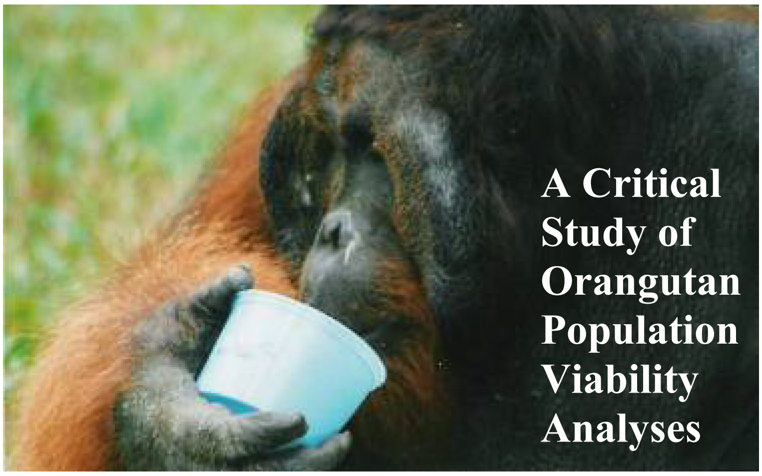

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Abstract

This report describes and evaluates work carried out with The Orangutan Tropical Peatland Research Project (OuTrop) in the summer of 2003 in the Sebangau catchment peat swamp forests of Central Kalimantan, Indonesia (see Figure 1.1) It will provide an up-to-date summary of the work which has been carried out recently aiming to protect the Orangutan and will discuss current threats to the increasingly endangered primate.

It will compare and contrast data collection methods for Orangutan Population Viability Analysis (PVA) – using data collected with the traditional line transect method and comparing this to what will be called plot transect data. Although it is shown line transect methods give an underestimation of population, due to constraints in time and budget they are still believed to be the best method of data collection. This paper arrives at a correction factor of 1.55 that can be used for analysis of future data collected and based on this study provides the latest population estimate for the Orangutan of the Sebangau catchment at 8,708 individuals – an increase of over 3000 compared to previous estimates using line transect methods alone.

Finally this paper will discuss some of the wider issues of concern in conservation biology today, using a quote from Wilson's 1988 seminal text "The Diversity of Life" to query questions of focus, immediacy and future management of the Orangutan.

Figure 1.1 – Map of South East Asia. The only remaining populations of Orangutan are found on the northern tip of Sumatra and in four distinct sub populations throughout Borneo.

Contents

Chapter 1

Introduction & Background

The name Orangutan comes from the Malay words 'Orang' and 'Hutan' and literally translates as man (of the) forest. During much of the Pleistocene epoch (1.8million to 11,000 years ago) Orangutan were found throughout Asia, from Java in the south to China in the North and India in the West (Commitante et al, 2003; Sugardjito & van Schaik, 1992). Their current range, however, is much restricted to fragmented populations on the islands of Sumatra and Borneo (see Figure 1.1) and it is estimated there are only 15-24,000 surviving in the wild. (Husson et al, 2002).

The data presented in this paper was collected in the peat swamp forest of Central Kalimantan around two hours from Palangkaraya (see Figure 1.3) by bus, boat and small railway (see Figure 1.2). The research was done as part of the on going work of the Orangutan Tropical Peatland Research Project (OuTrop) and was conducted during the summer of 2003. The aim of this work was to undertake a comprehensive Orangutan density and distribution survey, using both traditional and new methodologies, to add to the existing data collected by OuTrop to be used to gain protected status for the Orangutans of the Sebangau catchment.

Figure 1.2 – the 'railway' connecting base camp to the river. During the wet season this area is entirely flooded and boats can be taken into the forest (or logs floated out.) The forest in the background is where this study was undertaken.

The line transect method widely used in Orangutan population estimates is believed to underestimate population levels and analysis of the data is based on a number of assumptions. It was decided to attempt a new form of data collection using Plots rather Line transects. This essay will compare and contrast each method. It will analyse the data collected and arrive at a correction factor which could be used to estimate 'true' density. It will then go on to discuss wider issues in conservation biology which may affect future research in the Sebangau. Firstly though, it will examine the current population status, ecology and population structure and current threats to the survival of the Orangutan.

1.1 - Orangutan Population Status, Structure and Ecology

In 1999 the Orangutan was reclassified as "two distinct species: *Pongo pygmaeus* and *Pongo abelii*" separating the populations of Borneo (*p.pygmaeus*) and Sumatra (*p.abelii*). (Morrogh-Bernard et al. 2003:141) The Bornean population is in fact believed to consist or three or four sub-populations possibly further sub-species (Morrogh-Bernard et al., 2003). This distinction is important for conservation as these sub-populations may not breed together if they could be linked meaning that resources should be focused on protecting the individual populations rather than trying to set up networks between sub-populations.

Orangutans, unlike the other great apes, are essentially solitary creatures. Males and females only interact when breeding unless there is a mast-fruiting event (when 80-90% of forest tree species come into fruit at the same time) which will attract many Orangutans to the same area at the same time. Orangutans generally eat fruit, though depending on availability they will also eat flowers, shoots, cambium (a rubber like compound found under the bark) and if in desperate need have been known to eat termites and meat (Commitante et al., 2003). Females first give birth between the age of 12-15 and will only carry one child at a time meaning they have an interbirth period average of 8 years (Galdikas, 1995). In any area there will be a resident dominant male with a range of around 10km^2. This male will sire around 50% of the females in his home range. Populations are polygamous however, and a female will not go unmated when her interbirth interval expires (Leighton et al, 1995).

Current population estimates give a maximum figure of 24,000 Orangutans left in the wild (Commitante et al., 2003). In 1995 it was estimated that there were between 10,200 and 15,500 remaining Bornean individuals (Rijksen et al., 1995). Uncertainty surrounding estimates arises from "an incomplete knowledge of species distribution, combined with evidence that suggests population numbers are undergoing continuous decline" (Morrogh-Bernard et al., 2003:141). Even given this uncertainty there is no doubt that the Orangutan population is declining – indeed "at this rate of decline some biologists have predicted they could go extinct in the wild by 2010" (Commitante et al. 2003:76). The Sumatran Orangutan is rated as Critically Endangered by the IUCN Red List, the Bornean being slightly better off rated as Endangered, meaning it has a "very high risk of extinction in the wild in the near future". (IUCN, 2004) Both are on Appendix 1 (endangered species, trade in which is normally prohibited) of the Convention on the International Trade in Endangered Species (CITES) (Morrogh-Bernard et al., 2003).

So what has caused the decline? Sugardjito & van Schaik (1992) write, "The answer to this puzzle may be staring us in the face: humans." They argue that there are three main threats to Orangutan populations: Firstly hunting for meat and the pet-trade, secondly the mass deforestation of the areas in which the Orangutan used to live and the continued exploitation of the remaining forest. Thirdly there are species-specific behavioural and reproductive issues. We will look at these each in some detail.

1.2 - Threats to the Orangutan

1.2.1 - Hunting

Although hunting has hopefully reduced since the early 1990's, it is still an issue, especially as those Orangutans taken for the pet trade are generally juveniles whose mothers are killed in the process of capture. Husson et al. (2003) argue that as forests become more fragmented, forcing orangutans into smaller forest blocks, interaction with local farmers is becoming more of an issue as orangutans raid fruit plantations. These farmers, protecting their livelihood, capture or kill those orangutans trespassing on their land.

Husson et al. (2003) report that hunting of many other species also occurs – they report evidence of hunting of "pigs, sambar deer, muntjac, mouse deer, long-tailed macaques, gibbons, fruit bats, pythons, crocodiles, turtles, parrots (particularly the blue-crowned hanging parrot), many song-birds and small birds in general" and argue "hunting occurs for a variety of reasons, including for meat, the local pet-trade, pest-control and for fun" (2003:30) and as Sugardjito and van Schaik write "The sluggish Orangutans make easy targets for an experienced hunter who can kill his prey from a distance." (1992:142) They continue to argue that hunting of Orangutans is linked with the indigenous population. As a reduction was seen in head hunting and cannibalization, so the hunting of Orangutans went up. In Sumatra they argue that the remaining range of the Orangutan is only in areas where Muslim traditions have meant local populations have not hunted for centuries. The low level carrying capacity of the Orangutans sub-optimal habitat preferences also means that "in some areas the forest can sustain so few orangutans that a very slight hunting pressure is enough to make the local population disappear." (Sugardjito and van Schaik, 1992:142)

1.2.2 - Habitat Destruction and Exploitation

The Orangutan preferred habitat is primary and secondary forest, typically dipterocarp, freshwater and peat swamp forests "all of these habitats are reducing in extent as a result of degradation and loss, principally from timber extraction (legal and illegal), forest fires and forest clearance for agriculture and settlement." (Sugardjito and van Schaik, 1992:141) It is estimated that up to 80% of orangutans' forest habitat has been lost over the past 20 years (EIA, 1998) Work by Meijaard & Dennis (2003) using satellite images has shown rates of destruction increasing to around 14,000 km^2 /year and with breeding habitat for Bornean Orangutan amounting to only 80,000 $^+/-$ 4,000 km^2 it can easily be deduced that unless something drastic is done in the very near future the Bornean Orangutan could be extinct by 2010 (Meijaard and Dennis, 2003:3).

Compounding the problem of deforestation for the Orangutan is the vast occurrence of forest exploitation and degradation. As well as supporting lower densities of Orangutan "logged and degraded forests are much more fire prone than pristine forest" which is usually extremely fire-resistant except in times of extreme drought. Once a fire takes hold in the peat swamp forest it is impossible to put out until the rains come as the peat continues to burn below the surface and can thus cause vast amounts of damage and forest loss. During the fires of 1997-1998 ten million hectares of forest burnt across Indonesia (Commitante et al, 2003:78). In Central Kalimantan, where this study took place, only "11% of the remaining habitat consists of primary forest, the rest being affected by logging." (Meijaard and Dennis, 2003:6) Selective logging like this is generally not problem for local biodiversity, although some tree species such as Ramin (*Gonystylus bancanus*) have been logged to the point of extinction (Commitante et al, 2003:76), however Orangutans are "very sensitive to forest exploitation. Its densities in selectively logged forests are much reduced relative to those in unlogged forests." (Sugardjito and van Schaik, 1992: 144) This is reiterated by Commitante et al "Some studies show logged area are able to support only 30-50% of the densities of pristine forests." (2003:77).

