Orang-utans density in the Sebangau.

MSc Project for Nottingham University.

Claire Lardy 1999.

ABSTRACT

Densities of orang-utans were obtained in four forest sub-habitat types of the upper catchment of the Sebangau river (Central Kalimantan) to assess changes in population distribution as a result of human disturbance. Densities were calculated by nest counting along line transects. Low densities were found in forest subject to high levels of illegal logging, with other areas thought to be suffering the effects of overcrowding due to migration from recent logging and fire disturbance. A questionnaire revealed that local communities were unaware of the orang-utan extinction threat, although they were concerned about their local environment and were generally supportive of potential protective measures for the surrounding forests. Immediate protection for this peatswamp habitat is strongly recommended in order to prevent further decimation of the forest and almost certain extinction of the orang-utan in this region.

INTRODUCTION

Orang-utans (*Pongo pgymaeus*) are confined to the islands of Borneo and Sumatra, where they exist as two geographically separated sub-species. The present restricted range of these great apes does not reflect their previous distribution, which once extended throughout the Indonesian archipelago from Java as far north as China (Von Koeningswald, 1982). The orang-utan is classified by the World Conservation Union (IUCN) as endangered (Groombridge, 1993), with total population estimates ranging from 15,000 to 25,000 (**Sugardjito & van Schaik, 1991**). Such figures are however, unlikely to be sustained if current survival threats remain constant, and recent population figures suggest orang-utans may have declined by up to 50% in only 10 years (Soemarna *et al*, 1995a).

Orang-utans are dependent on primary forest or suitably regenerated secondary forest, feeding predominantly on fruits typically found in lowland dipterocarp, freshwater swamp and peatswamp forests. It is these forests which are currently subject to high levels of degradation through timber extraction and forest conversion to agriculture or transmigration schemes. Illegal logging operations are widespread throughout Kalimantan (Indonesian Borneo), even penetrating into national parks with protected status (Environmental Investigation Agency, 1998).

Other causes of habitat loss include forest fires, primarily caused by land conversion and illegal logging, which are exacerbated by drought. A more open canopy produced by logging activity exposes ground flora to effects of the sun, causing susceptibility to forest fires. An estimated million hectares of suitable orang-utan habitat has been destroyed throughout Kalimantan as a result of forest fires in 1997/8 alone. The combined effects of habitat destruction are further compounded by hunting of orang-utans for food and for the trade of infants as pets. The orang-utan has been listed on Appendix I of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITIES) prohibiting all trade since 1975. Despite the success of previous anti-smuggling campaigns (Eudey, 1995), illegal traffic in orang-utan infants still exists. Infants continue to be confiscated during exportation attempts, and finding infants held as pets is not uncommon throughout Kalimantan. Increased accessibility to orang-utans through illegal logging and forest fires has reportedly led to a resumption of hunting in some local communities, (Leiman & Ghaffar, 1996).

The effects of such a wide range of environmental impacts are translated to wild populations with dramatic consequences. Orang-utans are naturally predisposed to vulnerability if mortality exceeds 1% of natural levels, (**s & van s**). This is a function of the species biology, having a high inter-birth frequency (typically 8 years), (Galdikas & Wood, 1990), slow development to sexual maturity (around 12 years) (**Harvey *et al*.,** 1987), and an associated slow reproductive rate. Minimum viable populations which do not significantly suffer from the effects of random genetic drift, inbreeding depression and demographic stocasticity, are therefore calculated to require at least 2000 individuals, (**Sugardjito & van schaik 1991**). The sustainability of viable populations is particularly influenced by females, who invest highly in parental care (Leighton *et al*., 1995). It is females, however who are particularly vulnerable to hunting ; they are often killed during attempts to capture infants destined for the pet trade.

A population and habitat viability analysis workshop held in 1993 calculated the number of Bornean orang-utans to be within the range of 10,282-15,5460, representing a sharp decline relative to previous estimates, (Soemarna *et al*., 1995b). Knowledge of the distribution of the Bornean sub-species (*Pongo pygmaeus pygmaeus*) remains incomplete, with only 3 protected areas in Kalimantan sustaining a population of 2000 Orang-utans. Despite suggestions that significant populations may exist in irregularly distributed unprotected areas across Kalimantan (Rijksen *et al.,*1995), many areas are yet to be surveyed.

Orang-utans inhabit large tracts of the inland peatswamp forests of Central Kalimantan. These forests represent approximately 10% of the total forest cover of Kalimantan (Meijaard, 1997). Tropical peatswamps are now known to be biodiverse in both flora (Shephard, *et al*., 1997) and fauna (Page *et al.,*1997), and support a unique range of species and communities, some of which are classified as endangered or vulnerable. Peatswamps are also of international conservation importance primarily due to their ecological role in global carbon cycling (Rieley *et al*, 1997), but the status of tropical peatlands remains predominantly unprotected, (Prentice & Parish, 1992). These fragile forest habitats are vulnerable to dehydration and compaction essentially due to human disturbance through extraction of commercially valuable timber. Excessive drainage also hinders forest regeneration following logging activities. There is therefore an inevitable link between the conservation of the peat swamp forests of Central Kalimantan and the survival of local populations of orang-utan. Conversely, it is of course the orang-utan, which fulfils a vital role as a flagship species in the plight of this declining ecosystem.

The sungai (river) Sebangau catchment of Central Kalimantan is the focus of an integrated, international research program of tropical peatland management, (CIMTROP). The Sebangau region represents the largest tract of peat swamp forest in Kalimantan. A Natural Laboratory designated within the upper catchment facilitates the study of peat swamp ecology and forest biodiversity, and a comprehensive study mapping orang-utan densities in four sub-habitats of the upper sungai Sebangau catchment was carried out during 1995 and 1996, (Morrogh-Bernard *et al.,* unpublished). Densities obtained from an intensive study within the Natural Laboratory were extrapolated by reference to satellite land cover data, to estimate total orang-utan density over the entire 5,000km^2 catchment. Densities equated to 1.0 individuals per km^2, indicating a significant population of orang-utans, and a probable self-sustaining population.

At the time of the previous studies of orang-utan densities in the Sebangau catchment, a logging concession was in operation. This concession ceased in 1997, an in effect opened up an opportunity for illegal logging activities within the peat swamp forest. Such logging is not subject to the same stringent controls which aim to regulate location and size of legal logging concessions, and illegal timber extraction has escalated to currently unknown and uncontrollable levels. Extraction canals have been excavated by loggers to allow the removal of illegally logged timber from the peat swamp forest to surrounding rivers, consequently changing hydrology and potentially leading to sub-optimal forest which is prone to forest fire. There have also been extensive fires within the Sebangau catchment since 1996, with approximately 30km^2 of principal orang-utan habitat destroyed. More importantly, these fires appear to have affected what is considered to be the core of the orang-utan population, a forest type described as ‘tall

pole'. This sub-habitat type is capable of sustaining high densities of orang-utans due to a comparatively high biomass per unit area relative to surrounding areas.

The implications of these environmental impacts for the orang-utan clearly needed to be evaluated. This aim of this research was to assess current orang-utan population densities with respect to habitat constraints and increased human disturbance levels. Orang-utans are semi-solitary, canopy dwelling and are cryptically camouflaged. Direct sighting methods are therefore impractical and inaccurate in estimating densities. Estimating forest primate densities by line transects has been widely used (Marsh & Wilson, 1981, see Brockelman & Ali, 1987). The line transect methodology has been applied to assess orang-utan distribution by initially calculating nest density (arboreal sleeping platforms), with the results correlating well with known densities of orang-utans in Sumatra, (van Schaik *et al*., 1995a). Orang-utans make nests daily (Mackinnon, 1971), and individuals rarely re-use old nests. An assessment of nest-counts from line transects surveys would therefore indicate any changes in orang-utan densities as a result of these effects by comparison to 1996 field data.

In addition, it was realised that local people represent a wealth of valuable information pertaining to their local environmental, and the impacts upon it (particularly human-induced), and that this had previously not been addressed. A questionnaire was designed to give further insight into the effects of current human impacts on the forest, and to assess how local communities view these internationally important natural resources, with a view that there may be scope for local involvement in future conservation efforts. Specifically it focused on opinions regarding orang-utan conservation status and protection. It was hypothesised that local communities are not aware of the natural value of the peat swamp forests and the orang-utan in particular.

