Population density survey of primate species in unprotected primary peatswamp forest: Sabanga catchment area, Central Kalimantan

Alice Teixeira
Department of Life Sciences, APU Cambridge
Student number 0204645/1
Supervisor Dr. A. Smith
Abstract

Setia Alam is located within the Sabanga Catchment, within Central Kalimantan, Borneo, Indonesia. At the time of the research the forest was unprotected by law, however, since November 2004 568,000 hectares of the forest is now protected. The aim of this study was to survey populations of primate species by direct observation at Setia Alam Field station, with the area surveyed and within the area of the national park. The study was carried out from the 21st July 2004, within a 4km pre cut transect of primary peatswamp forest. Two transects were walked by two groups of two people nearly everyday, the walks started at six and continued until complete, the teams always walked in parallel in adjoining transects with radio contact at all times for safety and so that no animals were sighted twice.

The species of primate sighted are Bornean Orangutan (*Pongo pygmaeus pygmaeus*), Bornean Gibbon (*Hylobates agilis albibarbis*), Red langur (*Presbytis rubicunda*), Silver langur (*Presbytis cristata*) and the Pig tailed macaque (*Macaca nemestrina*).

DISTANCE 4.1 was used to analysis the Orangutan, Gibbon and all other species combined, due to lack of sightings not all species for which data was collected could be analysed separately. Population density estimates yielded the following results: 1.76 individual orangutan species per/km², 3.95 individual gibbon species per/km² and 5.94 individuals of listed primate species per/km². For the red langur there was not enough data to estimate a density using DISTANCE so an index was used to find the density, the density was
calculated by dividing the number of adult and juvenile animals in all of the identified social groups at each site by the study site area. (Merenlender 1998). The results showed 0.05 individual red langur species per/km walked.

Human disturbance continues to threaten the fauna and flora of the Sabanga National Park. It is hoped that these results will help in the ongoing effort to protect the primates of the Sabanga.
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1: Rationale and Objectives

The primary reason for the establishment of Setia Alam Field Station was to gather baseline data and information about the population of orangutans that inhabit the different habitats in the area. This type of research has been taking place since 1993 and has helped contribute to the Indonesian government’s decision to designate the area, stretching over 568,000 hectares of peat swamp forest, around Setia Alam a National Park in November 2004. This Natural Laboratory is now protected for the purpose of research and is run in cooperation with Orangutan Tropical Peatland Project (OuTrop) whose base in Indonesia is the Centre for International Cooperation In Management of Tropical Peatlands, (CIMTROP), based at the University of Palangkaraya, Universities of Nottingham and Leicester (YCI) and Cambridge, The Leaky foundation, the Orangutan Foundation, the Wildlife Conservation Society and WWF.

The objectives of the study were: (1) determine the distribution and population sizes of primates in peat swamp forest, concentrating on the orangutan and the agile gibbon. 2) To see if the results supported the densities of orangutans and other primates found by previous researchers.
2: Introduction

The island of Borneo Indonesia is one of the last strongholds of so many primate species. Asian primates such as the orangutan (*Pongo pygmaeus pygmaeus*) and Proboscis monkey *Nasalis larvatus* are more critically endangered than any others in tropical regions (IUCN 2004) this is mainly due to the large amounts of deforestation, the wild meat trade and also the pet trade (Robinson *et al* 2000; Robinson and Redford, 1991). The conservation efforts are hampered by a lack of knowledge about the size of populations. There are only a few estimates of population size or density for Asian primates, the orangutan population estimates are 15,953 - 24,497 (Morrogh-Bernard *et al*. 2003). The estimates that do exist tend to be limited to within an area of a few km². Out of all the Asian countries, Indonesia has the highest number of threatened mammals, at 135 species, and birds, at 115 species, in the world (IUCN, 2004).

The primates and forest research is based within Setia Alam, a field station within Kalimantan, Borneo in the Sabangau catchment. (figure 1) Research has been carried out here only since 1993. In 2005 research carried out at the national laboratory since 1995 was presented at a population habitat viability analysis (PHVA) conference, this research indicated that the orangutan population found in the Sabangau catchment, is one of the largest single contiguous population remaining, in Borneo with approx. 6900 individuals (Morrogh-Bernard *et al*, 2003 cited in OuTrop 2005).
The forest type in this region is peat swamp, which makes this forest extremely difficult terrain to walk through. In most peat swamp forests the water is over 1 metre high all year round, in the Setia Alam region the forest floor has been cut to make way for canals, which allow the water to drain out leaving the peat floor totally sparse from water throughout the dry season. Indonesia’s forests represent 10% of the world’s remaining tropical forests with an area of 260 million acres. According to the European League, in 2001 Indonesia had lost 99 million acres of forest over the previous 32 years, which is equivalent to the combined size of Germany and the Netherlands. In total, Indonesia has lost 80% of its original forest habitat and continues to lose 6.2 million acres a year. Of Indonesia’s approximately 40 primate species, 20 were found to have lost more than half their original habitat in the last 10 years. (Orangutan foundation, 2005)