1.2.3 - Behavioural & Physiological Threats

Even without the widespread habitat destruction and exploitation described above, Orangutan populations are naturally vulnerable as "Orangutans are the slowest breeding primates on Earth" owing to a low reproductive rate from the long time taken to reach sexual maturity, 12-15 years, and the mean interbirth period of 8 years (Sugardjito and van Schaik, 1992:143, from Galdikas and Wood 1990)

Sugardjito and van Schaik continue, "The adult survival per interbirth interval provides a good prediction of the fate of a primate population. When this value falls below 0.7, the population will go extinct. In the case of the orangutan this will happen when the annual survival of adult females falls below 0.95 or 95%. In other words, if the chance of falling victim to a hunter is only a little bit above background mortality, less than one in twenty in any given year, the orangutan population will inexorably nose dive toward extinction!" (1992: 142) What this means is that "a very slight increase (i.e. less than 1%) above its natural mortality rate can cause rapid extinction within three decades." (EIA, 1998)

1.3 - OuTrop

The Orangutan Tropical Peatland Research Project (OuTrop) was initiated in 1999 by Simon Husson and Helen Morrogh-Bernard who are both PhD candidates at the University of Cambridge's Wildlife Research Group. Their work in the area is supported by scientists at the University of Palangkaraya (Indonesia) as well as the Universities of Nottingham and Leicester (UK) and is funded by a number of international organisations as well as volunteer contributions (Husson, personal communication).

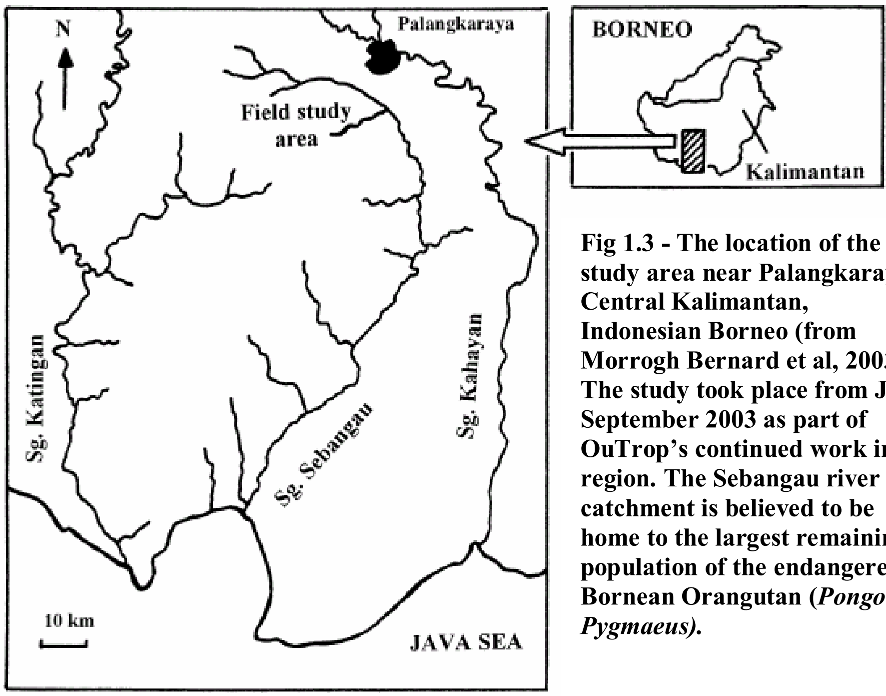


Fig 1.3 - The location of the study area near Palangkaraya, Central Kalimantan, Indonesian Borneo (from Morrogh Bernard et al, 2003). The study took place from July-September 2003 as part of OuTrop's continued work in the region. The Sebangau river catchment is believed to be home to the largest remaining population of the endangered Bornean Orangutan (*Pongo Pygmaeus*).

OuTrop is based in the peat swamp forest of the Sebangau river catchment (as shown in Figure 1.3). It is now believed to hold one of the largest remaining populations of the Bornean Orangutan (*pongo pygmaeus*). The peat-swamp forest is an extremely important habitat in the tropics and is a major global carbon store. The forest floor is consists "mainly of slightly or partially decomposed trunks, branches and roots of trees within a matrix of almost structureless organic material" (Page et al, 1999:1885) making all study done in the area extremely hard physically. The underlying peat structure is extremely important for the Orangutan. The depth of peat directly correlates with the type of vegetation present and Page et al. (1999) describe seven different habitat types in depth, ranging from 'Riverine' forest transitioning to 'Mixed Swamp' transitioning to 'Low Pole' to 'Tall Interior' and finally 'Very Low Canopy Forest'. Each different habitat type supports differing vegetation and as such the Orangutans are present in differing densities throughout. Research by Husson and Morrogh-Bernard in the Sebangau catchment has shown that densities are highest in the 'Tall Interior' forest and lowest in the 'Low Pole' forest. It is believed that this is due to the availability of food and levels of disturbance (Husson, personal communication).

Figure 1.4 – Illegal logging on one of the transects surveyed. It is estimated that 73% of all log production in Indonesia comes from illegal logging (Curry et al., 2001). Habitat destruction and disturbance like this is believed to reduce Orangutan density by at least 30-50% (Commitante et al., 2003).

In terms of habitat pressure the peat swamp forest is relatively expensive to log with few 'big' trees and is therefore less attractive to logging companies. Illegal logging is rife however (see Figure 1.4), and as was discussed above this has a serious impact on the Orangutan population leading to possible overcrowding of those less disturbed areas (Husson et al., 2004). The fact that the research carried out by OuTrop is in such disturbed forest may lead to population underestimation.

OuTrop carry out work on many aspects of the forest structure, Orangutan behaviour and ecology and, as with the research carried out for this paper, comprehensive density and distribution studies throughout the Sebangau catchment. The methodology used to undertake such studies is discussed below. The aim of this paper is to use both the traditional line transect and new plot transect methodologies to add to the existing data collected by OuTrop to be used to gain protected status of the Sebangau catchment for the Orangutan population. It is also hoped to add valuable insight into data collection methods for those working in the field, allowing better estimates of Orangutan population status in the future.

Chapter 2

Methodology

2.1 – Study Site

The study area is located 15km Southwest of Palangkaraya (see Figures 1.1 & 1.3) the provincial capital of Central Kalimantan, Indonesian Borneo. The data was collected at OuTrop's base camp, Setia Alam – a 500km^2 semi protected 'Natural Laboratory of Peat Swamp Forest' in the Northern Sebangau catchment. The entire catchment was designated as production forest until timber concessions ceased in 1997 to allow a thirty year fallow period. Since 1997, however, the area has been subject to extreme levels of illegal logging as well as the continued small scale harvesting of non-timber forest products such as rattan and latex (Husson et al., 2003).

A number of distinct habitat types have been described here based on tree species and forest structure as discussed earlier (Page et al, 1999). Due to restrictions of water availability this study was forced to concentrate on the Mixed-Swamp Forest (MSF) and Low-Pole Forest (LPF). The MSF occurs from 1km from the river edge to approximately 6km inland. The MSF canopy has three strata with a maximum height of 35m although in the area studied most of these trees had been extracted. From around 3km to 6km inland the forest is in transitional stage until MSF grades entirely to LPF. LPF has only two strata with a maximum height of 15m and the forest floor is densely covered with *Pandanas* an abrasive and spiky plant very difficult to penetrate. LPF then continues for approximately another 6km until it suddenly changes to Tall Interior Forest with four strata and trees reaching a maximum height of 45m. Tall Interior Forest shows the highest density of Orangutans, followed by Mixed-Swamp then Low-Pole (Husson et al., 2003)

2.2 Field Procedures

Field surveys were carried out in July-September 2003. For conservation of any species it is necessary to understand the range and densities of that species across the different habitats in which it occurs (van Schaik et al., 1995). To do this with the Orangutan a number of possible solutions have been offered. Firstly, sight records of known individuals have been used to estimate density in study areas. This requires intensive study however – with a density of 1 ind/km^2 and an effective strip width of 20m on either side of the transect sightings will be obtained for every 25km walked. Thus "we need hundreds of kilometres of survey before a reasonable estimate is obtained." (van Schaik et al., 1995:131) Obviously this is neither time nor cost effective, though Buij et al., (2003) argue that studies like this (such as the long running surveys in Ketembe, Sumatra) allow ‘true’ data to be collected which can then be used for comparison of quicker data collection methods such as the Line Transect method described below.

2.2.1 - Production of Orangutan Densities

Orangutans, like all the Great Apes, make nests to sleep in at night, or for rest during the day, and these nests can be used rather than relying on animal sightings as long as certain parameters (decay rate of nests *t*, construction rate *r* and proportion of next builders in the population *p*) can be determined. Orangutan density is then calculated using the formula (from van Schaik et al., 1995; Buij et al., 2003; Morrogh-Bernard et al., 2003; Husson et al., 2002):

$$D = \frac{N}{(L * 2w * p * r * t)}$$

In which: D = Orangutan density (animals/km^2)

N = number of nests observed along the transect

L = length of transect covered (km)

w = estimated width strip of habitat censused (m)

p = proportion of nest builders in the population

r = rate at which nests are produced (n/day/individual)

t = decay rate of nests : time during which a nest remains visible (in days).