It was hoped that information generated as a result of this study regarding the distribution of orang-utans and the views of local communities would contribute to overall management strategies for the sustainable development and conservation of the peat swamp forest in the Sebangau region. Secondly, confirmation of the importance of this area for orang-utans particularly with respect to the effects and magnitude of suspected illegal logging would strengthen a case for protected area status of this catchment with greater urgency.

Study Location

The study was conducted at an old logging concession (Setia Alam Jaya), now formally designated as a National Laboratory for peat swamp research. This 500km^2 area of forested peatland is situated 20km South-West of Palangka Raya, the provincial capital of Kalimantan Tengah, Indonesia. The study site is situated within the catchment of the river Sebangau, which runs north-south through the province, (**see maps x and x**). Access to forested areas was provided by an abandoned railway constructed for logging extraction during the previous concession. This enabled access 13.5km into the interior. The study site consists of four sub-habitat types, which relate to peat deposits, briefly outlined in Table 1 below. For an extensive description of habitat types, refer to Shepherd *et al*. (1997). Official logging within the Natural Laboratory has previously been carried on a selective basis at low intensity, with efforts mainly concentrated in the tall pole habitat. The forest sub-habitat which transitions from low to tall is referred to as "transitional".

Forest sub-type	Characteristics
Mixed Swamp Forest (1-5km from the sungai Sebangau)	• The most extensive sub-habitat in the Sebangau region • Stratified canopy, with upper canopy of 35m • Contains commercially valuable trees • Can support high orang-utan density
Low Pole Forest (6-10km from the sungai Sebangau)	• Remains waterlogged through much of the year • Low canopy of 20m, canopy relatively open • Low abundance of fruit sources • Few commercially valuable trees • Low density of orang-utans obtained in 1995/1996
Transitional Low/Tall Pole Forest (11-12km into interior)	• Transitions to tall pole with taller canopy height than low pole and greater numbers of fruiting trees • Covers small area • Intermediate habitat for orang-utans as found in '95/'96
Tall (Interior) Pole Forest (13km onwards from river Sebangau)	• Stratified, closed canopy. Upper canopy of 45m with emergents of 50m. • Area of high biodiversity, although relatively small area • High composition of commercially valuable trees and high biomass per unit area • Some secondary regrowth after previous concession logging • Highest densities of oran-utans found here in 1995/6.

Table 1. Summary of characteristics of forest sub-habitat types based on forest structure and relative importance as orang-utans habitat (based on Shepherd *et al*., 1997 and Page *et al*.,1997).

TRANSECT METHODOLOGY

Line transects were completed between 25 July and 30 September 1999, during the dry season. Standardised field techniques were employed by all observers, this was ensured by walking preliminary transects with experienced field surveyors. Transects of length 1-2km were then completed by myself and two field assistants from the University of Palangka Raya (UNPAR). The observers walked transect lines slowly, and perpendicular transect-to-nest distances were recorded in the horizontal plane. Nest parameters recorded included height in the tree, width (in 0.5m classes from 0.5m-1m up to 2.5m), stage of decay, and position in the supporting tree(s) relative to the main stems. Trends in these parameters between habitat types are possible indicators of demographic patterns, since individuals differ with respect to nest site selection. Vulnerable females with dependant infants generally nest higher in the canopy than adult males (Sugardjito, 1983). Males also tend to produce larger nests (Djojosudharmo, cited in van Schaik & Azwar, 1991). Where the canopy cover allowed, GPS (Global Positioning System) recordings were taken to improve the accuracy of transect length measurements, otherwise these were estimated.

Transect sampling in Mixed Swamp Forest (MSF) enabled assessment of directional change in orang-utan density from marginal MSF to the transition of mixed swamp/low

pole forest, covering 5km at approximately regular intervals. Several transects in mixed swamp and low pole forest types ran approximately perpendicular to the logging extraction railway (see map x). Transects were randomly sampled in both transitional and tall pole forest to cover a representative area around our base camps. The distance at which canals and logging skids crossed or touched the transect route, and the approximate age of logging skids were recorded. Each were recorded as a separate event, although it is probable that the transect crossed the same skid/transect more than once. I assumed these events to be an approximate indicator of past or present habitat disturbance.

The assumptions of the line transect methodology applicable to this study are as follows: (see Burnham *et al*., 1980).

1. Nests directly over the transect line are not missed
2. Perpendicular sighting distances are measured accurately

>>An overview of study area and location of transect samples – map x. Satellite imagery figure to show extent of habitat types and show transect routes?

Nest density

Nest density can be calculated by known length of line transect and width sampled. Since visibility varies across sub-habitats, the effective transect width in each forest habitat type was estimated. The effective strip width (*w*) is the perpendicular distance from the transect to the extreme of effective distance on both side of the survey route. Preliminary calculations of strip width were based on histogram-inspection and cumulative-sighting methods discussed by Whitesides *et al*., (1988) (see Appendix 1), although final analysis used the effective widths calculated by the DISTANCE program. This automated technique is reliable where transect lengths are accurately estimated, (Cassey & McArdle, 1999), but results from these alternative methods serves as a comparison of techniques. Densities calculated by DISTANCE are comparable to those obtained in 1996 using the TRANSECT program, since DISTANCE is simply an updated version. **Check.**

Nest densities are then converted to orang-utan densities using three known parameters :-

- *p*, proportion of nest makers in the population
- *r*, rate at which nests are produced
- *t*, time a nest remains visible

Orang-utan density *d* is calculated as : $^{N}/_{(p \times r \times t)}$ where N = nest density.

Only infant orang-utans do not build nests. Infants represent around 10% of the population (van Schaik *et al.*, 1995a), and therefore (*p)* is estimated to be 0.9. Individuals produce nests at different rates, dependent on age and sex class. Based on known nest building rates for demographic classes (males, females, adults, juveniles, sub-adults), van Schaik *et al.* used a figure of 1.7 nests per day for (*r*), weighted for population structure, which is also used in this study. Nest degradation time however,

potentially varies with tree species characteristics and climatic conditions, and must be calculated separately for each study location. Due to an extensive dry period in 1999, nest degradation time was re-calculated for the Natural Laboratory during this study, since it was expected that degradation rate in days may exceed that calculated in 1996.

Nest degredation time.

To estimate nest degradation time (*t*), 53 nests along 5 mixed swamp forest trails were marked and classified by age class a-d, (see Table 2 below and Plates 1 & 2 on pages x and x).

Age Class	Nest Characteristics
a.	Fresh; leaves are still green
b.	Older; leaves may still be attached and the nest is still firm and solid
c.	Old; leaves are gone and holes visible in the nest
d.	Very old; twigs and branches still present, but no longer the original shape

Table 2. Classification of nest decay stages.

Plate 1. Orang-utan nest – decay stage "b".

Nests were resurveyed for decay stage after approximately 30 days (mean 28.1) had elapsed, and again after 90 (mean 87.3) days, to estimate the transition between decay states. During re-assessment of decay stages, the previous decay stage was not known to field surveyors. The transitions between decay states represent a stepwise Markov chain with an absorbing state (the nest has gone). The expected number of steps to reach the absorbing state and the visibility duration of the nest was calculated, (see Kemeny *et al*., 1956). The fundamental matrix N, of the Markov chain was determined by applying the transition matrix (Q), (nest stages a through d among non-absorbing states), and the identity matrix (I), to the following formula:

$$\mathbf{N = (I - Q)^{-1}}$$

where N is the expected number of steps in each of the non-absorbing states from each possible non-absorbing starting state. Summing the first row of the matrix N, indicated the number of steps from stage a until absorption (nest disappearance), see Appendix 2.

RESULTS – FIELD WORK

Verifying assumptions of methodology

Particular emphasis was placed on the canopy immediately above the transect line to verify assumption 1, but we cannot verify that no nests were missed, since nests are camouflaged and inconspicuous. Transects were randomly cut relative to features such a topography and vegetation, therefore assumption 2 was not violated. Habitat heterogeneity was minimal, therefore error pertaining to short transects was judged to be negligible. Transect-to-nest distances were generally estimated, and may potentially

have been subject to measurement errors. Decay states were subject to the observer's opinion. The author was not present during 7 of the 28 transects included in this analysis.