Figure 1: Map of Indonesia outlining Central Kalimantan region.
2.1: **Forest type**

**(Peat swamp forest)**

In South East Asia peatland forest covers extensive parts of Indonesia, Malaysia, the Philippines and Thailand. The peat lands of Borneo have been classified under three categories, coastal, basin/valley and high peat. This is due to past and present climate conditions, land erosion, sediment transport and fluctuations of sea level. (Rieley 2003) Peat age tends to vary from around 2000 to 9000 years old; however the peat within Setia Alam (figure 1) has been aged as 10,000 years which is very old for a peat forest (OuTrop 2004).

![Figure 2 Peat swamp forest within Setia Alam](image)

The flora found within peat swamp forest must be able to cope with the extreme levels of acidity in the soil, with a pH ranging from 3.0 to 4.5. The chemical and physical properties of peat swamp, make it very
poor for crop growth; the high acidity makes it unsuitable for agriculture unless supplements are added.

Peat swamp forest is extremely important habitat for supporting wildlife, it has at least 9 primate species, including the slow loris (Nycticebus coucang) and the pig-tailed macaque (Macaca nemestrina). It is also home to many other types of species such as the sun-bear (Ursus malayanus), bearded pig (Sus barbatus), clouded leopard (Neofelis nebulosa diardi), marbled cat (Pardofelis marmorata), civets (Diplogale hosei) and (Viverra tangalunga), pen-tailed tree shrews (Ptilocercus lowi), and a diverse blend of tropical birds, of which many are habitat specific to peat swamp. There is also a diverse abundance of reptile species including painted bronze-back tree snake (Dendrelaphis pictus) and the waglers pit viper (Tropiodolaemus wagleri).

Despite the diversity of fauna and flora the forests are still being cleared at an alarming rate. The reason such large areas are being burnt or cut down is due mainly to agriculture.

2.2: The primates of the Sabangau rainforest

There are nine species of primate found within the Sabangau rainforest. They are the Bornean Orangutan (Pongo pygmaeus pygmaeus) (figure 2), Bornean Gibbon (Hylobates agilis albibarbis) (figure 5), Red langur (Presbytis rubicunda), Silver langur (Presbytis cristata), Long tailed macaque (Macaca fascicularis), Pig tailed macaque (Macaca nemestrina), Proboscis monkey (Nasalis larvatus)
(figure 4), Western tarsier (*Tarsius bancanus*) and Slow Loris (*Nycticebus coucang*) (figure 3). All these species are under threat from the destruction of their forest see appendix 1.1 for more information.

**Figure 3** Bornean Orangutan (*Pongo pygmaeus pygmaeus*)

**Figure 4** Slow Loris (*Nycticebus coucang*)

**Figure 5** Proboscis monkey (*Nasalis larvatus*),

**Figure 6** Bornean Gibbon (*Hylobates agilis albibarbis*),
3: Methods

3.1: Study site

Setia Alam (loyal to nature) field station is the research site and base for Orangutan tropical peat land project (OuTrop). The base camp is managed by the University of Palangkaraya (UNPAR), solely for the purposes of scientific research (OuTrop 2005). OuTrop set aside an area of forest, which surrounded the field station for a Natural Laboratory research area (NLPF).

Figure 7 Setia Alam (loyal to nature) field station in the dry season, showing access by rail.

Research into the forest and peat structure, ecology and biodiversity with particular focus on orangutan distribution, density and ecology, has been ongoing at the site since 1993, under the auspices of the
Centre for International Co-operation in Management of Tropical Peatland (CIMTROP), the University of Palangkaraya (OuTrop 2005). OuTrop is located 3 km from the Sungai (River) Sabangau, within the Sabangau catchment, in the lowlands of Central Kalimantan, approximately 20km SW of the provincial capital of Palangkaraya as seen in figure 7. The Sabangau catchment, bounded by the Sungai Katingan to the west and Sungai Kahayan to the east, remains largely forested (>7000km²) and forms one of the largest areas of tropical peat swamp forest remaining in South East Asia.