2.3 - Line Transects

Orangutan nests were counted following the standard nest-count methodology proposed by van Schaik et al. (1995). Observers walk slowly along a transect cut in the forest, the starting point of which is “chosen in a restricted random manner” (Husson et al., 2003:144) to allow all habitats to be sampled without human bias. Whilst walking the transects the following details were noted:

- The forest subtype and the length of transect.
- The perpendicular distance from the transect to the nest was measured for every nest observed.
- The decay stage of the nest in four classes (see Appendix A for photos and description of each class).
- The estimated height of the nest in the tree and the estimated height of the tree.

The survey is then repeated by a second team, walking in the opposite direction to attempt to ensure the maximum amount of nests are spotted thus giving a better reflection of true nest density (N) and strip width (*w*). The decay stage and estimated heights of each nest were "recorded to assist with their recognition on subsequent surveys" (Buij et al., 2003) – data which is important when estimating time of decay (*t*).

This methodology has become well known and is widely used by researchers and this is the method that has been used for all of the work Husson et al. have carried out in the Sebangau (Husson and Morrogh-Bernard, 2003). However, this method, particularly the estimates of *w* and *t*, does have some problematic assumptions associated with it so the Plot Transect data collection method (see 2.4) was proposed.

2.3.1 - Estimating *p, r, t and w*

Knowledge of the parameters *p,r,t* and *w* is needed to turn the numbers of nests counted on the transect into Orangutan density. As each of these parameters must be assessed based on the individual population being censused or the individual survey undertaken, it is important that we understand the values placed on each parameter for the Orangutans in the study area.

p = proportion of nest builders in the population = **0.9**

This value of *p* is based on long term field studies in both Sumatra and Borneo which have estimated that 10% of individuals in the distinct populations were infants and young juveniles that do not make nests but instead still sleep with their mother. Husson et al (2004) do not expect this value to be any different in the Sebanagu population.

r = rate at which nests are produced (n/day/individual) = **1.16**

This figure is highly variable between populations and seems to be dependant on the availability of food (Husson, personal communication). Sumatran Orangutans are less likely to have to travel large distances in search food and are therefore more likely to make day nests in which to rest. Bornean Orangutans, however, seem to make little use of day nests, sometimes travelling large distances between feeding trees before nesting at night. Rijksen (1995) also points out how the difference in population structure affects the amount of nests built with females with young children being more likely to make a day nest than adult males who tend to roam their territories. Recent work by Morrogh-Bernard & Husson in the Sebangau has confirmed the value of *r* at 1.16 meaning each individual builds just over one nest per day/night.

t = decay rate of nests (days) = **286**

The value of *t* is the time during which a nest remains visible and is the most likely to change between habitat types and thus needs constant monitoring to provide the most accurate estimates to be made. Depending on location estimates of *t* have varied between 81 days for lowland freshwater swamp forest and 319 days for low hill forest (Morrogh-Bernard et al, 2003). This wide range is due to the fact that *t* can be affected by many factors of which Rijksen (1995) argues rainfall, temperature and wood density are the most important variables. Because the peat swamp forest in which this study was undertaken is "botanically and structurally different from other types of lowland, tropical forest and its microclimate conditions are also likely to vary. It is important, therefore, to calculate a…value for *t* that is relevant to the conditions prevailing within the particular study area, rather than using a value derived from studies in other forest subtypes and other geographical locations." (Morrogh-Bernard et al, 2003: 145). The value of 286 days used here has been derived from data collected and analysed by Simon Husson and is constantly under review (personal communication). Husson has arrived at this value using a technique based on re-recording the decay stage of nests of a known initial state of decay. This data enables a stepwise Markov Chain to be undertaken which produces the decay rate (see Morrogh-Bernard et al., 2003).

w = estimated width strip of habitat censused (m) = **Distance 4.0 / 40m**

w is collected to allow the density of nests to be calculated and thus be turned into Orangutan density. Using the line transect method the data collected (ie the distance along the transect and the perpendicular distance from the transect to the tree in which the nest is in is input into the computer program Distance 4.0 as discussed below. For the plot transect, as discussed in Chapter 2.4, the strip width is exactly 40m.

2.3.2 - Distance Analysis

Orangutan nest density is calculated using the computer program Distance 4.0 (Thomas et al., 2001). This automated technique uses distance sampling data – in this case total transect length, number of nests observed and the perpendicular distance of each nest from the transect – to estimate the effective strip width (Morrogh-Bernard et al., 2003; Husson et al., 2002). The program attempts to fit sophisticated statistical models to the data in order to estimate the effective strip width, and selects the model with the best fit according to the Akaikes Information Criterion (Buckland et al. 2001: 69). Distance analysis is reliable when transect length is known accurately, assuming a number of assumptions have been met. This will be discussed further in Chapter 3.

2.4 - Plot Transects

As is has been discussed previously, it is believed that line transects provide an under-estimation of population levels due to inherent observation errors. When discussing this fact it was decided to attempt a new form of data collection (also being tested in the Mawas region by van Schaik et al) in the Sebangau. Rather than simply walking a 2km transect as described above it was decided to create a cross between traditional plot methodology (Morris & Doak, 2003) and the line transect. By using the same transects for both methods a comparison of data collected can be undertaken.

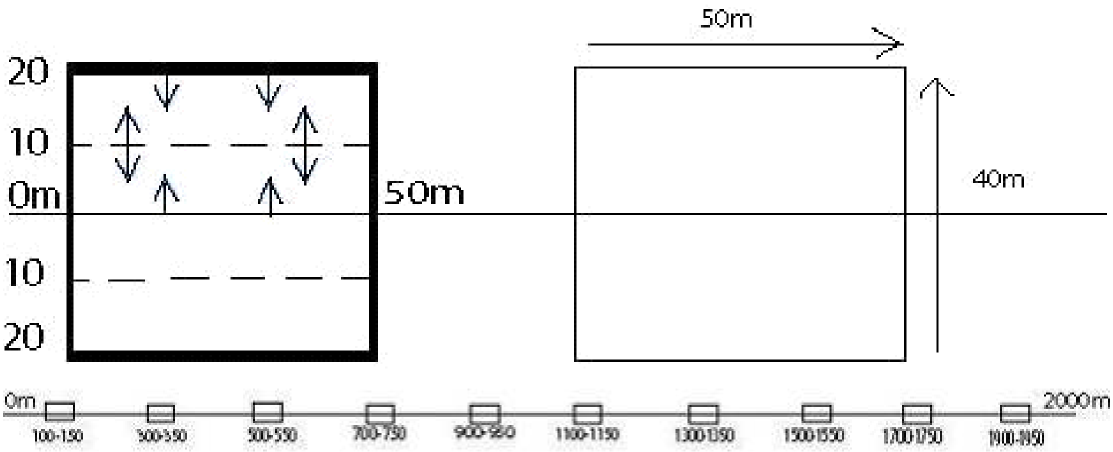


Figure 2.1 – Plot methodology. Each plot is 40x50m and is surveyed by 5 observers at 0m, 10m 20m on each side of the transect line. Plots are measured using standard measuring tapes and compasses are used to guide each observer through thick undergrowth, maintaining the plot size.

Plot data was gathered by creating 40m x 50m plots at certain intervals along the transect. Ten plots were surveyed on each transect, again in a restricted random manner. Five observers survey the plot as shown in Figure 2.1. Plots were placed 150-200m apart as recommended by van Schaik et al., (unpublished) in order to "avoid sampling the same clusters of nests if nests tend to be distributed in a clumped way around major food trees, and thus ensures independence of plot counts and similar habitat coverage as the line transects." As surveyors have unlimited time and movement throughout the plot, it should be possible to spot every nest in the plot as each observer has only an overlapping 10m strip to search. The results can then be examined using the same parameters *p, r* and *t* to produce an Orangutan Density. Using plot transects should give 'true' density estimates.

Chapter 3

Data Analysis, Interpretation and Discussion

Over the course of the study seventeen transects (total length 33km) were surveyed and 256 nests were noted. This data was collected as part of OuTrop's continued monitoring of the Orangutan population in the area. For the purposes of this analysis however we will only be considering seven transects which were surveyed specifically for this study and had both Line and Plot data collected from each transect. These transects were all in Mixed Swamp Forest as Plot work is not possible in Low Pole Forest and due to access difficulty and lack of water we could not survey the Tall Interior Forest.

3.1 - Line Transects

Seven transects were surveyed in the Mixed Swamp Forest, with a total length of 13km. As is shown in Table 3.1 a combined total of 112 nests were spotted. Full data sets can be found in Appendix B. Each transect was walked twice by different teams, either on the same or subsequent days to minimise data discrepancy caused by new nests being built. Work by van Schaik et al., (*in preparation*) has shown that by repeating the survey in this manner means more nests are spotted and so nearer a 'true' density can be established.

Transect Number	**Date survey**	**Transect Length (km)**	Number of nests seen by Team 1	Number of nests seen by Team 2	**Total Number of nests**
0.4	19-Aug	2	9	11	16
0.8	11-Sep	2	20		27
	12-Sep			21	
1A	05-Sep	2	7		12
	04-Sep			12	
1.6	19-Aug	2	16	15	23
2.25	04-Sep	2	9		20
	05-Sep			17	
2.75	09-Sep	2			9
3.5	12-Sep	1	5		5
	11-Sep			4	
		13	71	86	**112**

Table 3.1 - Overview of all transects surveyed and nests numbers spotted using the Line Transect method.

For full data sets for all transects surveyed see Appendix B.

Strip width for these transects was calculated using Distance 4.0 (Thomas et al., 2001). Perpendicular distances were truncated at 95%. Analysis followed the same procedure as van Schaik et al., (*in preparation*) Buij et al., (2003) and Morrogh-Bernard et al., (2003), based on five models recommended by Buckland et al., (2001) to which the observed distribution of perpendicular distances were fitted. Calculations were made for each team and for the combined total. Each team was made up of two experienced nest counters and one less experienced observer. The study by van Schaik et al., (*in preparation*) compared the data collected by both experienced and non-experienced teams. They found that more experienced observers detect more nests and thus tend to produce higher density estimates. This study should, therefore, be directly comparable with van Schaik et al.

