.87%
Person (plantation)		251	331	1.32	289	3.35%	3.49%
Person (unknown)		603	978	1.62	720	6.78%	8.71%
Test card		502	502	1.00	462	6.69%	5.59%
Vehicle (non-plantation)		25	26	1.04	26	0.36%	0.31%
Vehicle (plantation / conservation)		77	77	1.00	66	0.96%	0.80%
Wreathed hornbill	*Aceros undulates*	1	1	1.00	1	0.01%	0.01%
White breasted waterhen	*Amauronis phoenicurus*	12	14	1.17	13	0.16%	0.16%
Argus pheasant	*Argusianus argus*	2	3	1.50	3	0.03%	0.04%
Rhinoceros Hornbill	*Buceros rhinoceros*	2	2	1.00	2	0.03%	0.02%
Plantein squirrel	*Calosciurus notatus*	8	8	1.00	8	0.12%	0.10%
Domestic dog	*Canis familiaris*	33	47	1.42	32	0.33%	0.39%
Greater coucal	*Centropus sinensis*	1	1	1.00	1	0.01%	0.01%
Sambar	*Cervus unicolor*	28	29	1.04	18	0.25%	0.22%
Emerald Dove	*Chalcophaps indica*	4	4	1.00	3	0.04%	0.04%
Dhole	*Cuon alpinus*	21	29	1.38	26	0.29%	0.31%
Banded palm civet	*Diplogale derbyanus*	2	2	1.00	2	0.03%	0.02%
Domestic cat	*Felis cattus*	5	5	1.00	5	0.07%	0.06%
Jungle fowl	*Gallus gallus*	109	130	1.19	123	1.51%	1.49%
Sun bear	*Helarctos malayanus*	35	39	1.11	27	0.38%	0.33%
Short tailed mongoose	*Herpestes brachyurus*	25	25	1.00	24	0.35%	0.29%
East Asian porcupine	*Hystrix brachyuran*	137	147	1.07	134	1.83%	1.62%
Three striped ground squirrel	*Lariscus insigins*	4	4	1.00	4	0.06%	0.05%
Crestless Fireback	*Lophura erythrophthalma*	2	3	1.50	3	0.03%	0.04%
Long tailed macaque	*Macaca fascicularis*	44	68	1.55	35	0.36%	0.42%
Pig tailed	*Macaca nemestrina*	507	759	1.50	647	6.25%	7.82%