(Figure 8 map of Borneo showing base camp Setia Alam (OuTrop 2005))

This area has been highly utilized for hardwood, tapping gelatine sap from the Gutta-percha tree from the genus *Palaquium* and hunting, up until 2004, till the 500km² became a national park.
The research was carried out from July to September 2004. It started at the end of the wet season and went through the dry season; data collection finishing just as the wet season started again. In the NLPF area the water receded in the dry season due to canals being cut through the forest by loggers. This is extremely damaging to the forest structure, dramatically affecting the fauna and flora. All logging concessions in the area have been inactive since 1998, however, illegal logging remains widespread within this region and the construction of the timber extraction canals is promoting drainage of the high water table which is needed to maintain the peatland substrate. This threatens the long-term integrity of the ecosystem and increasing the habitats susceptibility to fire.

During the survey the levels of water would have only directly affected the primates in how often they would be found on the floor of the forest, these primates are arboreal and so therefore only spend a very small amount of time on the forest floor. However, in a short period of time, the drying out of the peat will also cause increased tree falls and shorter fruiting cycles (Great ape survival project 2005) The resulting increase in canopy gaps and hence the increased difficulty in moving around the forest, plus the less abundance of fruit have been considered a possible cause of a decrease in the population of Orangutans, especially females in hand logged areas. (Felton et al, 2003). Thus a similar effect could be caused here in the short term as during the dry season of this survey the peat dried to a depth of one metre.
3.2: **Transect sites**

The transect sites are all located within one habitat type, lightly logged primary peat swamp forest. All of the observations were made in a 2km by 2km transect. The individual transects were laid out as shown in figure 8. The transects had been cleared and marked at 25m intervals with red tags, stating the distance travelled. Each route was walked over 4 times in a random fashion. With the line transects method, density estimates are calculated using the number of animals, or groups counted within the distance censuses along a transect and an estimate of the width sampled. (Gautier-Hion 1988) As most primates in the area where habituated to humans, there is little reason to assume that any monkey species would avoid the existing routes.

**Figure 9** Map of transects at Setia Alam
3.3: **Other animals sighted**

Although not the focus of this study, other animals were seen along the transects. The same data was noted for these species as for the primates. Observations of species type recorded were many squirrel species, including plantain squirrel (*Callosciurus notatus*), pigmy squirrel (*Exilisciurus exilis*), shrew faced ground squirrel (*Rhinosciurus laticaudatus*) and a black flying squirrel (*Aeromys tephromelas*), the common tree shrew (*Tupaia glis*) and slender tree shrew (*Tupaia gracilis*), Borneon yellow muntjac deer (*Muntiacus atherodes*), any small mammals encountered, bearded pig (*Sus barbatus*), sun bear (*Helarctos malayanus*) unidentified skink, Malayan box turtles (*Cuora amboinensis*), the wrinkled hornbill (*Aceros corrugatus*), Asian black hornbill (*Anthracoceros malayanus*) and the Oriental pied hornbill (*Anthracoceros albirostris*), brown wood owl (*Strix leptogrammica*), unidentified bats, Monitor lizard (*Varanus salvator*), Wagler’s pit viper (*Tropiodolaemus wagleri*) and a Sumatran cobra (*Naja sumatra*).

3.4: **Line transect surveys**

During observations, there were two teams of two observers, walking along designated transects. Each survey team was led by either a field assistant or myself. For safety and communication reasons the two transects were always chosen so that the two teams of observers were in adjoining transects as seen in figure 9.
The entire 4km transect was covered a minimum of four times. In the last 2 weeks of the survey the transects were covered in the reverse order. For example, transects that had been covered in the order AB then CD were now covered in the order DC then BA shown in figure 9. The reason for this was to try and allow for different animals being more active at certain times of the day and thus more likely to be sighted at certain points along the transect.