The main results are summarised in Table 3.2. The second pass of the transect (Team 2) has added a further 15 nests (21%). Combining all of the nests seen (either by Team 1, Team 2 or seen by both teams) gives the best estimate of Orangutan density. van Schaik et al. (*in preparation*), predict, however, that even using experienced observers this estimate may be as much as 30% underestimation of true density.

Team	**N nests**	***w* estimate (m)**	Distance criterion	**Orangutan density ind/km^2**
1	71	17.07	Half-normal	0.54 $^+$/- 0.12
2	86	18.33	Hazard rate	0.60 $^+$/- 0.11
Combined	112	16.66	Uniform Cosine	**0.87** $^+$/- 0.14

Table 3.2 – Main results from Line Transect Data

The value of **0.87 $^+$/- 0.14** Orangutan per km^2 is lower than the most recent figure published for this area and habitat type of **0.97** ind/km^2 (Husson et al, 2004) which is most likely due to the small sample size in which two of the transects (2.75 & 3.5 see Appendix B) produced very low nest counts probably due to recent disturbance in this area. The larger studies by Husson et al. would balance this data anomaly. Removing the data from these transects gives an Orangutan Density of **0.98 $^+$/- 0.15** ind/km^2 which is much closer to the value expected by Husson et al.

3.2 - Plot Transects

The same seven transects were surveyed with this method as is shown in Table 3.3. This meant surveying 65 separate plots wherein 56 nests were spotted. Again these surveys were carried out as close to the date of Line surveys as possible to reduce the chance of new nests being created.

Transect Number	Date survey	Transect Length	Number of nests
0.4	20-Aug	10 plots over 2km	13
0.8	14-Sep	10 plots over 2km	9
1A	06-Sep	10 plots over 2km	8
1.6	21-Aug	10 plots over 2km	14
2.25	07-Sep	10 plots over 2km	9
2.75	10-Sep	10 plots over 2km	2
3.5	15-Sep	5 plots over 1km	1
	Totals	**65**	**56**

Table 3.3 - Overview of all transects surveyed using the Plot Transect method. For full data sets for all transects surveyed see Appendix C.

Similar to van Schaik et al. (*in preparation*), this study found that contrary to theory some nests were missed using the plot method. van Schaik et al. found 10% of nests were missed where as this study has found only two nests (found in the corresponding areas using the line transect method) that were missed in the plots. This gives a figure of 4% of nests unobserved using the plot method. This may be because van Schaik et al. used different methodology using only 3 observers for their plots rather than the 5 used in this study.

The plot method did find a substantial amount of extra nests however, and gives a considerably higher Orangutan density. Of the 56 nests spotted, 20 had not been noted using the line transect methodology. This gives a 36% underestimation of nests using the line transect method – even using experienced observers and walking the transect twice. This is similar to the 44% found by van Schaik et al. and is hopefully more accurate as it surveys a greater number of plots (65 as opposed to 21).

Using plot method data for all seven transect estimates Orangutan density as **1.44** ind/km^2 which is 60% higher than the **0.87** ind/km^2 found using the line transect method. Again, removing the data from transects 2.75 & 3.5 gives a higher density of **1.77** ind/km^2 which is 55% higher than the **0.98** ind/km^2 predicted.

There are problems involved with this method however. It is slightly heavier on manpower in that experienced teams of 4 could do a line transect in both directions in one day whereas the plot transects need 5 observers. Apart from this however it is much harder work physically for the observers who have to cut through undergrowth through the plots, scrambling over or under whatever debris is in their way, rather than just walking along a pre-cut transect. While plot transect do give a more accurate estimate of population “single surveys of nests provide data that can be compared both spatially and temporally and are a quick and efficient way to estimate a minimum population size for an area." (Husson et al. 2004) We can also compare this data to the 'true' plot density estimates and derive a correction factor as is shown below.

Study	Method	Cf	MSF Average Density	Estimated Total Pop^n
Husson et al (2004) – similar to this study	Line transect – single (both directions)	1	0.97	5618
van Schaik et al. (in prep)	Line transect - Repeat (2 passes)	1.12	1.08	6292
Husson et al. (2004)	Line transect – multiple (every 40 days)	1.23	1.19	6910
van Schaik et al. (in prep)	Line transect– Multiple (16 passes)	1.37	1.32	7697
van Schaik et al. (in prep)	Plot transect	1.48	1.43	8315
This study	**Plot transect**	**1.55**	**1.77**	**8708**
Buij et al. (2003)	Long term observation – True density	1.25 -3	1.21-2.9	7023-16854

Table 3.4 – Estimated MSF density and total population size for the Sebangau catchment in 2003 based on the application of various derived correction factors (Cf). Adapted from Husson et al. (2004) to include the findings of this study.

Although extrapolating data across large areas where little is known about levels of forest exploitation and degradation and habitat subtypes is not ideal, but it is still the only method we have of providing tangible numbers of remaining Orangutan. Data from Morrogh-Bernard et al, (2003) and Husson et al, (2004) using the value of 0.97 ind/km^2 gives a value of **5,618** Orangutan left in the Sebangau catchment. Using the data collected for this study, however, would raise this figure to **8,708** individuals as is shown in Table 3.4.

While this is undeniably good news, Husson et al. (2004) do point out that whilst the population may be higher than previously thought it is still decreasing at an alarming rate. Previous to widespread logging starting in the 1970s it is estimated that there were over 25,000 Orangutan in the Sebangau alone. This number has plummeted in recent years as logging has increased with an extremely large drop in 1997/98 attributed to extensive forest fires. Husson et al. report that no matter which way of attaining density and population, these have more than halved since 1996 when the first surveys in this area were taken.

No matter whether the population estimate is 5618 or 8708 this is still the largest known population of the Endangered Bornean Orangutan (*pongo pygmaeus*) remaining and is still a viable population. However, "ultimately these numbers are meaningless without protection efforts. The population remains viable, but will do so only as long as forest cover remains on the Sebangau peatlands." (Husson et al, 2004)

Chapter 4

Discussion of Wider Themes

"Because extinction is forever, rare species are the focus of conservation biology. Specialists in this young scientific discipline conduct their studies with the same immediacy as doctors in an emergency ward. They look for quick diagnoses and procedures that can prolong the life of the species until more leisurely remedial work is possible." (Wilson, 1992)

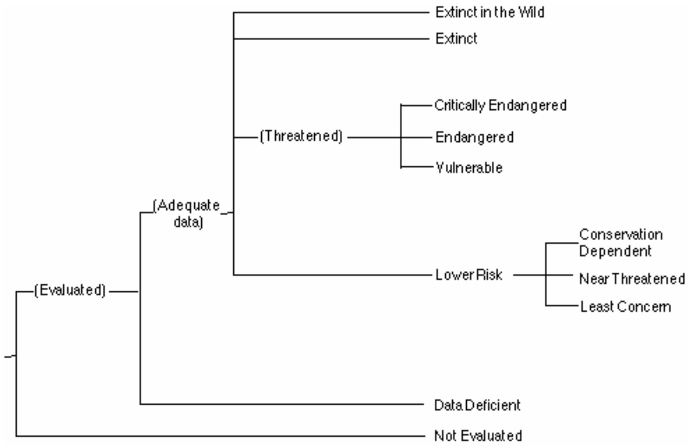
Over the course of the last 40 years biological scientists have become increasingly aware of the role human actions are having on the natural environment. As has been shown we continue to destroy some of the most biodiverse areas on the planet and as yet nobody knows what long term effect this will have. For the Orangutan, habitat destruction and exploitation could spell the extinction of wild populations within the next 20 years. Many believe we are in the midst of a human induced 'extinction crisis' (Pullin, 2002:72) and as interlocking debates such as climate change become increasingly to the fore, conservation biologists are struggling to keep up with demand for their services. As Prince Bernhard of the Netherlands wrote in 1970, "In each case, conservation must be precise and specific. It must have well defined, attainable goals, and because so much needs to be done and there are so few dedicated people and so little money to do it, conservation must have its priorities very carefully worked out and firmly based on scientific research." (in Hambler, 2004:341)

This discussion will focus on the three major themes in conservation biology which are implicit in the above quote from Wilson's (1992) seminal text "The Diversity of Life". It will look at ***focus*** (questions of rarity; keystone, flagship and umbrella species; biodiversity), ***immediacy*** (rates and definitions of extinction; difficulties in analysis and measurement) and ***management*** (the quick fix vs. longer term solutions; in-situ vs. ex-situ conservation; which direction should conservation biology be heading?). These are all issues which directly effect the Orangutan and as such this discussion will draw on the works of Wilson and Primack primarily to critically assess the above statement with relevance to the Orangutan.

"Because extinction is forever, rare species are the focus of conservation biology."

Wilson's argument is ultimately logical but it lacks the width of approach seen in modern day conservation efforts. He himself acknowledges that the concept of rarity "requires a multi layered definition, in order to be addressed realistically." (Wilson, 1992: 216) However he does not look at the issues surrounding the focus of conservation biology: the concepts of ‘keystone’, ‘flagship’ or ‘umbrella’ species. Nor does the above quote consider issues of biodiversity, which has recently become something of a buzz-concept in conservation biology.

Figure 4.1 – IUCN stratum for classification of species at risk. The Sumatran Orangutan (*pongo abeii)* is classed as Critically Endangered and the Bornean (*pongo pygmaeus*) is Endangerd – a further classification of Bornean Orangutan could see the four sub-populations reclassified as Critically Endangered also. This means they are likely to become extinct in the wild within 3 generations. (IUCN Redlist, 2001)



We should firstly consider issues of rarity and whether or not this is a good indicator for where the limited funds available to conservation should be spent. The International Conservation Union (IUCN) have layered strata of ‘rarity’ (see Figure 4.1) of which the Sumatran Orangutan (*Pongo abelii*) is Critically Endangered and the Bornean (*Pongo pygmaeus*) is Endangered. Wilson argues that there are three definitions of ‘rareness’. Firstly a species is rare if “it occurs over a wide area but is scarce throughout its range”, secondly a species is rare if “it is densely concentrated but limited to a few small populations restricted to tiny ranges”, and finally a species is rare “even if has a broad range and is locally numerous, but is specialised to occupy a scarce niche.” (Wilson, 1992:216-217) Wilson argues that the final category hosts most endangered species and that the continued habitat destruction by humans is in fact the most likely way in which we will continue to lose species. Pullin backs this up, “the most direct threat to biodiversity comes from destruction of the habitat on which it depends.” (Pullin, 2002:66) For the Orangutan, the second definition is perhaps most accurate as it is indeed limited to a few populations confined to increasingly fragmented forest blocks.