Total nest counts

A total of 329 nests were recorded across all habitat types, over 28 transects. Transects covered a total of 24.35 km, with mean transect length 902m (st. dev. = 235m, range 0.5-1.4km). Progress through forest by cutting trails was often slow due to dense understory vegetation, and the occurrence of fire damaged areas meant that certain transects fell short of the target 1km. However, as in the 1996 study, separate transects were pooled since each transect was considered representative of the habitat type.

A total of 72 nests were encountered in mixed swamp forest (area sampled 9.97km), 41 in low pole (over 3.07km), 80 in transitional (4.19km), and 136 in the tall pole (7.12km). Confirmed sightings of orang-utans over the period of study included one male in the low pole forest and four males and one female with an infant in mixed swamp forest.

Nest degradation rate.

Only one nest of 53 re-assessed for decay stage had been absorbed after 30 days, ie, the nest was gone. Plates 2 and 3 show little nest degradation between censuses 30 days apart. After 90 days, 15 nests of 52 had stayed the same age class, 28 had moved 1 class, 9 had moved 2 classes, with 14 nests absorbed and one nest not found, (see Table 3). The number of steps to reach the absorbing state was calculated to be 4.07, and the time a nest remains visible (*t*) estimated to be 271 days, (see Appendix 2). This exceeds the degradation rate of 1996, calculated to be 222 days. Error resulting from variation in nest transition rate between states a-b due to some nests remaining greener longer (as nest branches are bent rather than broken), (MacKinnon, 1974) is eliminated as the repeat census is sufficiently long for all "a" stage nests to progress to a further degradation state.

First survey	Second Survey						
	a	b	c	D	x	n	
a	0	3	4	0	0	7	
b	0	2	8	2	0	12	
c	0	0	5	6	3	14	1 NF
d	0	0	0	8	11	19	

Table 3. Transition states between nest age categories as determined by a repeat census 90 days after the initial census (where x = gone, and NF = not found).

Plate 2. Orang-utan nest - decay stage "c".
Plate 3. The same nest approximately 30 days after the initial census. Slight degradation is apparent (ie, leaf above centre).

Orang-utan Densities

Effective strip width and orang-utan densities calculated by the DISTANCE program are summarised in Table 4 below, with a comparison of the densities found in 1996 for each sub-habitat. It can be clearly seen from Table 4 that orang-utan densities have declined considerably in mixed swamp forest between 0-3 km from the river, and increased slightly between 3km and the mixed swamp/low pole boundary, since 1996. Densities in low pole and transitional low/tall pole are significantly higher than expected, with tall pole densities decreasing slightly overall.

Forest Type	Estimated Strip Width (m)	Density ind/km^2	Density ind/km^2 1995/1996
Mixed swamp forest (0-3km)	14.6	***0.34***	1.72 (overall)
Mixed swamp forest (>3km)	9.2	***1.95***	
Low pole	11.4	***1.73***	0.90
Transitional low/tall pole	13.9	***2.02***	1.25
Tall pole	17.0	***1.70***	2.10

Table 4. Comparison of orang-utan densities in each of the habitat types described at Setia Alam Jaya between 1996 and 1999.

Strip widths calculated by the histogram-inspection and cumulative percentage methods over-estimate transect width in comparison with DISTANCE, although the relative widths for each sub-habitat remain the same. Densities calculated by DISTANCE are comparable to those estimated in Appendix 1, giving increased confidence to the results. **CHECK**

Effects of disturbance – illegal logging

Nest sighting frequency in mixed swamp forest increased significantly with distance from the river towards the interior, (Spearman rank correlation, r_s =0.95 , df = 9 , p <0.005), see Figure 1. A total of 17 logging skids were encountered in MSF over a total distance of 9.97km, many of these appeared to be only a few months old, (see plate 4). A directional trend in disturbance was also apparent, 16 of these skids were found between 0 and 4km from the Sebangau river, and only one between 4 and 6km. Ten illegally constructed extraction canals were also encountered in MSF, many of which were associated with logging skids, and all were less than 4km from the river. Huts of illegal loggers were found in close proximity to canals. No canals were found in any other sub-habitat. Recent logging skids penetrate the forest only to the mixed swamp/ low pole boundary.

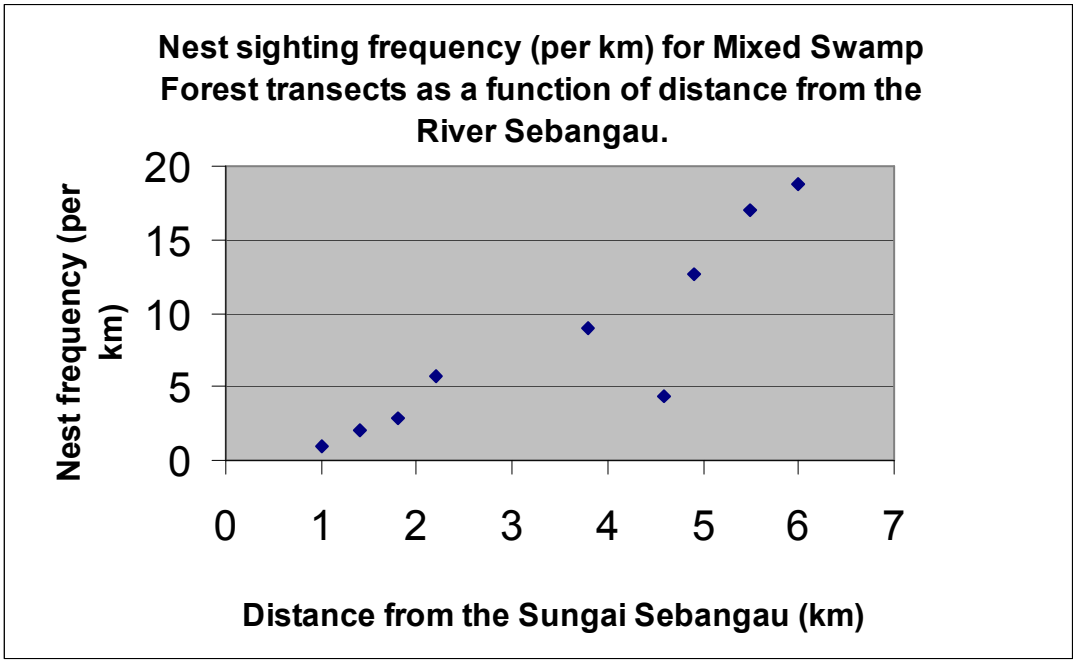

Figure 1. Directional change in the sighting frequency of nests in mixed swamp forest habitat is highly significant.

Plate 4. Illegal logging skid encountered in mixed swamp forest. The network of wooden rails facilitates transportation of logs.

Older logging skids from a previous logging concession were recorded in Transitional and Tall Pole habitats, but at a much lower density compared with those in MSF. Other signs of illegal logging were apparent in MSF, chainsaws were heard and collections of timber were often encountered both in the forest and awaiting transportation on the Sebangau river, (see plates x & x). Evidence of other human activity such as Jelutong (latex) collection from *Dyera lowii* trees was most evident in mixed swamp forest (see plate x), although the effect of such low impact non-timber harvesting on orang-utan distribution was considered to be negligible.

Plate x. Stockpiles of timber found within the Natural Laboratory.

Plate x. New illegal log rafts appear on the Sebangau river every day.

An increase in nest sighting frequency with distance from the river was also apparent across all habitat types, (r_s 0.91, df = 14, $p < 0.005$), see Figure 2 on page x. Observed nest sighting frequency differed significantly with expected frequencies based on the densities calculated in 1996, ($t = 3.23$, df = 13, $p < 0.05$) as demonstrated by Figure 3 below. This clearly shows the shift in orang-utan distribution over the past three years.