**Figure 10** Showing the two teams on adjoining transects, and the order of the transects they walked.

The surveys took place nearly every day, and always started at 6am local time. The observers walked at the same pace so that they were, in theory, always parallel to one another. This helped eliminate the possibility that they would observe the same animals twice; the
original group would inform, by radio, the other set of observers of any animals that were fleeing towards them. To help observers keep at a regular pace, and in parallel, the teams firstly checked their position every 100 metres and, then when a regular pattern was established, every 500 metres. Each team would walk slowly in single file, keeping as quiet as possible. The observer in front would look straight ahead and to the right and the observer behind would look behind and to the left. The observers scanned the surrounding for any animal sightings, distinguishable movements or calls. When an animal was heard or seen, the following data was recorded, 1) the time of the sighting, 2) if the sighting was auditory or visual, (the occasions where monkeys were heard but not actually seen were recorded as auditory but not analyzed with the visual sightings), 3) the distance travelled along the transect, 4) two bearings were recorded, from where the observer was standing. (The first bearing was in the direction of the animal sighting or call and the second was straight down the transect in the direction of travel.) 5) the estimated distance from the transect to the animal(s), 6) the species sighted and 7) the number of individual animals actually seen, or the estimated number of animals based on calls or movements. Where this data could not be reliably ascertained it was recorded as either a group or unknown. Weather conditions for the day were recorded and the time noted every 500 metres along each transect. Data was recorded on forms provided for this purpose shown in figure 10. Due to the time limitations, it was found at the end of
that study period that there was only sufficient data for analysis on certain primates, the red leaf monkey, orangutan and gibbons. It was not possible to collect data every day due to commitments to the CIMTROP project and a week’s illness.

3.5a: **Group primate estimates**

For those species for which I did not have sufficient data to calculate the density of groups, a simple index of abundance was used. This is the average number of times a primate group was encountered per kilometre; i.e. the total number of groups seen divided by the total number of kilometres walked.

3.5b: **Individual primate estimates**

When estimating the abundance of individual primates whose data was not large enough to calculate a density using distance software, the animals’ density was calculated by dividing the number of adult and juvenile animals in all of the identified social groups at each site by the study site area. (Merenlender 1998)

3.6: **Camera traps**

Whilst at Setia Alam, camera traps where brought over to Palangka raya to be used in the study. A survey of the area and ideas from the field assistants were used to determine the best places to put the camera traps so as to maximise the number of sightings and minimise the number of false captures. The cameras were not placed directly on
the transects. All were placed off into the forest away from the transect so as not to be triggered by field assistants. The cameras were set up on the 19/07/04.

Camera 1 was be placed on transect 0.4 at 675 metres, by a little canal off to the right. Camera 2 was placed on transect A at 200/225 metres, in an old transect off to the right. Camera 3 was placed on transect 0.4 at 475 metres, at a canal 10 metres to the left. Camera 4 was placed on the right side of transect 0.4 at 775 metres, on a fallen tree, this camera was off the ground in the lower canopy so it would capture any arboreal species.

To entice the animals towards the traps some marbled cat anal gland scent imported from America and some shrimp paste was laid down. Every week new scent and pastes were laid, but the area was not disturbed at any other time.

On the 20/08/04, one month later, the traps were taken in to change the films and locations. The traps were then all placed on transect 1A as there had been sightings of sun bears along this transect. Camera 1 at 525 metres, opposite a clearing leading down towards a canal. Camera 2 at 725 metres in a fallen tree to the right of the transect, Camera 3 at 650 metres off the transect to the left, Camera 4 at 700 metres also placed off the transect to the left. The area around each camera also had the marbled cat scent and shrimp paste on them. All cameras were recovered on the 28/08/04. Figure 11 shows the distribution of the camera traps with location 1 in red and location 2 in blue.
3.7: **Data analysis**

3.7a: **DISTANCE 4.1**

The software programme DISTANCE 4.1 was used to analyse these data.

DISTANCE is a Windows based computer package that allows you to design and analyze distance sampling surveys of wildlife populations. It enables reliable estimates of density to be made even when there is variability in detection due to such factors as cue detection, observer effectiveness and environmental factors. (Buckland et al, 1993)

To ensure validity of the results when using line transect methods, there are four basic assumptions that must be met, they are: 1) objects are detected at their initial location, 2) all objects located...
exactly on (or above) the transect line are detected, 3) distances are measured accurately and 4) transects are located randomly in the habitat (Morrogh-Bernard et al 2003).

I used DISTANCE 4.1, to analyses the orangutan and gibbon data. DISTANCE is used to help work out the population density, or size of a species within an area (Buckland et al 2001). DISTANCE is an automated technique that uses distance-sampling data to estimate a density. (Total transect length, number of sightings observed and perpendicular distance of each sighting from the transect base line). It is reliable when transects are measured accurately (Morrogh-Bernard et al 2003). DISTANCE attempts to fit several possible models to the data in order to estimate the effective strip width and then selects the models with the best fit according to the Akaike's information Criterion (AIC; Buckland et al 1993 cited in Morrogh-Bernard et al 2003).