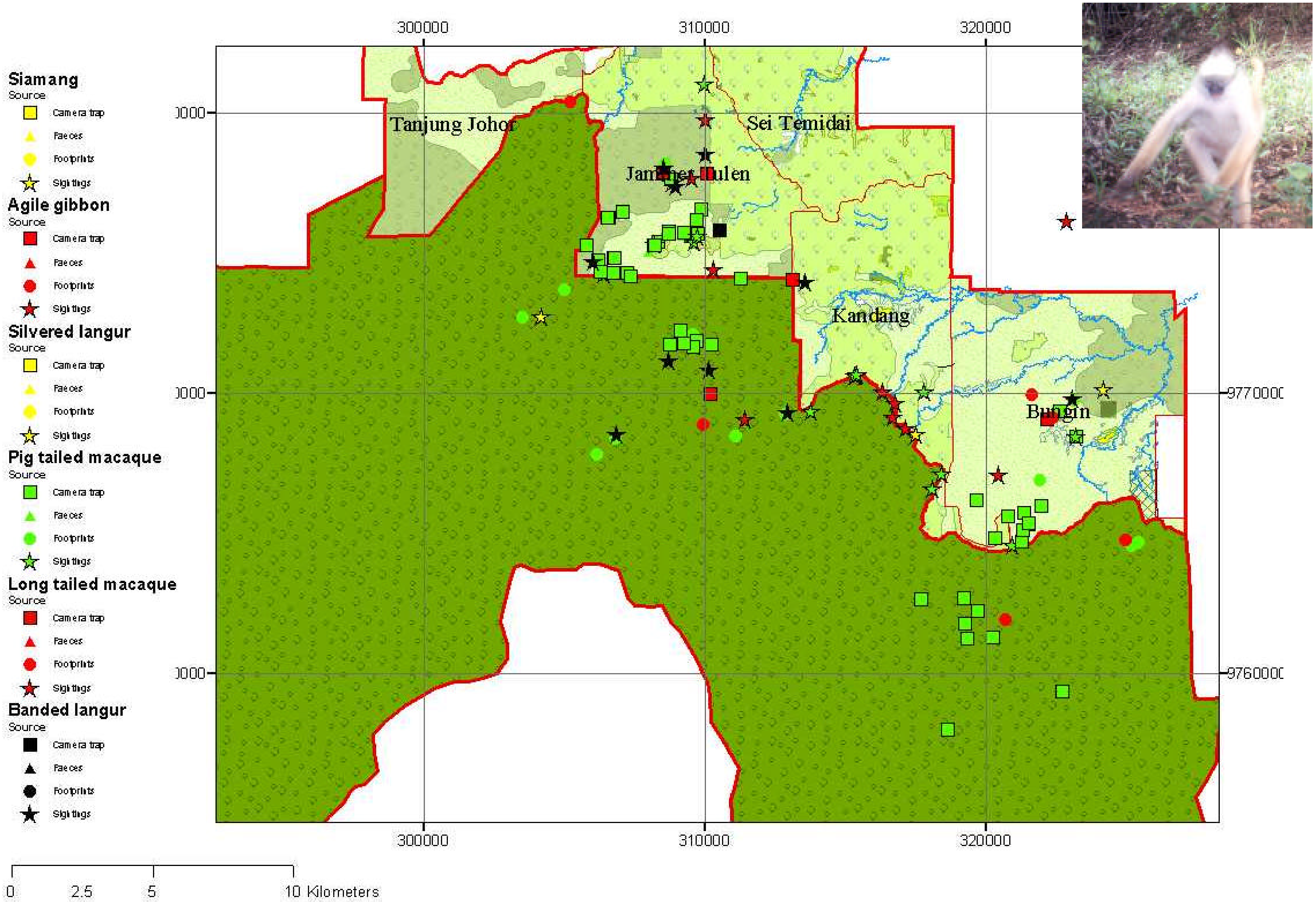
macaque							
Pangolin	*Manis javanica*	2	3	1.50	3	0.03%	0.04%
Yellow throated marten	*Martes flavigula*	2	2	1.00	1	0.01%	0.01%
Red spiny rat	*Maxomys surifer*	1	1	1.00	1	0.01%	0.01%
Muntjac	*Muntiacus muntjak*	84	95	1.13	86	1.12%	1.04%
Clouded leopard	*Neofelis nebulosa*	2	2	1.00	2	0.03%	0.02%
Tiger	*Panthera tigris*	112	113	1.01	102	1.46%	1.23%
Common palm civet	*Paradoxurus hermaphroditus*	57	57	1.00	56	0.81%	0.68%
Banded langur	*Presbytis melalophos*	1	1	1.00	1	0.01%	0.01%
Leopard cat	*Prionailurus bengalensis*	193	194	1.01	184	2.65%	2.23%
Crested partridge	*Rollulus rouloul*	1	4	4.00	4	0.01%	0.05%
Bearded pig	*Sus barbatus*	168	349	2.08	308	2.26%	3.72%
Pig (wild)	*Sus scrofa*	1201	1701	1.42	1558	16.11%	18.84%
Malayan tapir	*Tapirus indicus*	54	54	1.00	48	0.70%	0.58%
Lesser mouse deer	*Tragulus javanicus*	15	15	1.00	14	0.20%	0.17%
Greater mouse deer	*Tragulus napu*	9	11	1.22	11	0.13%	0.13%
Long tailed porcupine	*Trichys fascilulata*	1	1	1.00	1	0.01%	0.01%
Common tree shrew	*Tupaia glis*	1	1	1.00	1	0.01%	0.01%
Large tree shrew	*Tupaia tana*	2	2	1.00	2	0.03%	0.02%
Monitor lizard	*Varanus salvator*	6	6	1.00	5	0.07%	0.06%
Malay Civet	*Vivera tangalunga*	19	19	1.00	17	0.25%	0.21%