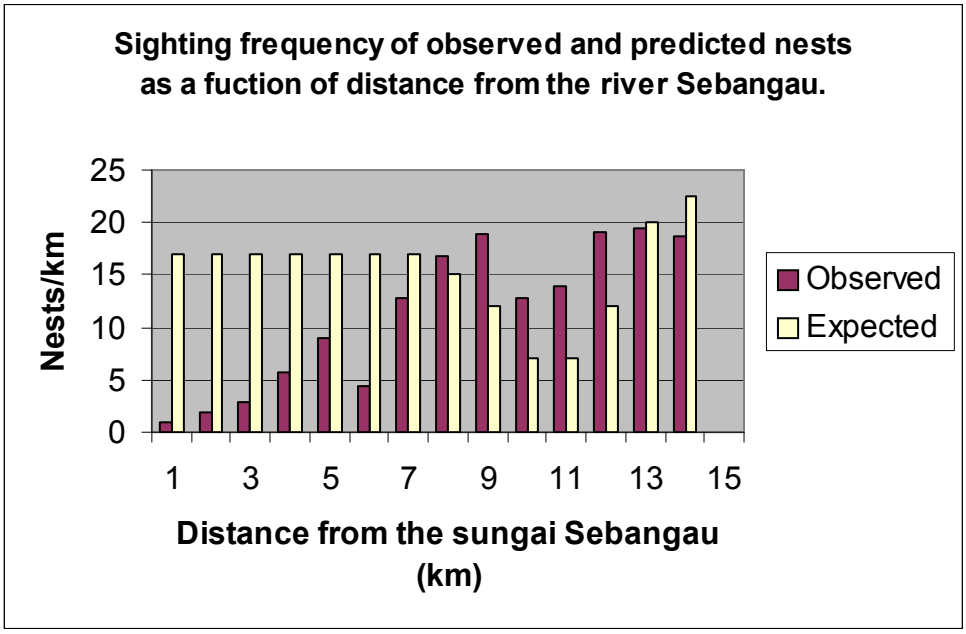

Figure 3. Comparison of nest sighting frequencies obtained with frequencies predicted based on 1996 data. (*NB. These are not the actual nest sighting frequencies obtained in 1996*).

Effects of disturbance - fire damage

Map x shows a satellite image of a fire damaged area of tall pole forest previously inhabited by orang-utans, thought to cover around 30km^2. It can be seen from plates x and x depicting undamaged and fire damage respectively, that the change in forest structure and vegetation as a result of fire, is marked. It was noted that in transitional and tall pole, nests tended to be spatially clumped around disturbed areas, such as fire damaged forest. On one single 500m transect proximal to fire damage, 29 nests were found in transitional forest**. The variation in nest sighting frequency between transects in transitional forest compared to transect variation in other habitats is demonstrated in table x. STATS IF TIME AT END!!**

Plate x. Principal orang-utan habitat (tall pole - undamaged).

Plate x. Fire damaged forest. Present ground flora is dominated by bracken and few trees. Regeneration will be insufficient for return of the orang-utan for many years.

Overall orang-utan density of the study site

Although sighting ability does vary slightly between sub-habitats, nest sighting frequency is approximately proportional to the number of orang-utans and therefore gives a good indication of density. Assuming that our transect samples are representative of the sub-habitats at Setia Alam Jaya, a crude indication of orang-utan numbers was obtained by examining the area under nest sighting frequency graphs (approximate lines of best fit) across the whole range of habitat types to obtain an overall density for the study site. This enabled a comparison of the combined effects of illegal logging and fires on the total populations of the Natural Laboratory.

Despite a markedly different distribution, it can be seen from figures 2 and 4 that the population of orang-utans does not appear to have declined significantly in comparison with 1996 results, with the areas under the graphs totalling 23 and 24.5 units for 1999 and 1996 respectively. This suggests that the population at the Natural Laboratory between has remained approximately constant during 1996-1999 between 0 and 13.5km from the river Sebangau.

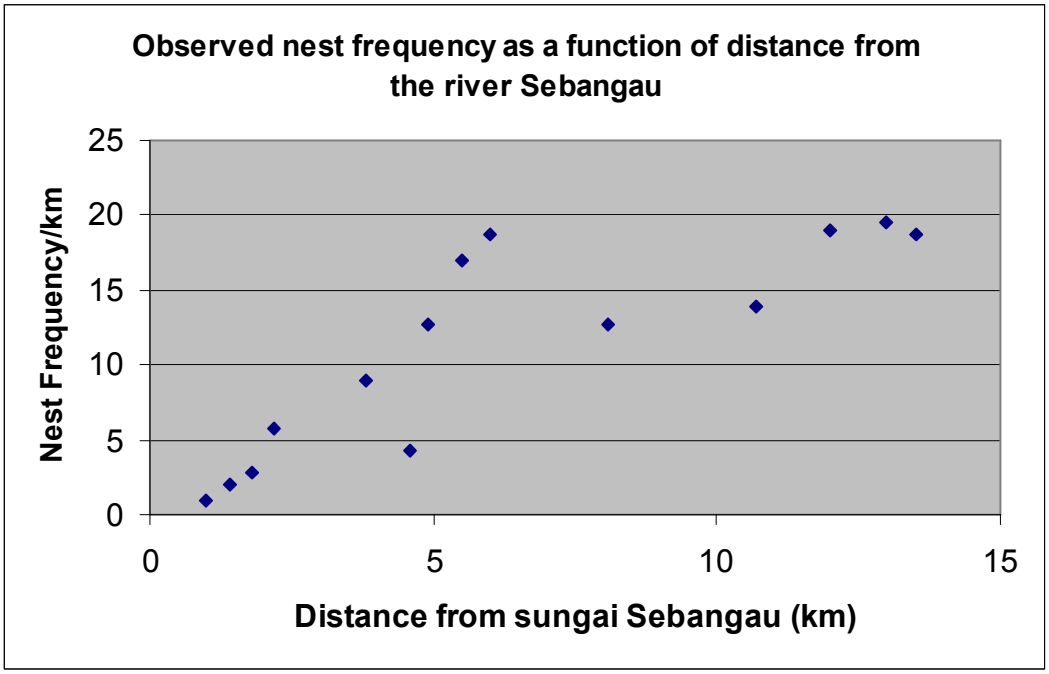

Figure 2. Directional relationship between nest sighting frequency and distance from the river Sebangau for all habitat types. Nest sighting frequency is approximately proportional to orang-utan density. The area under the graph represents 23 units, (calculated by applying a line of best fit).

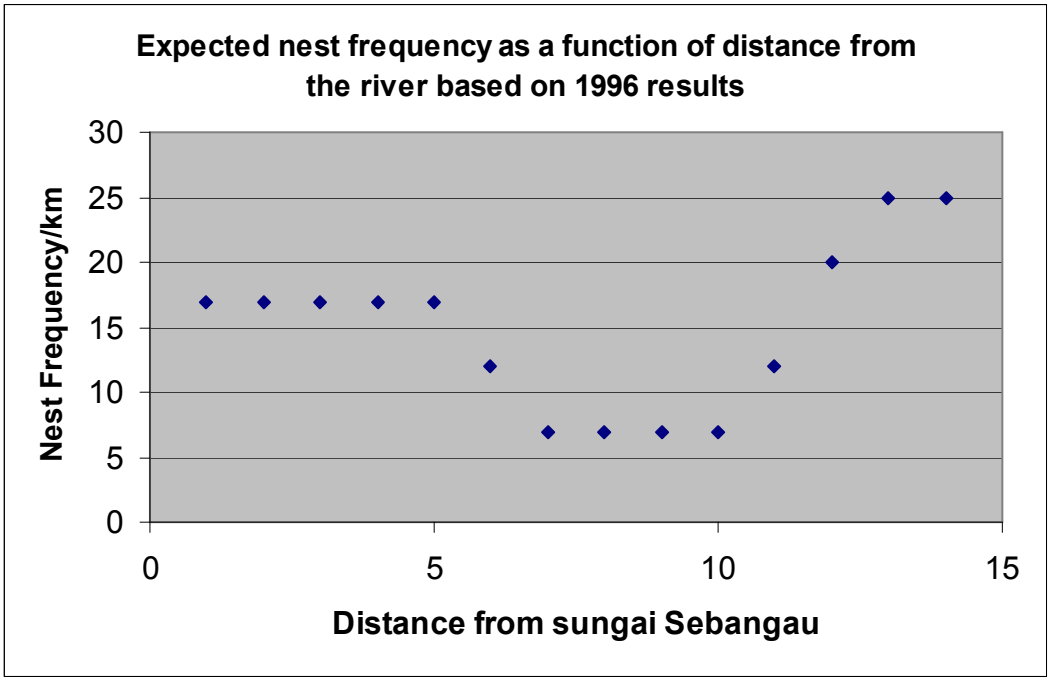

Figure 4. Predicted nest sighting frequency across all habitat types, based on 1996 data. The area under the graph represents 24.5 units.