3.7b: **Cumulative frequency graphs**

Cumulative frequency graphs of the species frequency in percent for increasing distance off the transect into the forest in metres will be plotted. The point at which these graphs level off will give the distance into the forest, from the transect, at which the number of sightings decreases. Thus indicating a cut off point beyond which the number of sightings cannot be considered reliable.
4: Results

4.1: Line transect surveys

DISTANCE 4.1

Due to lack of sighting of the red leaf monkey, silver leaf monkey and pigtail macaques their data were pooled along with the orangutan and gibbon data as recommended by Buckland *et al* (2001) and by Chiarello and De mello (2001). For these results, I used half normal and hermite polynormal as my model definition. There were 4 intervals ranging from 0 to 70 metres and truncated at 70 metres. This resulted in an overall density of 5.94 individuals of listed primate species per/km².

The density was multiplied by the overall size of the study area researched, 4km². 5.94 multiplied by 4 gives a population density of 23.76 individuals of listed primate species within the area researched. The original density was then multiplied by the overall size of the protected area, to see what abundance the national park held of these species. The Sabangau National Park covers 568,000 hectares, equating to 33,739.2 individuals of listed primate species.

When analysing the Bornean orangutan data I used half normal and hermite polynormal as my model definition, there were 5 intervals from 0 to 56 metres, then truncated at 56 metres due to a lack of sightings after 56 metres. This resulted in an overall density of 1.76 orangutans per/km².
When analysing the Bornean Gibbon data I used uniform and cosine as my model definition, there were six intervals from 0 to 75 metres, then truncated at 65 metres due to a dramatic drop in the sightings at 55 metres.

This resulted in an overall density of 3.95 gibbons per/km².

The same was then done for both the orangutan and gibbon densities as for the pooled primate species to find out the overall density for the 4km² area researched and the entire 568,000 hectares of the Sabangau National Park, resulting in the orangutan density for the 4km² research area being 7.04 individual orangutans per/4km², and for the gibbon density within the same area resulting in 15.8 individual gibbons within the 4km² area. The orangutan and gibbon data was then used to find the density of each species within the Sabangau national park, resulting in the orangutan density being 9996.8 individual orangutans per/km² and the individual gibbon density being 22436 per/km². This is assuming that the forest type does not change throughout the area. Distance severely over estimates on density sizes.

DISTANCE also shows the estimated strip width of each species. All species combined strip width was estimated at 32.50 metres. Orangutan estimated strip width was 46.49 metres and the Gibbons estimated strip width was 32.50 metres. This data shows the estimated distance at which you can clearly sight the animals in the forest according to DISTANCE 4.1.
Unfortunately due to low sightings only the pooled species data and the orangutan and gibbon data are able to be analyzed using DISTANCE, the other species were sighted but due to low data they cannot be analysed separately, for these species a simple index of abundance was used.

4.2a: **Group primate estimates**

To find the average number of times a monkey group were encountered per kilometre.

The red langur group size was 4 and the total number of kilometres walked 83.4805 equaling 0.05 red langur groups seen per kilometre walked.

The pig-tailed macaque and sliver langur groups where only seen once having an average of 0.01 groups per kilometre walked.

4.2b: **Individual primate estimates**

When estimating the abundance of individual monkeys whose data was not large enough to calculate a density using distance, the animal density was calculated by dividing the number of adult and juvenile animals in all of the identified social groups at each site by the study site area (Merenlender 1998).

When estimating abundance of individual red langurs, the number of individual red langur animals is 11 and the total area of the transect is 4km², equating to 2.75 individual red langurs per km².
For the silver langur the number of individuals seen is 4 equating to 1 silver langur individual per km².

For the pig-tailed macaque the number of individuals is 3 equating to 0.75 individual pig tailed macaques per km².

4.3: Cumulative frequency graphs

These were used to find the distance of sight from a transect into the forest to determine the distance in which you no longer can see the primates clearly from the transect. Due to lack of sightings the Silver langur and pig-tailed macaque did not have sufficient data to complete a cumulative frequency graph.

The Summary of the results is in Table 1

<table>
<thead>
<tr>
<th>Type of species</th>
<th>Distance of sight from transect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bornean Orangutan (Pongo pygmaeus pygmaeus)</td>
<td>60 to 64.9 metres</td>
</tr>
<tr>
<td>Bornean Gibbon (Hylobates agilis albibarbis)</td>
<td>50 to 54.9 metres</td>
</tr>
<tr>
<td>Red langur (Presbytis rubicunda)</td>
<td>30 to 34.9 metres</td>
</tr>
<tr>
<td>Silver langur (Presbytis cristata)</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Pig-tailed macaque (Macaca nemestrina)</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

Table 1 Summary of cumulative frequency graphs.
Distance of sight from transects of Individual Orangutans (Pongo pygmaeus pygmaeus)

This cumulative frequency graph shows the abundance of individual orangutans, and the distances that they were seen in to the forest. It shows that the cumulative frequency curve starts to straighten out at around 75%, which is at 60 to 64.9 metres.