The above quote from Pullin’s 2002 “Conservation Biology” uses the term ‘biodiversity’ rather than species and is perhaps a good indicator of where the discipline has moved in the past ten years. As Wilson writes, “Conservationists now generally recognise the difference between rifle shots and holocausts. They place emphasis as the preservation of entire habitats and not only the charismatic species with in them.” (1992:247) Primack illustrates this in Figure 4.2. Conservation in this way does not directly deal with rarity of species, although in practise those species we choose to protect are often in areas of high alpha and gamma diversity – the tropical rainforest home of the Orangutan for example. In many cases, we target 'flagship species' – those "conspicuous and attractive species which can be used… to build public interest in an area or to raise funds." (Hambler, 2004: 103) – usually large mammals such as the Orangutan (see Figure 4.2). Pullin writes that these "species naturally form a focus for conservation because they are recognisable units whose loss can be quantified, but more importantly because the public can relate to species in a more direct way than to ecosystems or to genes." (2002: 199) Indeed focusing resources onto flagship species has other positive effects.

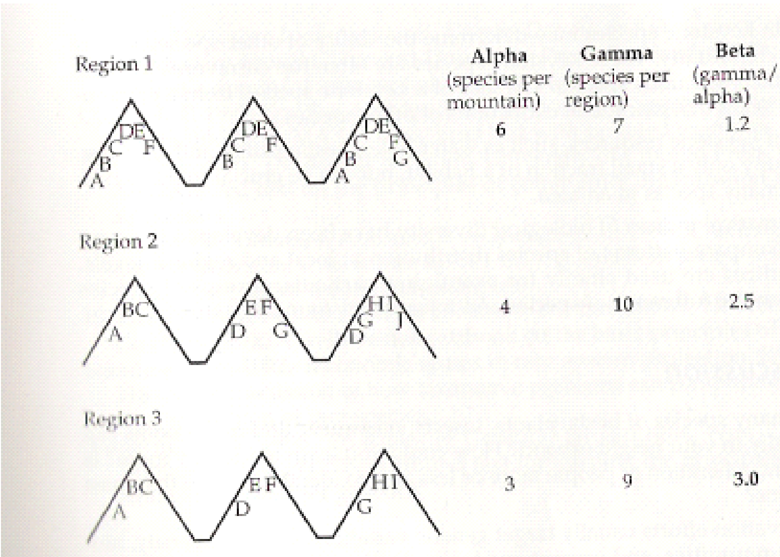


Figure 4.2 - Biodiversity indices for three mountain regions. Each letter represents a separate species. If funds were available to save only one region, region 2 should be conserved as it has the highest Gamma diversity – the largest number of species in a large geographical area. However, if fewer resources are available then the third mountain in region 1 should be protected as it has the highest Alpha diversity – ie. the highest number of individual species. From Primack (1998:51)

These species are sometimes also called 'umbrella' species as by protecting them the habitat they live in and hence many other species are also protected. As Wilson writes "The relationship is reciprocal. When star [flagship] species like rhinoceros and eagles are protected, they serve as umbrellas for all life around them." (1992: 247)

However, many biologists believe that we should instead be focusing resources on 'keystone species'. As Primack writes, "within biological communities, certain species may determine the ability of other species to persist in the community. These keystone species affect the organisation of the community to a far greater degree than one would predict… protecting keystone species is a priority for conservation efforts, because if a keystone species is lost from a conservation area, numerous other species will in all likelihood be lost as well." (1998:44) Again the Orangutan fits into this category. An analysis of different rainforest areas in Sumatra and Borneo has highlighted that the areas which have Orangutan populations also have higher plant and animal species diversity and this is believed to be due to the fact that Orangutans as frugivores play a large role in seed dispersal (EIA, 1998). By removing this one species the whole forest ecosystem will suffer greatly. Little work has been on other keystone species in the Orangutan's favoured habitats, however, and with increasing exploitation of these habitats it would be useful to be aware of other species or particular environmental features on which the Orangutans themselves may rely.

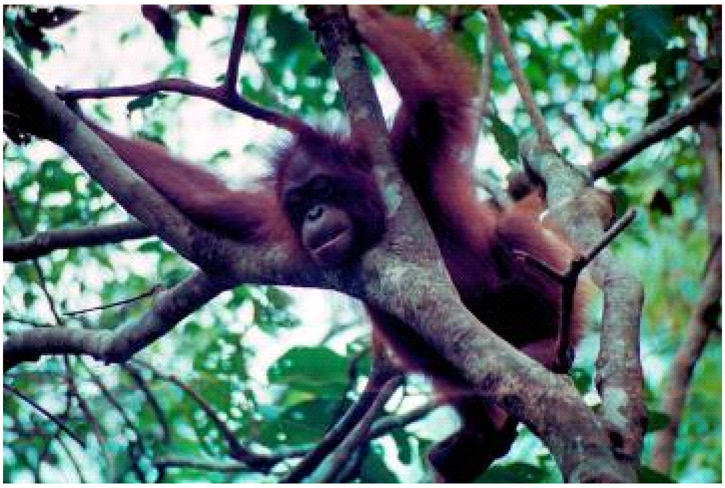


Figure 4.2 – An Orangutan in Tanjung Puting National Park, Central Kalimantan. Orangutans are a prime example of a 'Flagship' or 'Umbrella' species: where funding to protect them is used to wider effect to conserve habitat and thus many other species. Orangutans are also considered 'Keystone' species whose loss would cause change disproportionate to their biomass.

The loss of a keystone species "would lead to changes disproportionate to their biomass" (Hambler, 2004:103). Figure 4.3 shows the impact that certain species have on their environment proportional to their biomass – showing that keystone species have a disproportionate influence. Primack (1998) argues that identification and protection of keystone species and environments – resources such as salt licks or deep pools in streams which "may occupy only a small proportion of a conservation area yet be of crucial importance in maintaining many animal populations" (Primack, 1998:49) – is of key importance for three main reasons: firstly if a keystone species is identified it can be protected or even encouraged, secondly it may be necessary to protect the keystone species that another species depends upon either directly or indirectly and finally and most importantly the loss of a keystone species may well precipitate the loss of other species causing what is known as an extinction cascade.

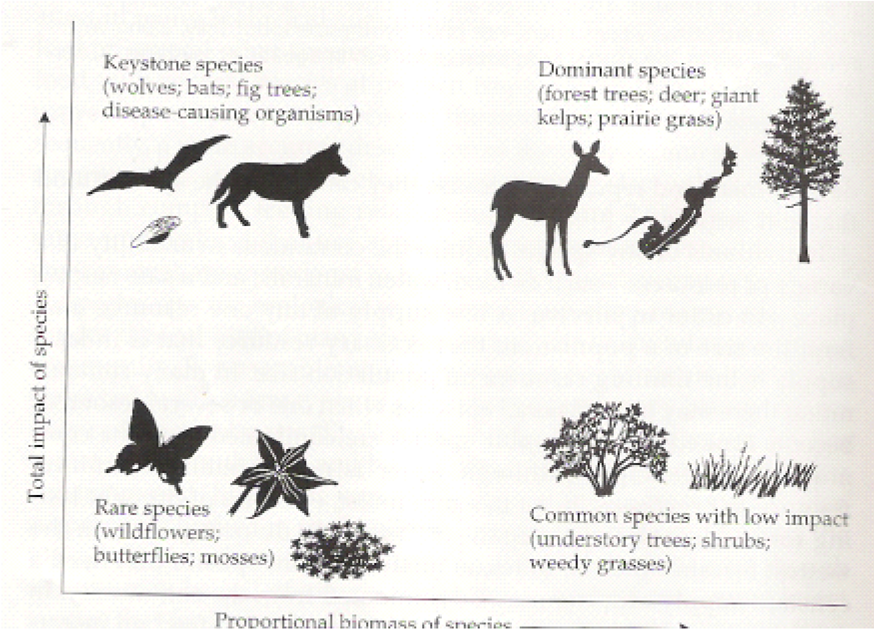


Figure 4.3 – Impact of species groups (Primack 1998:44) Orangutans are keystone species and although they are rare and form a small proportion of the biomass, their loss is believed to have a large negative impact on plant and animal species biodiversity.

"Because extinction is forever … Specialists in this young scientific discipline conduct their studies with the same immediacy as doctors in an emergency ward."

As Wilson writes once a species is extinct it is gone forever. However the concept of extinction requires somewhat deeper exploration. Firstly rates of extinction must not be ignored – whilst it is difficult to comprehend long-term evolution, over the course of the Planet Earth's lifetime over 99% of all the species that ever existed have become extinct. We need to make the distinction between timely and untimely extinctions, which is a complex bioethical argument outwith the remit of this discussion. However, many believe that the current rates of extinctions are human induced and that this is not acceptable. Pullin (2002:72) writes "we are in the midst of an extinction crisis" this is backed up by most writers on the subject. Primack argues that at the present time around 11% of the worlds bird and mammal species are threatened with extinction, he believes that "the threat of extinction is greater for some groups than others. Some groups are especially vulnerable for a combination of reasons, including high levels of human exploitation." (Primack, 1998:155) This correlates directly with the fate of the Orangutan.