DISTRIBUTION MAPS

CANIDAE DISTRIBUTION



CERCOPITHECIDAE AND HYLOBATES DISTRIBUTION



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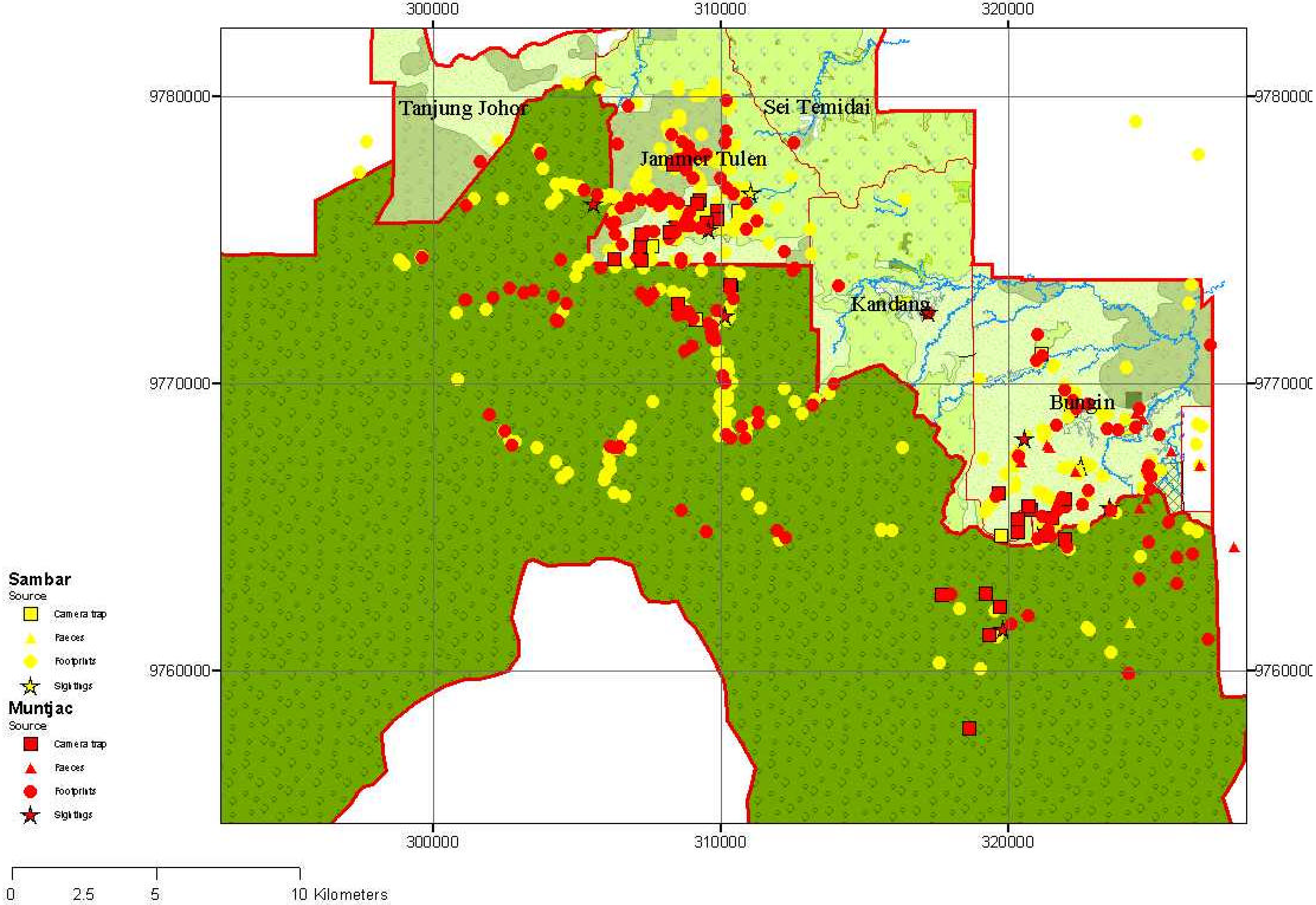

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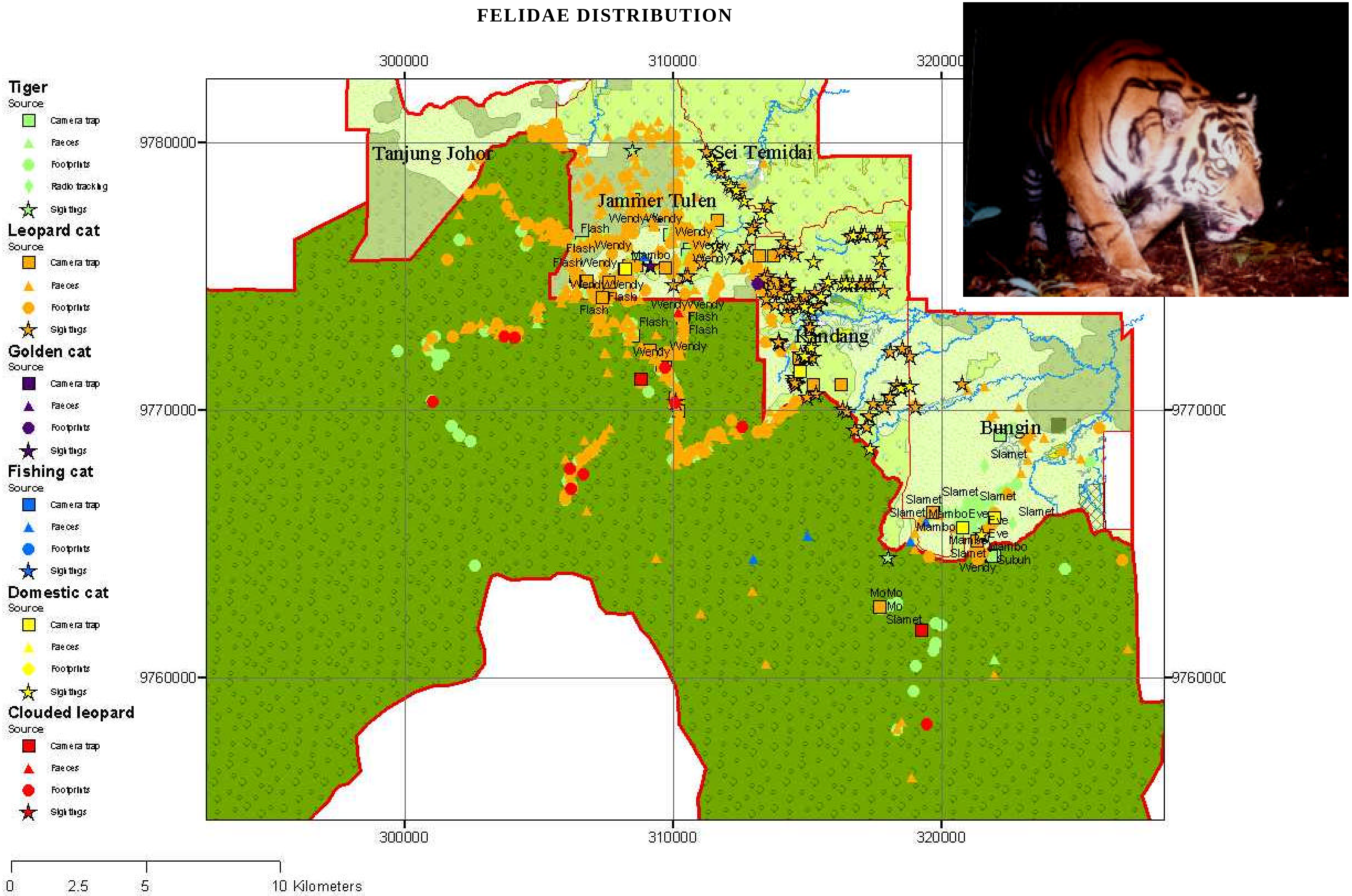