Graph 1 Distance of sight from transect for Orangutans
This cumulative frequency graph shows the abundance and distance of individual Gibbons. The cumulative frequency curve straightens out at 50 to 54.9 metres, with a percent number of 75%.
This cumulative frequency graph shows the abundance and distance of the number of Red langurs and the distances that they were seen in the forest. The curve straightens out at 30 to 34.9 metres this is also 75% of red langers seen. It should however be noted that there were only 11 sightings in total and as can be seen from the graph most of these occurred at 30-34.9 metres.
4.4: **Camera trap results**

From the 19/07/04 to the 20/08/04 Location 1 and from 20/08/04 to the 28/08/04 Location 2 the four cameras caught:

<table>
<thead>
<tr>
<th></th>
<th>Location 1</th>
<th>Location 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Camera 1</strong></td>
<td>Caught nothing</td>
<td>1 monitor lizard <em>(Varanus salvator)</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 Bearded pig <em>(Sus barbatus)</em></td>
</tr>
<tr>
<td><strong>Camera 2</strong></td>
<td>1 pig tailed macaque <em>(Macaca nemestrina)</em></td>
<td>Caught nothing</td>
</tr>
<tr>
<td><strong>Camera 3</strong></td>
<td>Caught nothing</td>
<td>Caught nothing</td>
</tr>
<tr>
<td><strong>Camera 4</strong></td>
<td>3 Plantain squirrels <em>(Callosciurus notatus)</em></td>
<td>Caught nothing</td>
</tr>
<tr>
<td></td>
<td>1 small-toothed palm civet <em>(Arctogalidia trivirgata)</em></td>
<td></td>
</tr>
</tbody>
</table>

**Table 2** Results of camera trap sightings

Photo’s can be seen in appendix 2.

4.5: **Other animals sighted**

Due to lack of data these species cannot be analyzed, they are purely for the purpose of information and interest.
5. Discussion

5.1a: Line transect assumptions

In order to use Distance software with Line transect sampling methods four basic assumptions must be met to ensure validity of results.

Assumption 1) The assumption that objects are detected at their initial location is hard to achieve with moving objects. In this survey the assumption was met by having two field assistants on each route at one time, with one assistant looking forward and to the right the other looking behind them and to the left, thus making it extremely difficult for any animals to move without being heard or seen. The measurements were taken to the first position observed. The use of radio transmission to alert the field assistants in the parallel transect of any movement towards them also helped to ensure that sightings were taken at the initial location.

Assumption 2) In order to ensure that animals actually on the transect line were spotted one field assistant looked in front and to the right while the other looked behind and to the left. Thus there were two opportunities for animals on the transect to be seen. As peat swamp forest is relatively unstratified with a generally low canopy (Morrogh-Bernard et al 2003) it is more likely that the animals would have been spotted in this forest type than in many others.

Assumption 3) Due to the lack of measuring equipment, measuring distances accurately proved to be a difficult task to perform. To try to
eradicate the inaccuracy the two field assistants estimated the distance separately and then conferred with each other to reach a distance that they were both happy with. Even with this in place the further distances proved to be hard to estimate accurately, so all distances over 70 meters were truncated when analyzing the results in DISTANCE, to make the results more accurate.

Assumption 4) all transects were pre cut before arrival. (personal comment Husson 2004), Husson underwent the layout of the transects for a PhD report on nest counts. In this area the “Transects were located without bias towards habitat features or high-density areas. Trail location within flat, homogeneous peat swamp forest is probably of less importance than it would be in areas of rugged terrain. It was impossible to bias surveys consciously towards high-density areas as there was only one access route into the forest and surveyors had no prior knowledge of the area. Thus, assumption (4) is adequately met. Seasonal variations in density are probable but the direction of potential bias is as yet, unknown.” (Morrogh- Bernard et al, June2003)