Primack expands upon this argument however by stating "the word 'extinct' has many nuances and can vary somewhat depending on context." (1998: 148) Both Hambler and Pullin back this argument up stating that there are a number of definitions of extinction which vary according to the scale of management practise. This makes analysis and measurement of change incredibly difficult especially considering "we do not know the majority of species of organisms well; we have yet to anoint around so many as 90% of them with scientific names." (Wilson, 1992:243) Firstly they argue that a species can be *extinct in the wild* meaning that although there may still be populations breeding in captivity there is no wild population anywhere. As has been mentioned previously, if the conservation methods currently in place fail, the Orangutan may be extinct in the wild by 2020. Secondly, a species can be either *globally or locally extinct*. The Orangutan is already locally extinct throughout much of its former range. Those remaining in Sumatra and Borneo are the last remaining global populations. Finally a species can be *ecologically extinct* which occurs when population size is so low that scientists do not believe that the species can reproduce with wide enough gene pool to allow the continuation of the species. For the Orangutan this figure is believed to be around 2,000 individuals (Morrogh-Bernard et al., 2003) in a single population and this is a huge issue in current conservation of the Orangutan as many of the remaining sub-populations in Borneo are under this value. Should resources be concentrated only on populations that meet this cut off? As Primack writes, "we live at a historic moment, a time in which the world's biodiversity is being rapidly destroyed." (1998: 147)

"They look for quick diagnoses and procedures that can prolong the life of the species until more leisurely remedial work is possible."

With this being the case, the management of the habitats and species must begin. Wilson argues that initially "quick diagnoses and procedures" are put in place and he is backed up by Pullin who writes that "Conservation action to this day concerns itself with the short term rescue of species and communities and the medium term management to maintain them." (2002: 270) Increasingly however, conservation biologists are looking beyond to long-term solutions, both in-situ and ex-situ.

Figure 4.4 – a juvenile Orangutan in Nyaru Menteng Rehabilitation Centre. It is illegal to own an Orangutan and those that have been confiscated or recovered from conflict with humans are rehabilitated before release into semi-wild monitored environments.
In many cases they cannot be released back into the wild as they may introduce human disease to the wild population or simply because they would not be accepted into the complex social hierarchy.

In-situ measures include projects such as those undertaken where Orangutans are fed daily to allow them to survive in a national park. Figure 4.4 shows an Orangutan in a rehabilitation centre. The hope is that eventually Orangutans like this will learn to fend for themselves and return completely to the 'wild'. Measuring levels of priority for in-situ projects is done by "international listings such as the IUCN or CITES where… species are evaluated on their global status. Recovery actions have then to be cognizant of a hierarchy of scale from local to global." (Caughly & Gunn, 1996: 18)

Ex-situ measures involve "when a species reaches very low numbers or its habitat becomes critically endangered the decision may be taken to remove some or all individuals from the wild and attempt to conserve them in captivity." (Pullin, 2002: 227) This is a controversial approach however and is very much a last resort where "the ultimate goal must be to reunite species and habitat through reintroduction" (Pullin, 2002:227) a process littered with difficulties.

In the future many conservation biologists argue that we must aim to conserve habitat and continue the "long term management of change to enhance biodiversity" (Pullin, 2002: 271) Some do not believe that current efforts are helping. Hambler for example writes, "Reviews of the effectives of conservation programmes using keystone, umbrella or flagship species suggest they often fail. Conservation efforts for one species may conflict with those for another… it could be argued that they are a distraction from more productive conservation methods, particularly the protection of habitats." (2004: 104)

Chapter 5
Conclusion

This report has described and evaluated work carried out with The Orangutan Tropical Peatland Research Project (OuTrop) in the summer of 2003 in the Sebangau catchment peat swamp forests of Central Kalimantan, Indonesia. It has provided an up-to-date summary of the work which has been carried out recently aiming to protect the Orangutan and discussed current threats to the increasingly endangered primate: including habitat destruction due to logging and fire, hunting and species specific behavioural issues such as the long time taken to reach sexual maturity and the longest interbirth period of any primate.

The current method of data collection for Orangutan Population Viability Analysis (PVA) using nest counts on Line transects has been compared and contrasted with a new approach surveying 40x50m plots in the Mixed Swamp Forest. Seven transects were surveyed with a total length of 13km. 112 nests were spotted altogether by two teams – densities were calculated for each team and for the combined total giving the best estimate of 0.87 $^{+}/-$ 0.12 individuals / km^2. By rejecting data from two of the transects which gave unusually low nest counts this density increased to 0.98 $^{+}/-$ 0.14 ind/km^2 comparable with the latest estimates from Husson et al. (2004) working in the area.

Sixty-five plots were created on the same seven transects and 56 nests were spotted within the plot boundaries. This correlates to an Orangutan density of 1.44 ind/km^2 though again removing the suspect data gives an estimate of 1.77 ind/km^2. Each of these estimates are at least 55% higher than the Line Transect requisite. In terms of total population this gives a value of 8708 individuals in the Sebangau catchment – over 3000 more than previous estimates.

Although being more accurate than line transect surveys, plot transects are more labour intensive and it is not clear how affective they would be in other habitat types – for example the Low Pole Forest in the Sebangau has dense undergrowth that it is not feasible to survey in this manner. Recent work by Acrenaz et al. (2004) has started to use aerial surveys and so far this seems to be an accurate way of gathering data over larger distances than has been possible in the past. Husson et al. are currently discussing this method and hope to trial it in the near future (personal communication). In the mean time, the plot data collected can be used, as has been shown, to produce a correction factor to allow line transect data to be recalculated more accurately. This study suggests a correction factor of 1.55 although this is higher than van Shaik et al. (*in preparation*) who show a value of 1.48 from a similar study.

This paper has also discussed wider themes in conservation biology with regard to the Orangutan. Issues of focus, immediacy and management have been queried. It has been argued that the Orangutan is an ideal species for conservation efforts being both a 'keystone' species as well as a 'flagship' or 'umbrella' species. Ultimately, however, the protection of the forest in which the Orangutan lives is the most fundamental necessity.

To this regard, recent news from the Sebangau is extremely hopeful. On October 16th 2004 The Sebangau National Park was officially designated by ministerial decree. This was formally announced at the World Conservation Congress in Bangkok on November 20th. The National Park covers 568,000 hectares of Peat Swamp Forest between the Sebangau and Katingan rivers and is established to protect one of the most important populations of Orangutan remaining on a global scale as has been discussed in this paper.

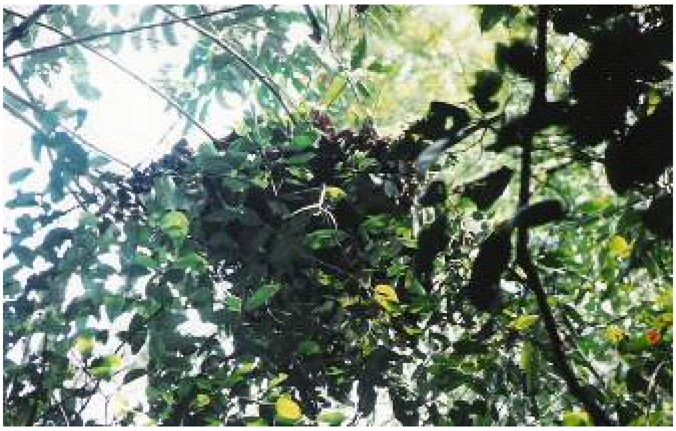
This is a fantastic achievement after years of hard work by Simon Husson, Helen Morrogh-Bernard and all of the OuTrop team who have worked with the Indonesian Government and the WWF to help bring this about. OuTrop are committed to remaining in the area monitoring the local Orangutan population, continuing to pursue conservation strategies to make sure the National Park is a success – reducing levels of illegal logging and working with the local population to support the conservation of forest and Orangutan in Borneo.

Acknowledgements

I would like to thank Simon Husson for his advice and guidance throughout data collection and analysis. The data collection itself would not have been possible without the efforts of Indonesian students Ari, Cis-Coes, Ferly, Lampang, Ella and Ahmat. Also thank you to Laura D'Arcy, Rosalie Trench, Tristram Allinson, Rachel Pullan and Kate Harris for efforts in this respect. Data collection was mentally and physically hard and tiring work – thanks to all of the OuTrop team last summer who helped to keep spirits up throughout the study – especially the aforementioned, Hugh Sturrock, Anna Lyons and Joanne Kelly. Thanks in the UK to all those who came to fundraising events held to allow me to raise enough money to undertake this research and thank you to Dr Trevor Hoey for allowing me the license to complete this work and for offering advice and assistance along the way.

Appendix A

Class A – Fresh, Leaves still green. Probably built within the last 3-4 days.



Class B – Older, nest still in original shape, firm and solid. Leaves still attached but brown.

Class C – Old, most leaves gone, holes appearing in nest.

Class D – Very old, twigs and branches still present, but no longer in original shape.