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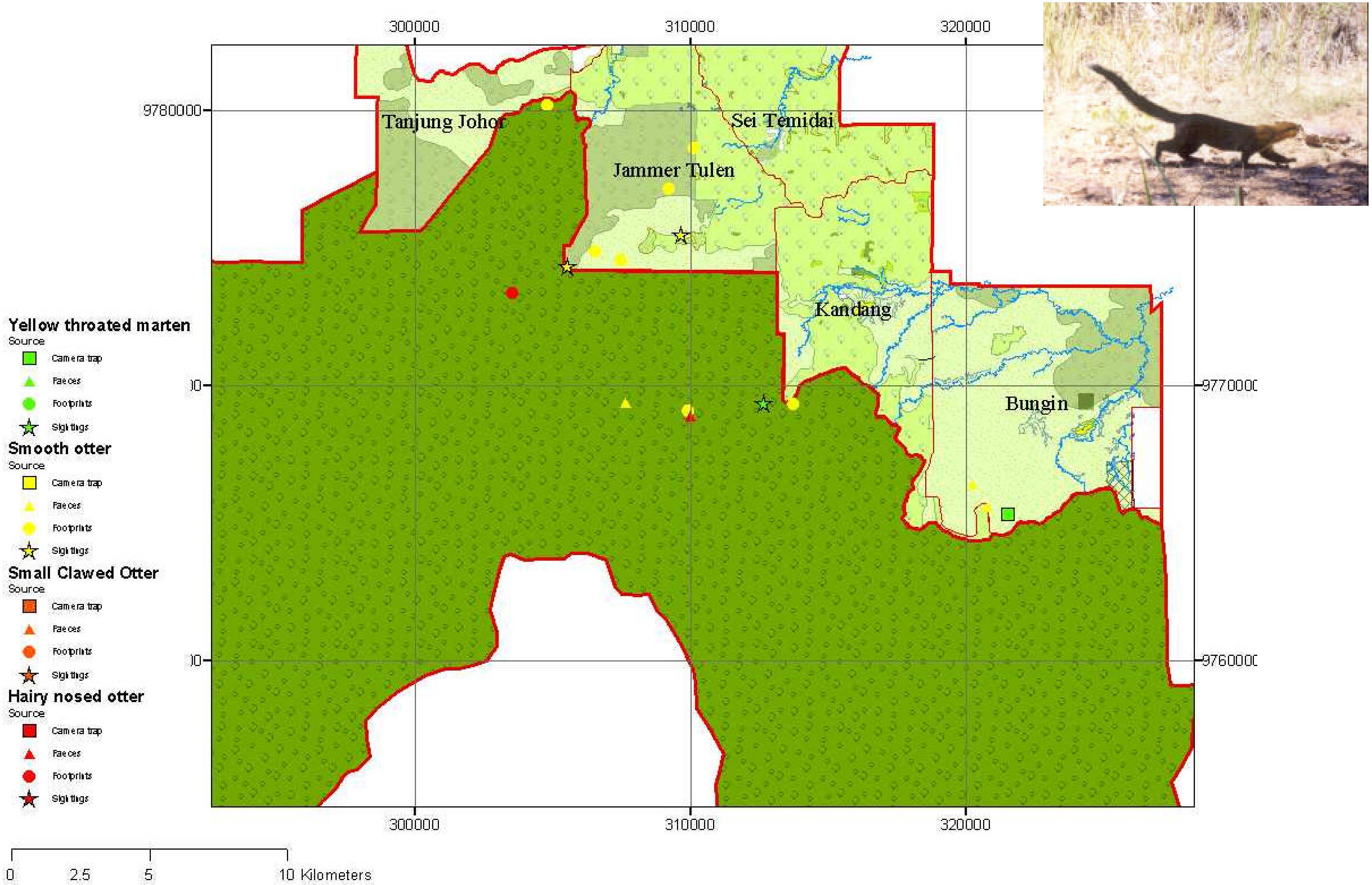