Demographic patterns

The results showed no obvious patterns in demography throughout the National Laboratory. Nest heights were reflective of canopy height throughout habitat types, with averages of 13.7m for MSF, 11.0 for low pole, 16.8m in transitional and 20.6 in the tall interior forest. However, there was a higher variance in nest height within the mixed swamp forest compared to other habitats ; with some very low nests found. The lowest (ground) nest found was only 1.5m from the ground.

Average nest widths for each of the sub-habitat did not differ significantly, although nests in mixed swamp forest tended to be slightly smaller than elsewhere. The percentage of nests greater than 1.5m in each habitat is summarised in table x below. One way ANOVA??
14m
24l
29tr
23ta

CONCLUSION – FIELD WORK

The results demonstrate the combined effects of illegal logging and fire on orang-utan densities in the National Laboratory of the Sebangau catchment. Low densities were found in mixed swamp forest subject to high levels of illegal logging, with higher densities in the same habitat type subject to less illegal logging, clearly implicating a causal relationship. The decline is most dramatic proximal to the river, where logging is most intense. Illegal logging was apparent by high encounter rates with logging skids, and further demonstrated by strip width analysis, with the disturbed, logged areas of

mixed swamp having a significantly greater strip width as a result of a more open canopy than less disturbed mixed swamp. Nest sighting frequency and distance from the river (and therefore decreasing disturbance) was highly correlated in mixed swamp. Orang-utans are clearly escaping from areas of highest disturbance towards the interior, concentrating immediately prior to the transition to low pole forest.

Overall density for mixed swamp remained lower than expected compared to 1996 results. In contrast, densities obtained in the low pole habitat were considerably higher than in previous studies, suggesting displacement from the mixed swamp. Movement from disturbance is well documented for forest primates, (Wilson & Wilson, 1975, Marsh & Wilson, 1981) and particularly so for orang-utan populations (van Schaik and Azwar, 1991). Only after sufficient regeneration will orang-utans eventually return, which may take a considerable number of years. This is vitally important since the low pole is considered to be an impoverished, sub-optimal habitat, supporting fewer large trees essential for nest building sites, and low densities of fruiting trees. Although no logging is apparent here, the carrying capacity of the low pole is significantly less than the preferred mixed swamp forest; the primary, most prolific habitat for the orang-utan in the Sebangau region. Individuals have adapted to low pole in the short term, and its importance cannot be underestimated as an overflow habitat. However, the requirements that large numbers of individuals dictate are greater than this sub-habitat can sustain indefinitely.

Increased densities of orang-utans in transitional forest can be attributed to refuge provision from fire burnt areas encountered throughout transitional and tall pole forest, and possibly from logging. Since it is difficult to directly assess the effects of these habitat constraints separately, they are considered holistically. Based on densities calculated in 1996, an estimated 50 orang-utans would have been displaced following the destruction of 30km^2 of tall pole forest by fire, and it is probable that some of these individuals have dispersed into surrounding transitional forest. The transitional and tall pole forests are not subject to illegal logging at present, although the indirect pressures of logging elsewhere may still be apparent, with the possible movement of individuals from the mixed swamp.

Previous studies indicate that orang-utan density is greatest in the tall pole forest, with an overall density of 1.7 individuals km^2 and a peak of 3.7 individuals/km^2 at 22km into the interior, (Morrogh-Bernard *et al*., unpublished). Our surveys in this habitat type were concentrated at 12-13km from the river Sebangau, with sites further into the interior proving inaccessible. A density of **x** individuals/km^2 was found in the tall pole. Although our results indicate lower densities for tall pole than in 1996 overall, results for this study are comparable with those from 1996 at the same distance from the river (approximately 1.3 individuals/km^2).

Survey data indicate that transitional forest and possibly tall pole forest may also be suffering from overcrowding, since nests tended to be spatially clumped in undisturbed areas proximal to fire damage. As a consequence of sporadic fire, the remaining tall pole habitat has become more fragmented. The net effect is that tall pole is probably at or nearing carrying capacity, and therefore unable to support further orang-utans escaping from illegal logging. Any recovery in carrying capacity as result of regeneration from past logging disturbance has been counteracted by loss through fire damage.

Overall, densities obtained at the Natural Laboratory show mass displacement of the population, consistent with movement away from areas of disturbance. The apparent overcrowding in the low pole, and possibly transitional/tall pole implies that the survival prospects of displaced individuals taking refuge is potentially in decline. Orang-utans are solitary and naturally highly dispersed, this is reflective of their optimal foraging strategy, since food availability represents a limiting factor to sociality. Where orang-utans are present in higher numbers than the habitat can sustain, the population is likely to become stressed causing reduced fecundity, lowered breeding rates and increased juvenile mortality.

Orang-utans also develop excellent knowledge of their local habitat over a long period of time, such as the location of fruiting trees, arboreal water holes and good nesting sites, (MacKinnon, 1974). Individuals cannot be expected to succeed as well in habitat that they are unfamiliar with, compared with their previous home ranges. Although it does appear that overall populations have not significantly declined until now, a dramatic decline in population numbers is inevitable through shifts in distribution to sub-optimal and overcrowded habitats if illegal logging continues at current indiscriminate levels.

Assuming that the results obtained at the Natural Laboratory are representative of the greater Sebangau region, the current population of the catchment is therefore still likely to exceed 2000 individuals. Whether this population can be sustained is dependent upon on the cessation of illegal logging activities, and ultimately the regeneration of logged-over areas. The population will however, inevitably suffer some decline as a result of logging activities in the future.

Demographic patterns are of relevance to conservation studies since the death of a female has the greatest influence on increasing extinction rates, although no firm conclusions regarding demography at the Natural Laboratory could be made from these results.

QUESTIONNAIRE - METHODOLOGY

The questionnaire was designed to be simple and specific, to enable all respondents to understand it completely, and for ease of translation. It was initially translated into Bahasa Indonesian (the national language of Indonesia), and secondly into the local dialect of Dayak by the interviewers, who were fluent in both languages (see Appendix 3a-c). This allowed all members of the population an equal opportunity of being sampled. The questionnaire was then back-translated into English independently (unknown to the interviewers) to identify and correct errors in the initial translation, and to ensure the meaning of the questions was not lost though translation.

Justification of the questions

Question's 1 & 2 aimed to gauge the respondent's familiarity with the forest and with current and previous impacts upon it. It was assumed that the respondents who visit forested areas every day, or even live in the forest might provide a more complete insight into the impacts or activities occurring within it, than those who never or

occasionally spend time in the peatswamp forest. Similarly, those who have spent several years living in the area may provide a more thorough assessment of changes over time than relative newcomers (question 3).

Question 4 aimed to confirm the impacts occurring which may influence orang-utan populations and the tropical peatland habitat in general. Although field-work confirmed that illegal logging activities were substantial, and forest fires had destroyed a significant area of forest, the relative threat from orang-utan hunting was unknown at the Natural Laboratory. It was also unknown whether local communities came across individuals of the substantial population of orang-utans in the Sebangau region, (and therefore were aware of their existence), particularly since orang-utans move away from disturbed, sub-optimal riverine habitat, which is easily accessible to locals communities. If orang-utans had been seen, the respondents were asked for the location of sightings, since this may indicate the presence of orang-utans in areas previously unsurveyed in fieldwork. It was also important to ascertain whether the magnitude of these impacts had changed over time, and since the 1996 fieldwork, (question 5), particularly since it is suggested that hunting is more prevalent where illegal logging provides increased accessibility to forested areas. Question 5 also aimed to distinguish between hunting and "removal" of live orang-utans from the forest, the latter I assumed would be destined for the pet trade.