Appendix B

Transect Number	**Date survey**	**Habitat Type**	**Transect Length (m)**	**Number of nests**	Number seen by first team	Number seen by second team	**Team 1**	**Team 2**
0.4	19-Aug	MIXED SWAMP	2000	16	9	11	Ferly, Martin, Tris	Ari, Ahmat, Laura
0.8	11-Sep	MIXED SWAMP	2000	27	20		Ferly, Cis-Coes, Kate	
	12-Sep	MIXED SWAMP	2000			21		Ari, Lampang
1A	05-Sep	MIXED SWAMP	2000	12	7		Ferly, Martin	
	04-Sep	MIXED SWAMP	2000			12		Ari, Lampang
1.6	19-Aug	MIXED SWAMP	2000	23	16	15	Ferly, Martin, Lampang, Kate	Ari, Ahmat, Laura, Rosalie
2.25	04-Sep	MIXED SWAMP	2000	20	9		Ferly, Martin	
	05-Sep	MIXED SWAMP	2000			17		Ari, Lampang
2.75	09-Sep	MIXED SWAMP	2000	9	5	6	Ferly, Rachel	Ari, Lampang, Kate
3.5	12-Sep	MIXED SWAMP	1000	5	5		Ferly, Cis-Coes, Kate	
	11-Sep	MIXED SWAMP	1000			4		Ari, Lampang
			Totals	112	71	86		

Transect No.	**Nest**	**Distance on transect (m)**	**Team**	**Perpendicular distance (m)**	**L/R**	**Width of nest (m)**	Nest angle (* = est)	Dist from nest	**Nest Height (m)**	**Estimated nest height A=0-4, B=5-9, C=10-14, D=15-19, etc.**	Tree angle	Dist from tree	**Tree Height (m)**	**Estimated tree height A=0-4, B=5-9, C=10-14, D=15-19, etc.**	Tree CBH (cm)	**Other Info.**	**Age**
0.4	1	200	2	13.0	L	1.0	34	13	10.3	B	40	13	12.4	C	33.0	TT2	C
0.4	2	219	1+2	6.4	R	0.8	58	10	17.5	C	67	10	25.1	D	90.8	TT1	C
0.4	3	299	1	6.2	R	0.5	48	10	12.6	C	54	10	15.3	D	40.1	TT1	B
0.4	4	302	1	4.6	R	1.0	26	10	6.4	B	26	10	6.4	B	30.0	TT5	D
0.4	5	339	1+2	5.1	R	1.5	10	10	3.3	A	10	10	3.3	A	18.0	TT1	B
0.4	6	635	1	4.2	L	0.9	48	10	12.6	D	49	10	13.0	D	30.2	TT1	A
0.4	7	930	1+2	9.4	L	0.5	34	10	8.2	B	38	10	9.3	C	30.7	TT1	D
0.4	8	1325	2	26.0	L	2.0	29	10	7.0	B	37	10	9.0	C	49.0	TT3	B
0.4	9	1430	2	3.1	R	1.5	35	10	8.5	B	35	10	8.5	B	30.0	TT2	B
0.4	10	1438	1	4.6	L	1.0	43	10	10.8	C	43	10	10.8	C	20.6	TT2	D
0.4	11	1450	2	10.9	L	0.5	35	10.9	9.1	B	42	10.9	11.3	C	22.0	TT1	D
0.4	12	1562	2	25.8	L	1.0	36	14.8	12.3	B	40	14.8	13.9	C	40.0	TT1	B
0.4	13	1623	2	2.4	L	0.5	36	10	8.8	B	43	10	10.8	B	35.0	TT3	D
0.4	14	1752	2	6.8	R	1.0	32	10	7.7	B	42	10	10.5	C	34.0	TT2	A
0.4	15	1900	1+2	13.1	R	1.0	34	13.1	10.3	B	40	13.1	12.5	C	33.0	TT2	C
0.4	16	1985	1	0.0	R	0.7	52	10	14.3	D	58	10	17.5	E	143.8	TT1	C
0.8	1	165	2	7.0	L	1.5	18	10	4.7	A	37	10	9.0	B	18.0	TT4	C
0.8	2	204	1+2	6.3	L	0.5	49	10	13.0	C	54	10	15.3	C	62.0	TT1	C
0.8	3	374	1	19.2	L	1.0	34	12	9.6	B	36	12	10.2	B	29.0	TT2	B
0.8	4	477	2	3.9	L	0.5	37	15	12.8	C	49	15	18.8	D	67.0	TT1	D
0.8	5	510	1+2	17.1	L	1.0	37	11	9.8	B	45	11	12.5	C	37.0	TT2	C
0.8	6	737	1+2	10.5	L	0.5	38	10	9.3	B	51	10	13.8	C	35.0	TT1	D

Transect No.	**Nest**	**Distance on transect (m)**	**Team**	**Perpendicular distance (m)**	**L/R**	**Width of nest (m)**	Nest angle (* = est)	Dist from nest	**Nest Height (m)**	**Estimated nest height A=0-4, B=5-9, C=10-14, D=15-19, etc.**	Tree angle	Dist from tree	**Tree Height (m)**	**Estimated tree height A=0-4, B=5-9, C=10-14, D=15-19, etc.**	Tree CBH (cm)	**Other Info.**	**Age**
0.8	7	751	2	1.0	L	0.5	40	11	10.7	C	54	11	16.6	D	34.0	TT1	D
0.8	8	882	1+2	1.0	L	0.5	37	10	9.0	B	52	10	14.3	D	36.0	TT1	D
0.8	9	884	1	18.3	L	0.5	41	11	11.1	B	44	11	12.1	C	110.0	TT1	B
0.8	10	884	1	23.6	L	1.0	32	16	11.5	B	41	16	15.4	C	41.0	TT2	C
0.8	11	902	1	21.0	L	1.5	44	12	13.1	C	48	12	14.8	C	45.0	TT1	B
0.8	12	1194	1+2	23.8	L	0.5	40	14	13.2	B	47	14	16.5	D	44.0	TT1	D
0.8	13	1202	1+2	6.3	L	1.0	32	10	7.7	B	51	10	13.8	D	55.0	TT2	C
0.8	14	1207	2	12.0	L	0.5	39	15	13.6	C	45	15	16.5	C	41.0	TT1	D
0.8	15	1243	2	4.0	R	1.0	35	10	8.5	B	35	10	8.5	B	24.0	TT1	C
0.8	16	1251	1	0.0	R	0.5	45	10	11.5	D	49	10	13.0	D	47.0	TT1	D
0.8	17	1277	2	21.0	L	1.0	29	10	7.0	B	46	10	11.9	C	42.0	TT1	B
0.8	18	1360	1+2	10.0	R	1.0	32	10	7.7	B	46	10	11.9	C	35.0	TT2	C
0.8	19	1527	1+2	13.7	L	1.0	28	12	7.9	B	35	12	9.9	C	39.0	TT2	C
0.8	20	1558	1+2	4.0	R	1.0	32	10	7.7	B	42	10	10.5	C	39.0	TT2	B
0.8	21	1721	1+2	15.0	R	0.5	40	12	11.6	D	44	12	13.1	D	45.0	TT1	D
0.8	22	1737	1+2	2.0	L	1.0	41	13	12.8	C	47	13	15.4	C	45.0	TT1	B
0.8	23	1750	2	9.0	L	0.5	43	12	12.7	C	50	12	15.8	D	45.0	TT1	C
0.8	24	1769	1+2	6.8	L	1.0	43	11	11.8	C	45	11	12.5	C	50.0	TT1	C
0.8	25	1771	1+2	0.5	R	0.5	50	10	13.4	C	55	10	15.8	D	86.0	TT1	D
0.8	26	1830	1+2	10.0	R	1.0	40	14	13.2	C	47	14	16.5	D	46.0	TT1	D
0.8	27	1938	1	3.0	L	1.0	42	10	10.5	C	48	10	12.6	C	40.0	TT1	D
1A	1	340	2	10.1	R	0.5				C				D	60.0	TT1	D
1A	2	510	1+2	2.7	R	1.5	39	10	9.6	B	45	10	11.5	C	39.0	TT2	B

Transect No.	Nest	Distance on transect (m)	Team	Perpendicular distance (m)	L/R	Width of nest (m)	Nest angle (* = est)	Dist from nest	Nest Height (m)	Estimated nest height A=0-4, B=5-9, C=10-14, D=15-19, etc.	Tree angle	Dist from tree	Tree Height (m)	Estimated tree height A=0-4, B=5-9, C=10-14, D=15-19, etc.	Tree CBH (cm)	Other Info.	Age
1A	3	575	2	5.4	R	0.5				D				D	29.0	TT1	C
1A	4	584	2	22.0	R	1.5				B				B	29.0	TT4	B
1A	5	754	2	17.1	R	1.0				C				C	35.0	TT1	B
1A	6	871	1+2	11.2	L	1.0	33	11	8.6	B	40	11	10.7	C	45.0	TT2	C
1A	7	923	1+2	4.0	L	0.5	36	10	8.8	B	43	10	10.8	C	44.0	TT1	D
1A	8	1000	2	10.0	R	1.0				A				A	13.0	TT6	C
1A	9	1084	1+2	20.3	R	1.0	31	12	8.7	B	40	12	11.6	C	44.0	TT3	A
1A	10	1325	1+2	4.0	R	0.5	38	15	13.2	C	43	15	15.5	C	54.0	TT1	B
1A	11	1413	1+2	17.2	L	1.5	32	15	10.9	C	39	15	13.6	C	28.0	TT5	C
1A	12	1706	1+2	1.5	R	1.5	35	10	8.5	B	47	10	12.2	B	31.0	TT2	C
1.6	1	2	150	24.0	L	1.5	21	24	10.7	B	24	24	12.2	C	70.0	TT5	A
1.6	2	1+2	232	4.8	R	0.5	23	10	5.7	B	27	10	6.6	B	21.0	TT3	C
1.6	3	1	232	10.9	R	1.0	24	10	6.0	B	32	10	7.7	B	28.0	TT3	C
1.6	4	2	305	9.0	L	0.5	52	10	14.3	C	54	10	15.3	C	90.0	TT1	B
1.6	5	1+2	307	11.5	R	0.5	42	10	10.5	C	44	10	11.2	C	61.0	TT1	D
1.6	6	1+2	427	6.5	L	0.5	54	10	15.3	B	56	10	16.3	C	36.0	TT1	C
1.6	7	2	450	7.3	L	1.5	35	17.3	13.6	C	41	17.3	16.5	C	57.0	TT2	B
1.6	8	1	453	16.8	L	1.2	50	10	13.4	D	54	10	15.3	D	29.0	TT2	B
1.6	9	1	521	18.1	R	1.0	50	10	13.4	D	52	10	14.3	D	46.0	TT2	B
1.6	10	1	521	18.1	R	0.5	51	10	13.8	D	51	10	13.8	D	48.0	TT2	B
1.6	11	1	521	17.8	R	0.6	51	10	13.8	E	55	10	15.8	E	43.0	TT1	C
1.6	12	1+2	525	17.5	R	0.5	54	10	15.3	D	54	10	15.3	D	45.0	TT1	D
1.6	13	2	550	10.0	R	1.5	10	19	4.9	B	12	19	5.5	B	23.0	TT6	B