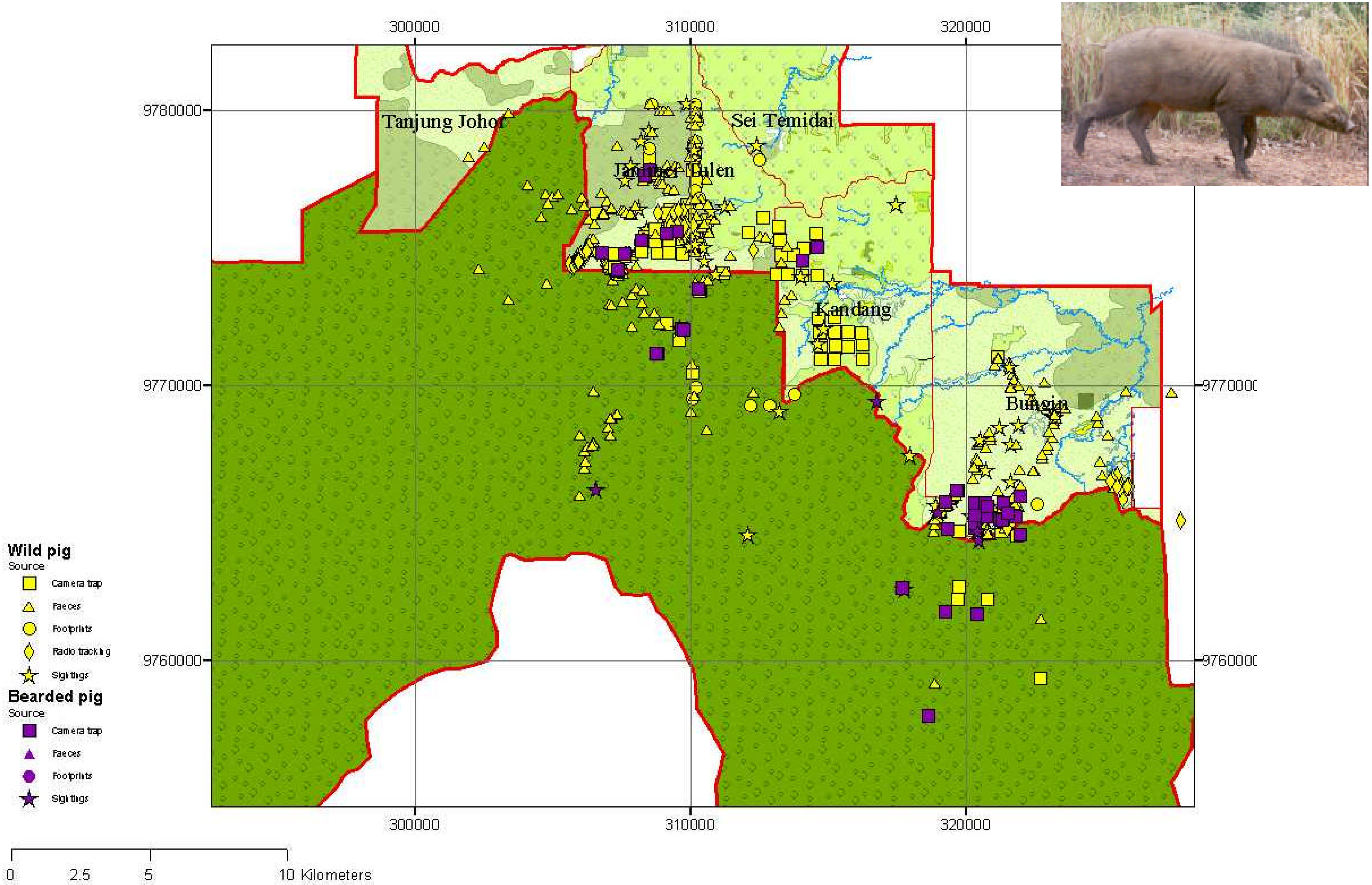
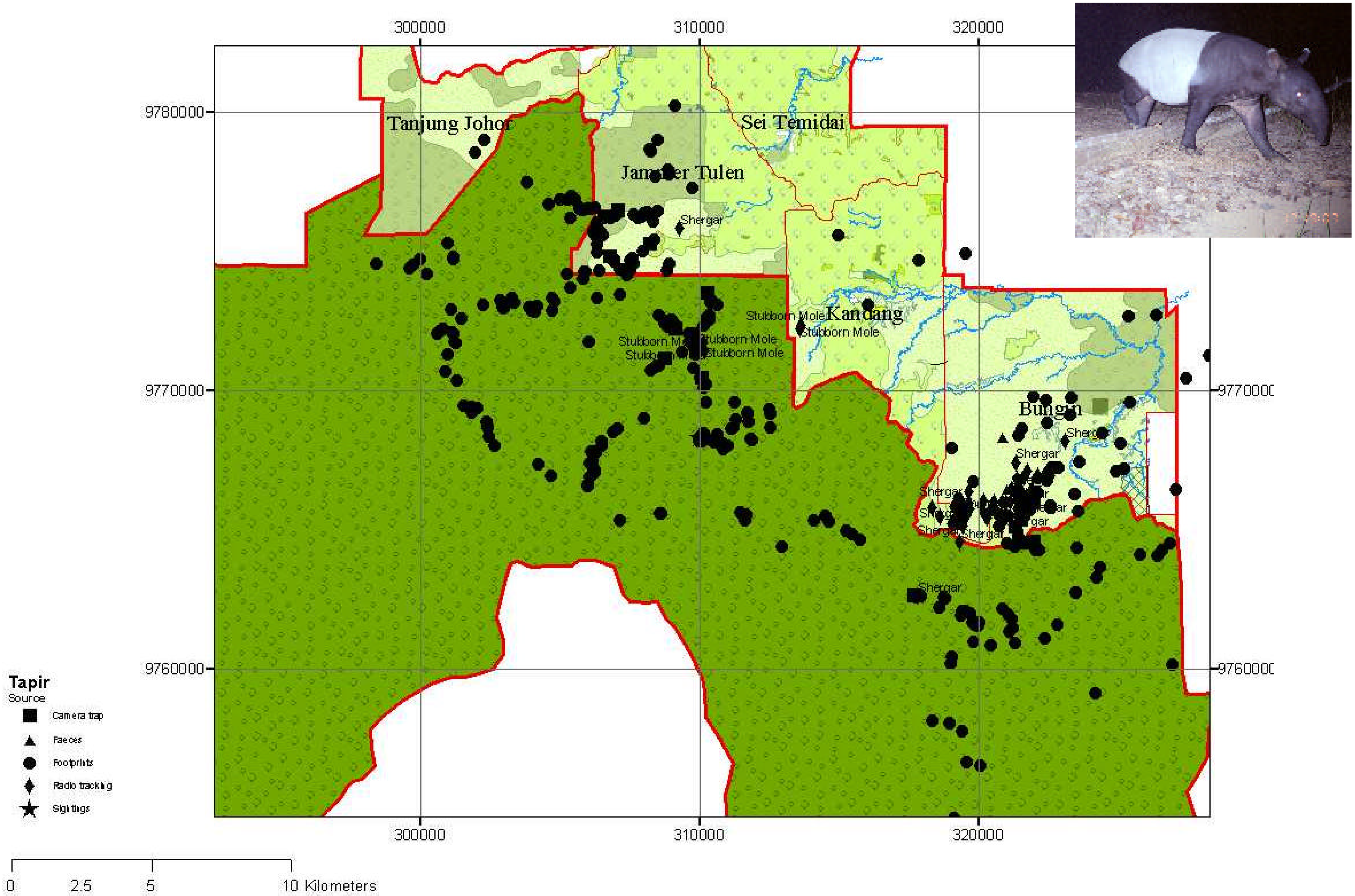