The remainder of the questions were applicable to all respondents, regardless of whether they actually go to forested areas or not, since they related to awareness and opinion. Question 6 indirectly asked local people if they were aware of the international conservation importance of orang-utans, by asking their opinion on orang-utan extinction. Conservation of species (and natural resources such as peatswamp forests) can ultimately depend on awareness of the status of these resources with regard to potential loss by the local communities that surround them, and therefore this was considered an important question. Similarly, respondents were asked of their awareness of conservation strategies that may protect the orang-utan, (question 7).

Question 8 aimed to gain an indication of the magnitude of the Orang-utan pet trade network in the Sebangau region. It purposefully did not distinguish between personally obtaining an individual animal, and acquiring one by secondary means, due to its sensitive nature. Interviewers were however, specifically asked to record any additional information on obtaining orang-utans that was offered by respondents. Question 9 aimed to ascertain if local people are concerned with the protection of their natural resources, and if so, why (question 10). Additionally, I asked if local people had any other comments concerning the forest habitat, species within it, or any of the impacts upon them, to find out if anything had been missed out in scoping that local people considered important, (question 11).

Question 12 concerned willingness to participate with local Non-Governmental Organisations (NGOs) in efforts to protect the forest, indicating potential local participation in future conservation efforts in the Sebangau region. Finally, demographic questions were asked to determine if awareness or opinion varied with age group, occupation, or gender. The questionnaire thus covered aspects of behaviour, awareness, opinion and demography.

Sampling Methodology

Questionnaires were conducted in the town of Palangka Raya, at the National Laboratory site (Setia Alam Jaya), the small village community and inland port of Kereng Benkirai (3km up river from Setia Alam), and in rural locations along the Rivers Sebangau, Bakung and Piring, between 20-24 September 1999. Map x shows the distribution of questionnaire sampling. A letter of introduction was given to the head of the village of Kereng Benkirai from UNPAR explaining our presence. Access to remote sites was gained by klotok (small motorised canoe). A pilot of 2 questionnaires was conducted prior to interviewing.

The interviewers were both male students from UNPAR, one of which was indigenous to the area of Kereng Benkirai, although not to the immediate location of sampling. To minimise non-sampling errors, the interviewers were briefed to follow the wording of the questions, and to refrain from prompting the respondents in any way. They were encouraged to record any additional information given by the respondents that they judged relevant to the study. Each respondent was given a brief description of the study prior to interviewing. The sampling frame was simply to target individuals at random.

During sampling, the procedure of approaching respondents unavoidably varied with location. In the town of Palangka Raya, individuals were approached randomly, mainly in the street or market. Several students were also sampled at a university campus (not UNPAR). An effort was made to gain a cross section of ages, a range of respondent occupations and an equal number of males and females. At Setia Alam and at remote riverine sites, questionnaires were more opportunistic, and were conducted simply where people were found regardless of demographics. At the port of Kereng Benkirai, we sampled respondents by approaching houses at random, and conducted a questionnaire if individuals were available and willing. The author was present at all interviews and therefore had ultimate control over the sampling frame.

RESULTS

A total of 32 questionnaires were conducted, 13 of which were held in Palangka Raya, 5 in Kereng Benkirai, 7 at Setia Alam (within the National Laboratory), and 7 along the Sebangau river and its tributaries. Two thirds were conducted in Bahasa Indonesian, and a third in the local language of Dayak. Questionnaires often took 20-25 minutes, often with respondents extending hospitality, particularly in Kereng Benkirai. The pilot study revealed that all the questions has been properly understood, although improvements to the questionnaire design were difficult to assess and it was felt that some relevant qualitative information was lost simply through lack of translation of the responses.

Overall sampling was biased towards males, this was a consequence of a higher proportion of men found at riverine sites, and only men answering questions in the homes of families at Kereng Benkirai. In some instances, other members of the community or family members were present during the questionnaire procedure, although this was judged to be unavoidable, especially at Kereng Benkirai and at some remote locations. Only one individual refused to participate, this was a worker at a saw mill on the Sebangau river.

Overall, 72% of the respondents stated that they visited the forested areas surrounding the sungai Sebangau. Figure 5 indicates the frequency of individuals who stated they had sighted orang-utans or the impacts known to affect the species. Although sightings of people hunting orang-utans were witnessed to a lower degree than the more obvious effects of logging and fire, it thus confirmed hunting as an additional threat occurring in this region.

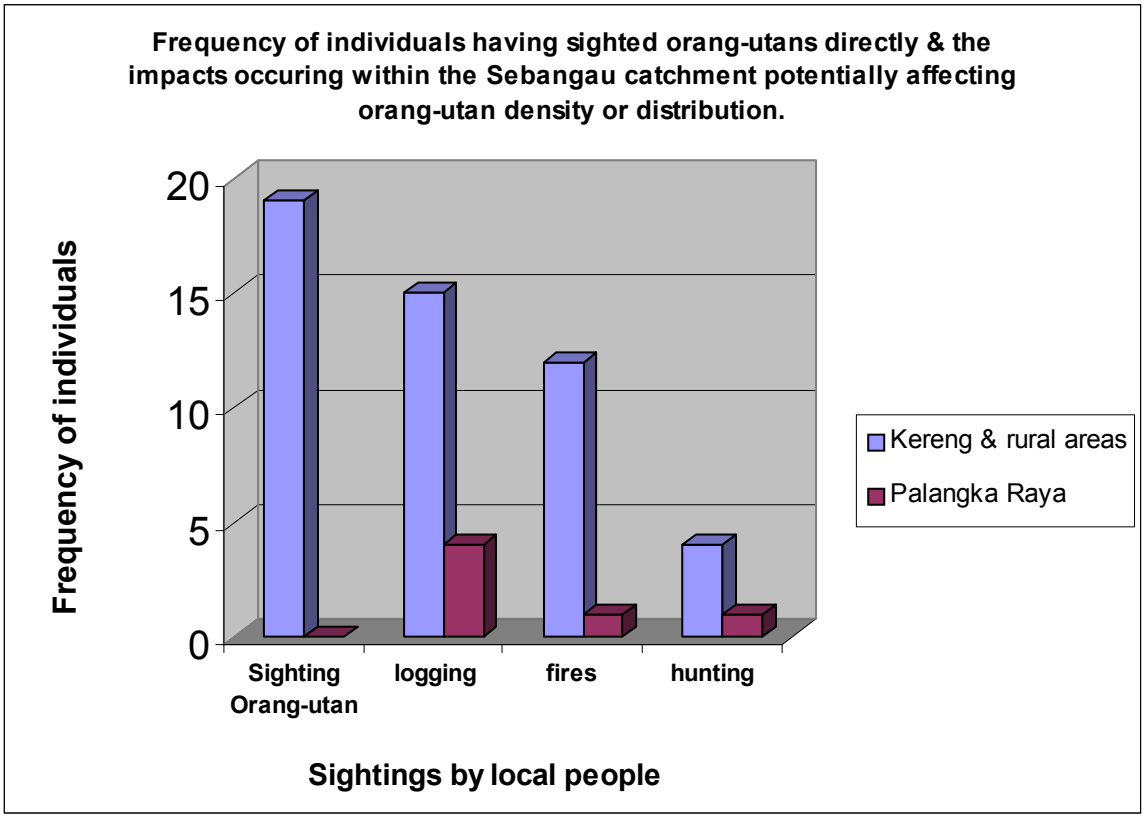

Figure 5. Impacts occurring within the Sebangau catchment as indicated by sightings by local people from the town of Palangka Raya, and the village of Kereng Benkirai and other rural locations who visit the forested areas of the region.

Individuals which had lived in areas surrounding the forest for more than 3 years were able to judge relative changes in these impacts over time (since 1996). No responses were offered with regard to the "removal" of orang-utans from the forest (either dead or alive). In contrast, 20 respondents of 23 questioned, confirmed there had been an increase in logging over this period, and 12 stated they had witnessed an increase in forest fires. Data was however, insufficient to assess relative percentage change offered by respondents for these impacts.

Figure 6 summarises the opinions of local people regarding orang-utan extinction threat. Overall, 77% did not agree that the orang-utan is in danger of extinction, with the remainder agreeing and with no respondents uncertain. Extinction opinion did not significantly differ with familiarity with the forest, ($\chi^2 = 1.7$, df = 2, p = 0.05), where those who visit the forest every day or every week are described as "very familiar", those who visit every month or occasionally "familiar", and those who never visit forested areas "unfamiliar".