5.1b: **Line transect survey**

The estimate for the overall orangutan density in Sabangau catchment is 1.76 individuals per/km². This is at the higher end of the range of estimates for other areas, for example Blouch (1994) estimated 0.5 orangutans/km² as the density throughout Lanjak Entimau national park, MacKinnon (1977) estimated a density of 1.5 orangutans/km²
Johns (1992) found a density of 0.3 orangutans/km² also in Ulu Segama. Davis and Payne (1982) found the highest densities of 2.0 individual orangutans/km². Bodmer et al (1991) reported that the estimates of Barito Ulu forests in Central Kalimantan, Indonesia Borneo is extremely low at 0.06 orangutans/km². The results from the Sabangau catchment are high this corresponds with the research done by OuTrop on the orangutan population found in the Sabangau catchment, helping to confirm that it is one of the largest single contiguous population remaining, in Borneo with approx. 6900 individuals (Morrogh-Bernard et al, 2003 cited in Outrop 2005). The estimate for the overall Gibbon density in Sabangau catchment is individuals 3.95 per/km². This is at the higher end of the range of estimates for other areas, for example O’Brien et al (2003) and Kinnaird, M (2004) reported similar findings with an average of 0.73 per/km² and 0.67 per/km² respectively within Bukit Barisan Selatan national park in Sumatra. Buckley, C (2004) reports that in the same area of forest at the same time as this research was carried out, Buckley was estimating the population density by obtaining compass points of groups through listening to song, she reports a individual density of agile gibbons as 7.4 individuals per/km². This estimate is much higher estimate this could be due to the fact that she was listening to song and then recording data, where as this data was actual sightings and so therefore expects to be of a smaller abundance.
5.2a: **Group primate estimates**

The group estimate results are extremely small; these results do not appear to be accurate. This may be due to the lack of time to survey the area for the necessary amount of time for species that are more illusive.

5.2b: **Individual primate estimates**

The method originally intended for analyzing the estimates of the abundance of individual monkeys, was unable to be used due to the fact that you would need to collect data on mean group size in case the entire group was not seen. These estimates can be made opportunistically but this can also cause problems as the opportunistic counts are more likely to be biased towards small groups as the likelihood of seeing all the individuals in a small group is higher. The density of the monkey groups should be multiplied by the average number of individuals found in each group and this should be done separately for each species.

However when looking at these particular species it was not possible to find the mean group size because these species have such a diverse social density. When looking at the red lagur in Kalimantan Tengah group sizes range from 1 to 8 individuals (Chivers and Burton, 1988). The group size for pig-tailed macaque *Macaca nemestrina* is from 5 to around 22 (ARKive 2004). This made this type of analysis difficult to complete. The method used divided the number of adult and juvenile
animals in all of the identified social groups at each site by the study site area (Merenlender 1998).

5.3: Improvements

There was little time for initial preparation for this investigation as it was a last minute replacement for my original research, which was cancelled due to visa and access difficulties.

The survey would have benefited from having time to work out estimate of group sizes of primates in that area as data from other sources gave a wide range of sizes.

The largest error in the results is likely to have been as a result of inaccuracies in measurement. These would have been more reliable if proper measuring equipment was available. The graphs of sightings indicated that some heaping of results had occurred at particular distances. In retrospect, and given more time to experiment the possibility, it may have been an improvement if the observers had tried pacing as a more accurate measurement instead of estimation. Other errors are likely to have occurred due to having to use different observers on different days and the lack of experience some of them had in making observations, although using a field assistant to lead the other group of observers was an attempt to minimise this problem.
Appendix 1

The primates of the Sabangau rainforest

The following species below are found in the Setia Alam region.

Primates are among the most prominent members of a tropical rainforest fauna, and also may be a vital part of its biomass. (Eisenberg et al 1972, Eisenberg 1980)

Bornean Orangutan (*Pongo pygmaeus pygmaeus*)

Ten thousand years ago, orangutans were found throughout Southeast Asia ranging all the way into southern China. Their population probably numbered in the hundreds of thousands. Today, however, the few orangutans left, live in the tropical rainforests of Borneo and Sumatra (Orangutan foundation 2005). Data collected in 1995-1996, estimated the total population on Borneo was between 15,953 - 24,497 with possibly 37% of the population living in the Greater Sungai Sabangau catchment of Central Kalimantan (Morrogh-Bernard *et al*. 2003). Orangutans are arboreal and they occupy tropical and subtropical moist broadleaf forests and peat swamp forest, which is, submerged almost all of the year. Orangutans are solitary species and also extremely aggressive to unfamiliar orangutans or other species, they can be quite easily habituated and followed for research once the habituation is complete which can take time. Orangutans are a "keystone" species for conservation. They play
an important part in the forest's regeneration through the fruits and seeds they eat. Their disappearance may represent the loss of thousands of species of plants and animals within that ecosystem. Saving orangutans helps to conserve the countless other mammal, bird, reptile, amphibian, insect, plant and other species that live in the Indonesian rainforest. Their habitat is being destroyed at an alarming rate, due to Illegal logging and the deliberate starting of forest fires in order to convert virgin forest to timber and palm oil plantations, these are the main factors responsible for the loss of over 80% of orangutan habitat over the last 20 years. Less than 16% of forests that the Borneon orangutans inhabit is officially protected under Indonesian law, and those which are, are still subjected to rampant illegal logging (EIA, 1998, 1999; Jepson et al. 2001 cited in Andrea E. Johnson et al 2002) The Bornean orangutan is listed as endangered by U.S fish and wildlife service (USFWS) and protected by Conservation of International Trade of Endangered Species (CITES) Appendix I (IUCN, 2004).