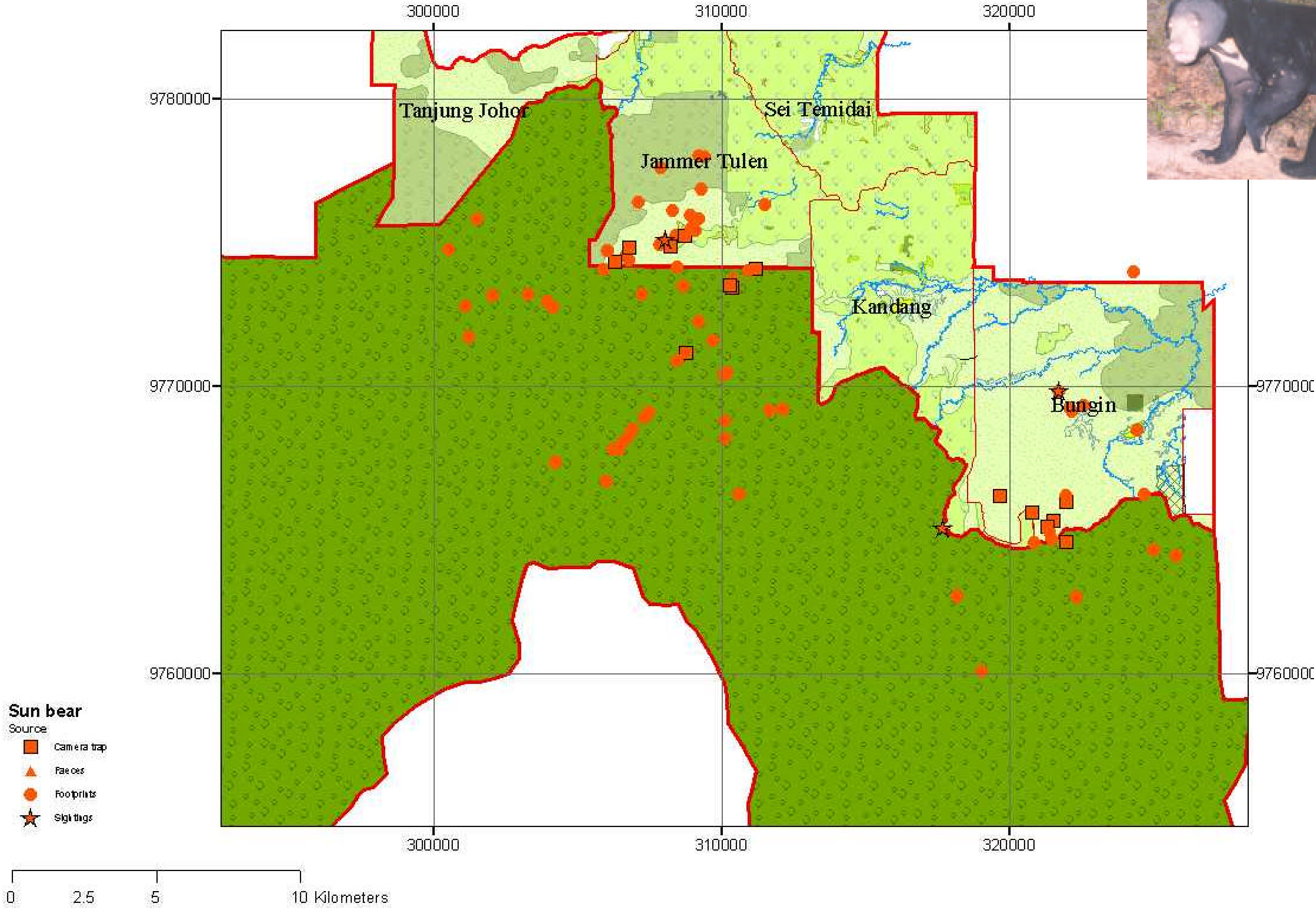
SUIDAE DISTRIBUTION



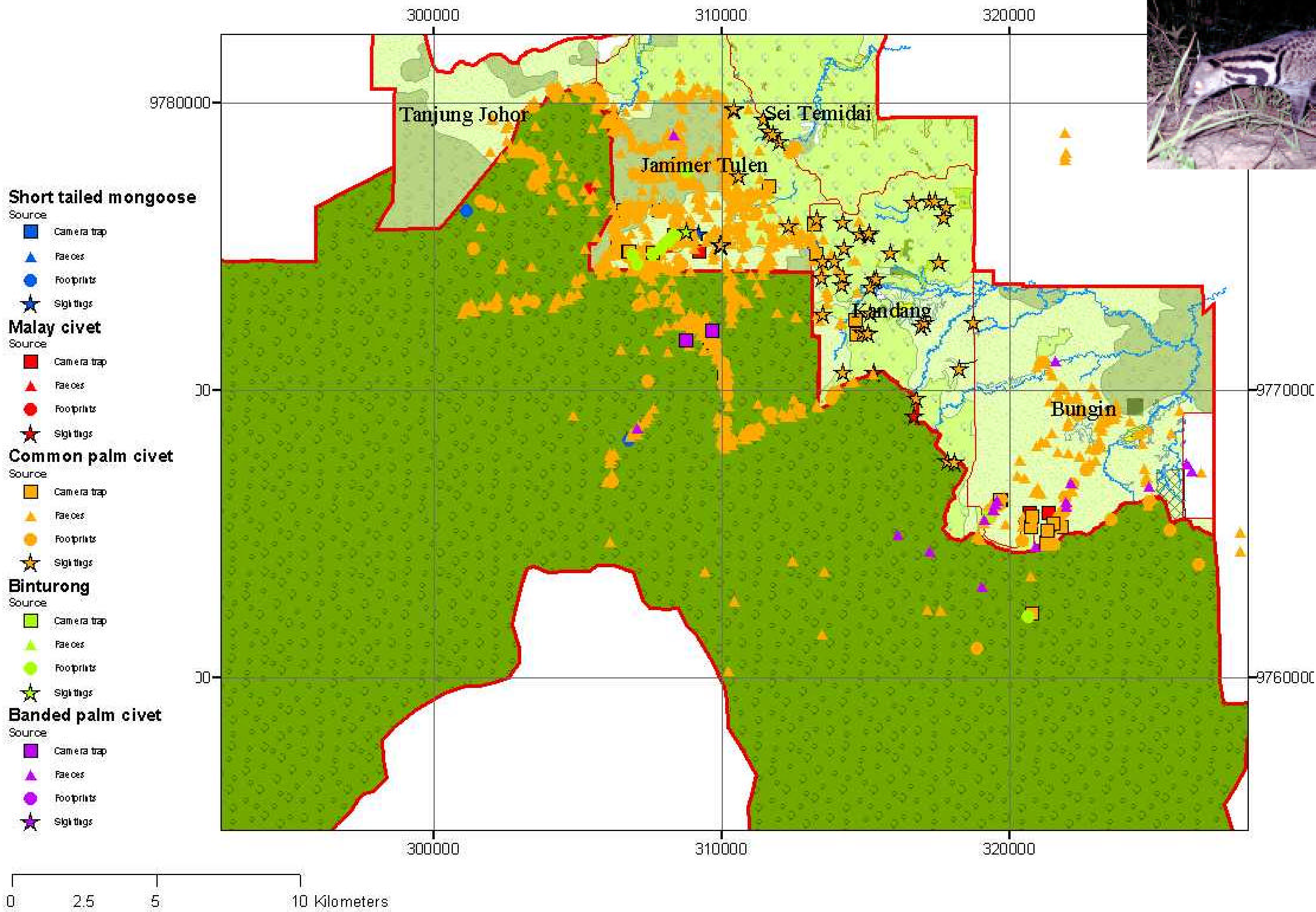
TAPIRIDAE DISTRIBUTION



URSIDAE DISTRIBUTION