Transect No.	Nest	Distance on transect (m)	Team	Perpendicular distance (m)	L/R	Width of nest (m)	Nest angle (* = est)	Dist from nest	Nest Height (m)	Estimated nest height A=0-4, B=5-9, C=10-14, D=15-19, etc.	Tree angle	Dist from tree	Tree Height (m)	Estimated tree height A=0-4, B=5-9, C=10-14, D=15-19, etc.	Tree CBH (cm)	Other Info.	Age
1.6	14	1	638	0.0	L	1.0	54	10	15.3	B	55	10	15.8	B	37.0	TT2	C
1.6	15	1	674	12.3	L	1.0	53	10	14.8	B	55	10	15.8	C	19.0	TT3	B
1.6	16	1	674	13.6	L	1.0	52	10	14.3	B	52	10	14.3	B	26.0	TT1	B
1.6	17	2	1175	24.7	L	1.0	25	24.7	13.0	C	29	24.7	15.2	C	60.0	TT1	B
1.6	18	2	1315	14.3	L	1.5	40	14.3	13.5	C	42	14.3	14.4	D	50.0	TT1	B
1.6	19	1+2	1350	13.7	L	0.5	33	13	9.9	C	46	13	15.0	D	40.0	TT2	A
1.6	20	1+2	1350	6.0	L	1.5	28	10	6.8	B	28	10	6.8	B	27.0	TT6	A
1.6	21	1+2	1410	14.5	R	1.5	16	14.5	5.7	B	16	14.5	5.7	B	15.0	TT9	A
1.6	22	2	1865	14.0	R	1.0	43	10	10.8	B	46	10	11.9	C	35.0	TT1	C
1.6	23	1+2	1905	11.0	R	1.0	35	10	8.5	B	40	10	9.9	B	27.0	TT3	C
2.25	1	146	2	12.0	R	0.5				B				B	32.0	TT6	C
2.25	2	147	2	14.0	R	1.5				B				B	21.0	TT11	B
2.25	3	147	1+2	9.3	L	1.5	32	10	7.7	B	34	10	8.2	B	29.0	TT3	C
2.25	4	197	2	3.0	L	1.0				B				C	49.0	TT3	D
2.25	5	835	1+2	3.0	R	1.0	36	10	8.8	B	42	10	10.5	C	30.0	TT2	A
2.25	6	852	2	0.0	R	0.5				C				C	43.0	TT1	D
2.25	7	870	1+2	4.0	R	1.0	40	10	9.9	B	46	10	11.9	B	35.0	TT4	C
2.25	8	872	1	5.0	R	0.5	44	10	11.2	B	46	10	11.9	B	21.0	TT2	C
2.25	9	881	2	10.5	L	0.5				C				C	54.0	TT1	D
2.25	10	1094	2	12.0	R	1.5				B				B	36.0	TT4	B
2.25	11	1107	1	17.6	R	1.5	27	10	6.6	B	28	10	6.8	C	47.0	TT2	C
2.25	12	1112	2	6.0	R	0.5				A				A	11.0	TT4	D
2.25	13	1702	1	4.2	R	1.0	40	12	11.6	C	40	12	11.6	C	40.0	TT1	A

Transect No.	Nest	Distance on transect (m)	Team	Perpendicular distance (m)	L/R	Width of nest (m)	Nest angle (* = est)	Dist from nest	Nest Height (m)	Estimated nest height A=0-4, B=5-9, C=10-14, D=15-19, etc.	Tree angle	Dist from tree	Tree Height (m)	Estimated tree height A=0-4, B=5-9, C=10-14, D=15-19, etc.	Tree CBH (cm)	Other Info.	Age
2.25	14	1725	2	14.3	L	0.5				B				B	38.0	TT1	C
2.25	15	1725	1+2	14.3	L	2.0	29	14	9.3	B	39	14	12.8	C	48.0	TT4	B
2.25	16	1797	1+2	2.0	L	0.5	45	15	16.5	C	52	15	20.7	C	40.0	TT2	C
2.25	17	1798	2	14.4	R	1.5				C				C	54.0	TT2	B
2.25	18	1855	1+2	12.7	R	1.0	34	12	9.6	B	39	12	11.2	C	35.0	TT2	B
2.25	19	1880	2	7.4	R	1.5				C				C	39.0	TT2	B
2.25	20	1910	2	3.1	L	1.0				C				D	71.0	TT1	C
2.75	1	176	1+2	9.2	R	1.0	45	10	11.5	C	49	10	13.0	C	49.0	TT4	C
2.75	2	232	1	0.5	R	0.5	32	12	9.0	B	38	12	10.9	C	26.0	TT2	D
2.75	3	577	2	6.3	L	0.5	32	10	7.7	B	37	10	9.0	B	15.0	TT1	D
2.75	4	874	1	7.6	R	1.5	49	13	16.5	C	51	13	17.6	D	37.0	TT1	B
2.75	5	1037	2	12.1	R	0.5	43	10	10.8	B	51	10	13.8	C	39.0	TT1	C
2.75	6	1207	1	11.0	R	1.0	38	10	9.3	B	42	10	10.5	B	44.0	TT1	D
2.75	7	1410	1+2	17.4	R	1.0	52	11	15.6	D	52	11	15.6	D	63.0	TT2	C
2.75	8	1500	2	19.2	R	0.5	24	19	10.0	C	31	19	12.9	D	57.0	TT1	A
2.75	9	1927	2	26.8	R	0.5	37	10	9.0	B	39	10	9.6	B	25.0	TT2	C
3.5	1	206	1+2	10.0	L	1.5	47	10	12.2	C	55	10	15.8	C	32.0	TT2	A
3.5	2	208	1+2	9.0	L	1.0	54	11	16.6	C	58	11	19.1	D	58.0	TT1	C
3.5	3	570	1	22.2	R	0.5	31	10	7.5	B	38	10	9.3	C	25.0	TT5	C
3.5	4	745	1+2	8.4	L	0.5	44	10	11.2	B	52	10	14.3	C	30.0	TT1	D
3.5	5	860	1+2	10.3	L	0.5	26	10	6.4	B	29	10	7.0	B	44.0	TT2	D

TransNo.	Nest	Distance on transect (m)	Perpendicular distance (m)	L/R	Age	Estimated nest height A=0-4, B=5-9, C=10-14, D=15-19, etc.	Estimated tree height A=0-4, B=5-9, C=10-14, D=15-19, etc.	Width of nest (m)
0.4	1	300-350	0		D	B	B	0.5
0.4	2	300-350	0		B	C	D	1.0
0.4	3	300-350	20	R	C	A	A	1.0
0.4	4	500-550	0		B	A	A	1.5
0.4	5	500-550	20	L	C	B	C	1.0
0.4	6	900-950	10	R	C	B	C	1.0
0.4	7	900-950	10	L	B	D	D	1.0
0.4	8	900-950	10	L	C	C	D	0.8
0.4	9	1300-1350	20	L	D	B	B	0.5
0.4	10	1700-1750	10	R	A	B	C	1.0
0.4	11	1900-1950	0		B	B	C	0.5
0.4	12	1900-1950	10	L	B	B	C	0.5
0.4	13	1900-1950	20	L	C	B	C	0.7
0.8	1	500-550	20	L	C	B	C	0.5
0.8	2	700-750	10	L	D	C	C	1.0
0.8	3	1100-1150	20	R	D	D	E	0.5
0.8	4	1300-1350	20	R	B	C	C	0.4
0.8	5	1500-1550	0		C	C	C	1.0
0.8	6	1700-1750	0		B	C	D	1.5
0.8	7	1700-1750	10	R	D	C	D	0.5
0.8	8	1700-1750	20	R	C	C	D	0.5
0.8	9	1900-1950	0		D	B	C	1.0
1A	1	300-350	10	L	D	D	F	1.0
1A	2	500-550	0		B	C	D	1.0
1A	3	500-550	10	L	B	A	A	1.5
1A	4	700-750	20	L	D	C	D	0.5
1A	5	900-950	0		D	C	C	0.5
1A	6	1300-1350	0		B	C	D	1.0
1A	7	1500-1550	20	R	D	D	D	0.5
1A	8	1700-1750	0		C	B	C	1.5

TransNo.	Nest	Distance on transect (m)	Perpendicular distance (m)	L/R	Age	Estimated nest height A=0-4, B=5-9, C=10-14, D=15-19, etc.	Estimated tree height A=0-4, B=5-9, C=10-14, D=15-19, etc.	Width of nest (m)
1.6	1	100-150	20	L	B	C	C	0.7
1.6	2	300-350	0		D	A	A	1.5
1.6	3	300-350	10	L	C	C	D	1.0
1.6	4	500-550	20	L	A	B	B	1.0
1.6	5	500-550	20	R	B	D	D	1.5
1.6	6	500-550	20	R	C	D	D	1.5
1.6	7	500-550	20	R	D	C	C	1.5
1.6	8	500-550	20	R	B	A	A	1.5
1.6	9	1300-1350	10	L	A	B	B	2.5
1.6	10	1300-1350	10	R	B	D	D	1.5
1.6	11	1500-1550	10	R	D	E	E	1.0
1.6	12	1500-1550	10	R	D	B	B	1.0
1.6	13	1900-1950	10	L	B	C	C	1.5
1.6	14	1900-1950	20	L	B	D	F	1.0
2.25	1	100-150	10	L	C	B	B	1.0
2.25	2	100-150	10	R	B	B	C	1.5
2.25	3	100-150	10	R	C	B	B	0.5
2.25	4	900-950	10	R	D	D	E	0.5
2.25	5	1100-1150	0		B	C	C	0.5
2.25	6	1700-1750	0		A	C	C	1.0
2.25	7	1700-1750	10	L	C	B	C	1.5
2.25	8	1700-1750	10	L	B	B	C	0.5
2.25	9	1900-1950	10	L	B	D	D	1.0
2.75	1	100-150	10	L	D	C	D	0.5
2.75	2	1500-1550	20	R	A	B	C	1.0
3.5	1	700-750	10	R	C	D	C	0.5

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