Bornean Gibbon (*Hylobates agilis albibarbis*)

The Bornean agile gibbon is endemic to Borneo, between the Kapuas and Barito river (Geissmann, T 1995). They live in subtropical or dry tropical rainforests The IUCN red list for endangered species states that this gibbon species is protected under (CITES) Appendix II low risk near threatened species (IUCN, 2004).
Red langur (*Presbytis rubicunda*)
The red langur is found in the countries of Indonesia and Malaysia. Its habitat consists of primary and secondary inland forests not above 2000 metres. They also live in swamp forests. This species is also known to tolerate forests that have been redeveloped after logging has taken place. (Chivers and Burton, 1988)

Silver langur (*Presbytis cristata*)
Silver langurs live in coastal, riverine and swamp forests in Sumatra, Kalimantan, Riau, Lingga and Natuna islands. They are protected under Conservation of International Trade of Endangered Species (CITES) - Appendix II; the world conservation union (IUCN) - Lower risk: near threatened species, (IUCN, 2004).

Long tailed macaque (*Macaca fascicularis*)
The long-tailed macaque is found in 16 countries including Indonesia. It lives in subtropical/tropical dry and tropical mangrove forest. IUCN state that the long tailed macaque is protected by CITES - Appendix II; classifies it as a low risk near threatened species it is protected by CITES under Appendix II as they are in danger from degradation of their forests and hunting.
Pig tailed macaque (*Macaca nemestrina*)

The distribution of the pig-tailed macaque is found only in Brunei Darussalam, Malaysia (Peninsular Malaysia; Sabah), Thailand and Indonesia, but only in Kalimantan. Their habitat is subtropical/tropical dry forests, which is also suffering from degradation. The pig-tailed macaque is also being subjected to over hunting. IUCN listed as CITES APPENDIX I; Vulnerable species.

Proboscis monkey (*Nasalis larvatus*)

Proboscis monkeys are found in Brunei Darussalam, Malaysia (Sabah; Sarawak and Kalimantan, Indonesia. They are found in subtropical/tropical dry and tropical mangrove forests. These species are also being threatened with habitat degradation and over hunting. The proboscis monkey is classified under IUCN and listed under CITES Appendix I endangered species, A2C, C1 and 2A. This shows that within the next 10 years or three generations there is a suspected reduction of at least 50%, leaving the population estimated number to be less than 2500 mature individuals and an estimated continuing decline of at least 20% within five years or two generations. Also a decline in area of occupancy and the quality of their habitat, making it severely fragmented estimated to hold in each fragment no more than 250 individuals.
Slow Loris (*Nycticebus coucang*)

The slow Loris are arboreal primates. They live in the main canopy of the forest, but prefers the edge habitat of the forest. Possibly because the edge has more supports that may increase foraging efficiency (Johns, 1986).

Western Tarsier (*Tarsius bancanus*)

The western Tarsier can be found in Brunei, Indonesia, and Malaysia. The range in Indonesia extends from Borneo to the nearby islands of Karimata and Serasan, and also to southern Sumatra including the nearby islands of Bangka and Billiton (Nowak, 1999). This species can live in both primary and secondary forests, and also lives in forests along the coasts or on the edge of plantations (Niemitz, 1979).
Appendix 2

Camera trap photos

Camera 1 Location 2

Figure 12: Monitor lizard (Varanus salvator)

Figure 13: Bearded pig (Sus barbatus).
Figure 14: Pig-tailed macaque (*Macaca nemestrina*)
Figure 15: Small-toothed palm civet (Arctogalidia trivirgata)
Figure 17: 3 Plantain squirrels (*Callosciurus notatus*).
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