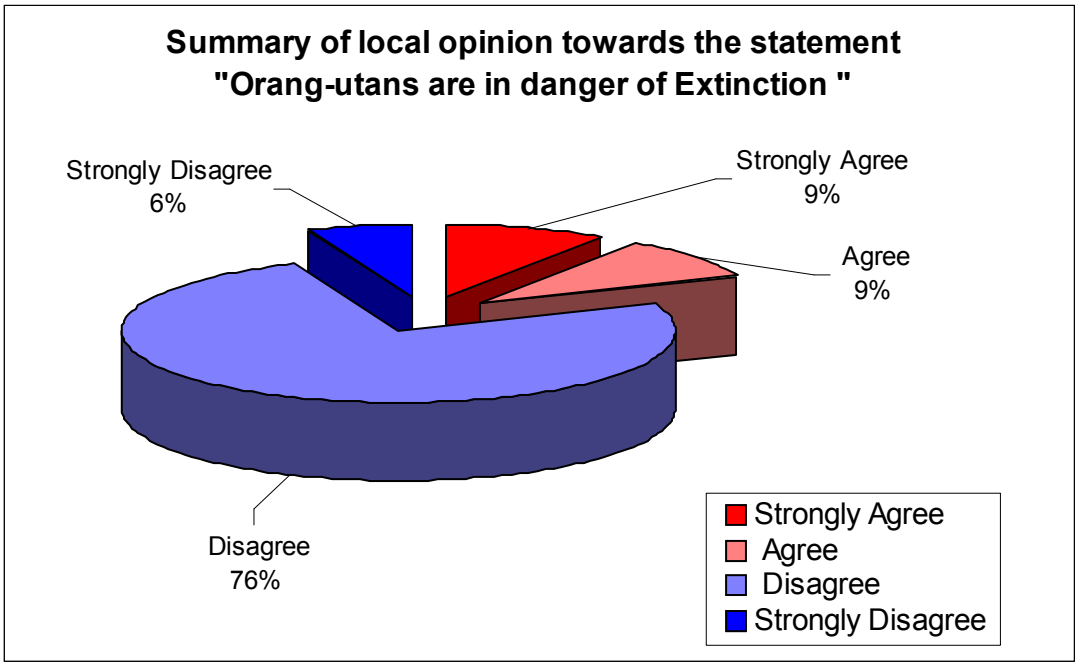

Figure 6. Responses by local people regarding orang-utan extinction threat.

Several potential methods to protect orang-utans were proposed by the respondents, (see table 5 below). The most frequent response (22%) was to prevent destruction of orang-utan habitat.

Protection method suggested	Frequency
Don't disturb habitat or cut trees	7
Do not hunt orang-utans	4
Prevent forest fires	4
Law enforcement through orang-utan Protection Acts	2

Table 5. Orang-utan protection methods suggested by local people.

Ten people stated that they knew how to obtain an orang-utan, although it was not explicitly stated if they knew how to do this personally, hypothetically, or if they knew of others who could obtain an animal. Geographic area (either Palangka Raya or "rural" areas) did not significantly affect ability to obtain an orang-utan (by whatever means), (χ^2 = 0.17 , df = 1, p = 0.05). Four people from rural areas suggested a method of obtaining an orang-utan, all were approximately identical and brief ; isolate a young individual by cutting down the surrounding forest with a chainsaw.

All the respondents except one believed that the forest should be protected, although the reasons given behind this were diverse, see Figure 7 on page x.

Members of local communities also offered additional comments regarding the forest, the threats upon it and it's conservation, summarised in Table 6 below.

Other comments concerning protection/impacts upon the forest	Frequency
Forest management should be continuous/improved/intensified	8
Forest should be maintained so that sustained use is possible	3
Trees should be re-planted so it is sustainable & looks natural	2
The Forestry Department should provide information about the forest	2
Information should be provided to say that animals should not be killed and trees should not be cut	1
Areas should be provided for local people to manage	1
We should improve the relationship between man and nature, because the plants are the lungs of the world	1
Forest could be protected by formulation of laws	1
Local people should be involved in protection of forest and should be given training	1

Table 6. Concerns and statements of local people regarding the peatswamp forest habitat not covered in the questions.

A high percentage of those questioned (88%) stated that they would consider participation with local groups to help conserve the forest and species within, such as the orang-utan. However, it was difficult to ascertain if occupation of respondents affected their opinions due to an unwillingness to disclose occupation, particularly in Palangka Raya and Kereng Benkirai. Occupations that were fully disclosed were market trader, driver, security guard, hotel worker, carpenter and student. The majority of people living along the rivers (although representing an overall minority) were dependent on the river or forest itself for part of, or their entire income, generally combining fishing with small scale tree felling and collection of bark. Three jelutong (latex) collectors were included in the sample within the National Laboratory.

Sampling error

Sampling and non-sampling errors inevitably influenced the results, although an effort to minimise error as much as possible was made. Questionnaires were conducted in only 3 streets of Palangka Raya, therefore systematic bias in the sampling frame was unavoidable ; only those individuals present at these geographic locations could be sampled. Time constraints also resulted in a relatively small sample size (32).

Subsequent to the initial selection of respondents and introduction of myself and the interviewers to them (where respondents spoke Bahasa Indonesian), I had no control over the interview process. I cannot verify that the interviewers did not simplify or shorten questions, suggest answers to the respondents or fail to record relevant information. I assumed that my presence did not affect the outcome of the

questionnaires, and many of the respondents were aware of my inability to speak Indonesian fluently (and therefore understand their answers), since they asked me directly. As with any social research, there is the possibility that respondents may have reacted in the way they thought the interviewers wished.

QUESTIONNAIRE CONCLUSIONS

The results suggest that local people do seem aware of the presence of orang-utans within the Sebangau region. There was also an awareness of the activities seen within the forest and a knowledge that logging in particular had increased substantially. In effect, these were control questions (see Wuelker, 1983), since it was already known that logging and forest fires had in fact increased over the period in question, but the outcome serves to lend support to other responses which are perhaps more sensitive, such as the knowledge of hunting or obtaining an orang-utan.

Hunting does seem to be an additional threat to orang-utans in this forest. Questionnaire results correspond with reports that local people have shot several orang-utans since concession logging ceased in 1997. Almost a third of the respondents (31%) stated that they could obtain an orang-utan, indicating that there may be some value in this information. Although current hunting threat would probably not affect population viability, as illegal logging further opens up the forest, there is the potential for this to become a more substantial threat.

Generally, local communities were not aware of the conservation status of orang-utans, regardless of whether they lived in the local town (Palangka Raya) or a rural area. However, this is perhaps to be expected since there is no education program regarding endangered species, and every respondent in rural areas had seen orang-utans, none reporting any decrease in sightings since 1996. In fact, several respondents instead reported an increase in sightings. This cannot reflect actual increases in such a short period, but it may be reflective of increased access to orang-utans as accessibility of the forest has increased through logging activities.

Protection methods offered by the respondents directly related to current survival threats, and actually addressed the cause of decline rather than more reactive methods of conservation such as rehabilitation. This demonstrated that there is some awareness that habitat loss is detrimental to orang-utan survival. The results also suggest that local people (for many varied reasons) do have an interest in their local environment more generally. Protection of the peatswamp forest was emphatically seen as beneficial to local communities. Obviously some individuals depend on forest resources for their livelihood, although many, particularly in the town of Palangka Raya do not. The forest is also seen to have a role in safeguarding the local environment against floods and erosion, but it also retains an existence value for local people. This is demonstrated by the fact that people want to prevent “extinction” of the forests and would like to see it protected, but they never actually go to these forested areas of the Sebangau region.

Hypothetical questions, such as willingness to participate in future conservation efforts are notoriously unreliable (Bulmer & Warwick, 1983) especially where people are unaccustomed to the concept (ie, conservation). I can only speculate on whether in practise members of local communities actually would participate in future conservation

schemes, although the results of this survey very positively suggest that local involvement is a real possibility.