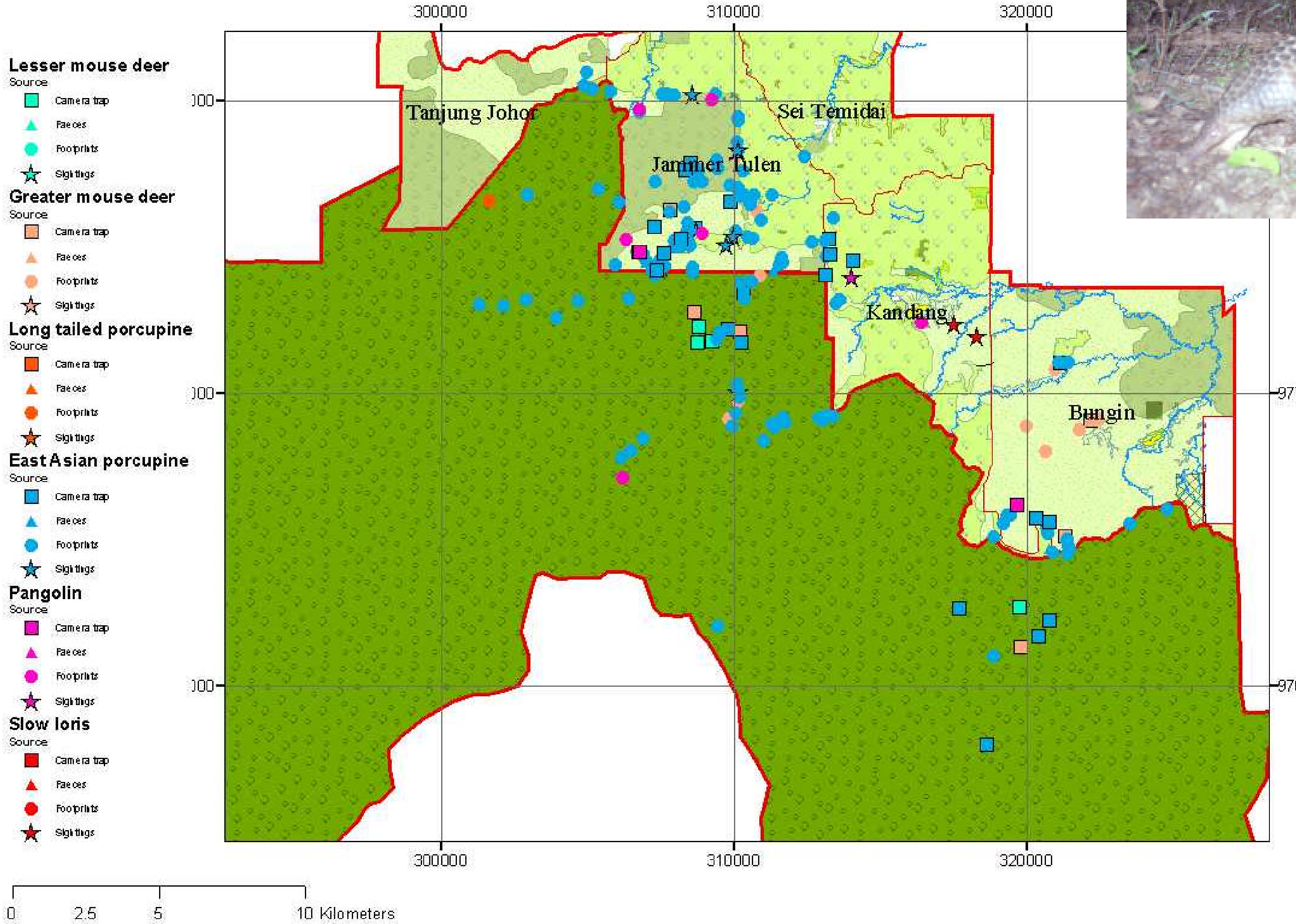


VIVERRIDAE DISTRIBUTION



OTHER SMALL MAMMAL DISTRIBUTION

(Lorisidae, Manidae, Hystricidae, Tragulidae)



HUMAN AND ILLEGAL ACTIVITY DISTRIBUTION