DISCUSSION

The peatswamp forests of the Sebangau region of Central Kalimantan are clearly one of the last remaining refuges for the orang-utan. The importance of this habitat not only locally or nationally but on a global scale cannot be underestimated. It is the only such area with an estimated self-sustaining orang-utan population which has no protected status. Human impacts and the risk of fire not only threaten the viability of this orang-utan population, but the whole ecosystem including other red data species. It is thus vital that the Sebangau region obtains protected area status, thus increasing the network of protection for this under-represented and biodiverse habitat.

The Natural Laboratory cannot sustain the current level of illegal logging without severe degradation. It seems only a matter of time before illegal loggers encroach deeper into the interior forest, to the core of the orang-utan population of this 500km^2 area, with potentially disastrous results for the population and other vulnerable animals previously recorded at this site. The endangered helmeted hornbill, known to be adversely affected by logging, (Wilson & Wilson, 1975) is another notable species at risk. Extensive logging at the tall pole will also result in enhanced surface run off from the domed-shaped surface thereby lowering the water table. Coupled with the effects of fire, a more patchy, fragmented habitat will result, which may act as an isolating mechanism for the orang-utan in some areas, with overcrowding in others as they absorb the over-spill.

Although illegal logging activity is primarily the cause of habitat decline here and throughout Kalimantan, government backed "mega" developments also continue to threaten Kalimantan's peatland resources, despite previous failures in attempts to convert peatswamp forest to commercial plantations such as rice and palm oil. The ill-fated project "Pengembangan Lahan Gambut" (PLG) aimed to increase rice production by converting a million hectares of mostly peatland (including areas of the Eastern Sebangau region) into rice fields, was finally ended in 1999, with complete failure. Drained peatswamp was found to be unproductive, rice production uneconomic, and fertilisers had to be substantial used, further degrading the local environment. More importantly, it is estimated that the project essentially destroyed a million hectares of orang-utan habitat. The peatswamp forest of the Sebangau catchment is all the more important in light of such destruction of forest cover seen elsewhere in Central Kalimantan.

The forests of the upper Sebangau have been shown to be invaluable natural resources for the local community. Non-wood forest products such as rattan, bark and latex are sustainably havested from the forests, and many local fishermen rely on the river Sebangau. Local people have explicitly stated that the forest provides economic, cultural, recreational and aesthetic benefits. Many people even expressed that they valued the forest simply for its existence. Allowing the next generation to inherit these natural resources was found to be the primary incentive for supporting potential conservation schemes. There appears to be a real concern regarding the long term effects of current human impacts on the local environment such as flooding, fires and

erosion. Peatswamps are natural hydrological regulators (Prentice & Parish, 1992) and local people are entitled to a continued sustainable environment which is buffered from these effects. Continuation of the exploitation seen at Setia Alam will therefore inevitably result in detrimental social impacts, in addition to a degraded environment.

Protection is of course conceptually simple, but the peatswamp forest continues to represent a substantial economic resource. Conflicts of interest will inevitably arise where conservation is undermined by individuals and companies intent on practising illegal (but economic) exploitation. Political corruption has left a legacy of unsustainable exploitation in Indonesia's forests, with conclusive evidence showing that many timber companies do not conform to the regulations of the Ministry of Forestry, both with regard to logging location and truthful declaration of the number of logs taken. The Environmental Investigation Agency has reported that several companies are operating illegal logging activities outside concession boundaries and in protected areas, (EIA, 1999). Tanjung Puting National Park, the largest protected area for orang-utan conservation and rehabilitation in Kalimantan has been subjected to several attacks of illegal logging. Legislation designed to protect designated conservation areas cannot always be enforced with the vigour required to withstand the immense power of the illegal logging companies, even in protected areas. Economic incentives outweigh penalties for illegal logging, and do not deter big logging companies from this activity. Although beyond the scope of this study, it is ultimately of course, the Government of Indonesia which must address this on a wider scale, by enforcing legislation and providing sufficient monetary resources for monitoring of timber practises, and ensuring protected areas are given the protection they deserve.

If absolute protection cannot be designated, the Sebangau region should at least be subject to sustainable management practises of selective logging with the provision of refuges. Orang-utans are resilient to some habitat alteration, and despite probable declines in overall density as a result of selective logging (van Schaik & Aswar, 1991), selective logging appears to affect orang-utans less drastically than illegal logging (Meijaard, 1997). Marsh & Wilson (1981) suggest primate populations may begin recovery 5 years after logging operations, although the time-scale obviously varies as a function of the species involved and with structural damage. Orang-utans have certainly moved back to areas of previous logging disturbance in the tall pole forest of the Natural Laboratory, since nests were found around old skids, but heavily logged-over forest may never return to its former condition. Future concession logging is therefore preferential to further illegal logging in this region, although the 35 year regeneration period of the Indonesian selective logging system is almost certainly too short for peatswamp forest, (Rieley *et al*., 1997).

To sustain populations of many large mammals, large protected areas are required, and this is certainly true of the orang-utan. The results show that the upper Sebangau catchment has a high density of orang-utans and should certainly be fully protected, but this study represents part of a wider program of research to assess the sustainability of orang-utan populations and to estimate population numbers over the entire Sebangau region. Concurrent to this study, previously unsurveyed areas elsewhere within the catchment and other surrounding areas of peatswamp forest were surveyed by the nest count method by other observers. This included areas of the eastern Sebangau catchment, where drainage and clearance for the PLG (mega rice) project had occurred.

Densities in the PLG area were very low, but elsewhere they compared favourably to those found at the Natural Laboratory, further lending weight to the importance of this region for orang-utan conservation. Retaining connectivity to these other suitable areas is vital in preventing isolation and local extinction by potentially enabling genetic influx from linked areas, especially where habitat becomes more patchy and fragmented and populations decline. Protection should therefore include all such areas and also areas of suitable habitat where there may be no orang-utans at present, but which may act as a buffer from further habitat loss. Illegal logging activities were also found throughout the catchment, and several saw mills were seen on the Sebangau itself.

It is hoped that the results of this work will form the basis of a long term monitoring study, both within the Natural Laboratory and within the wider Sebangau region. Previously surveyed areas will be re-assessed to monitor changes in orang-utan density and distribution over time. It is also increasingly important to continue to define the orang-utan distribution by identifying new areas of suitable habitat which may serve as wildlife corridors linking the Sebangau catchment. Ideally, future research and data dissemination should be co-ordinated locally, by a member of CIMTROP (University of Palangka Raya) and with the assistance of students and existing local NGOs.

Assuming the results of the questionnaire are valid, there appears to be scope for local community involvement in the protection of the upper Sebangau catchment, in **RIO 1992** Local people could potentially play a key role in the monitoring phase, which may simply involve regularly reporting where orang-utans have been seen. Although some local people may be benefiting from illegal logging, (one respondent admitted that their family owned a saw mill), generally local communities as a whole do not benefit from mass destruction of the forests, and this factor may prove influential in promoting local action towards protection and wise use of their inherited natural resources.

Future work should also focus on increasing local awareness, and perhaps even developing an education program to catalyse local people into greater appreciation of their wildlife. Right to be involved in resource management – **Communication Forum for Community Forestry local people by consultation (EIA, 1999)Resources- From where?** The principles of sustainable development (sustained use of resources), the provision of information from Government bodies such as the Ministry of Forestry, law enforcement of protection acts, and the involvement of local people in management were pressing issues that local communities would like to see operate in their forest. These are all consistent with the long-term aims and objectives of the ongoing "ORANGTROP"/CIMTOP partnership, of which this research is affiliated.

The orang-utan acts as a flagship for the whole tropical peatland ecosystem of the Sebangau region and as such is the focus of this research. This study confirms that orang-utans are adversely affected by illegal logging, and this allows judgement on potential long term effects of continued logging disturbance to be made with more conviction. Populations will inevitably decline unless the Sebangau is designated protected area status, or ilegal logging can be halted indefinitely. Firm commitment to address the threat of logging across the entire species range is essential, and until such time when this aim can become a reality, the future of the Orang-utan in Central Kalimantan remains uncertain.

Despite inevitable error in the calculation of some of the parameters used in the line transect methodology, and further error in extrapolating population numbers

for the catchment from density estimates, (by reference to land cover data), a baseline figure is useful to monitor populations over time and is certainly preferable to no figure at all.
Variation in Transitional habitat transects varied considerably,

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