CHAPTER 7

DISCUSSION AND VEGETATION MONITORING RECOMMENDATIONS

THE SECONDARY RAIN FOREST IN THE STUDY AREA

Following Langdale-Brown *et al.* (1964) the secondary rain forest cover of Ngamba Island (and the Ugandan Islands in Lake Victoria in general) constitutes or at least approaches the final stage of reforestation. The authors characterize such forests as *Piptadenestrum-Albizia-Celtis* Forest (Langdale-Brown *et al.* 1964) (Figure 3.21). The secondary rain forest cover on Ngamba Island represents a young to intermediate stage of this forest: *Albizia* spp. are still quite prominent and also a number of *Antiaris toxicara* trees are present (Figure 6.8 & 6.11). While those two species are indicators of the younger stages of this medium altitude moist evergreen forest type, the occurrence of *Entandrophragma utile* indicates that this forest approaches the middle stages of its development (Langdale-Brown *et al.* 1964) (Figure 6.11). Furthermore, the presence of *Dracaena fragrans* as prominent representative of the shrub layer and of *Commelina capitata* as the typical ground herb are additional indicators for the classification as *Piptadenestrum-Albizia-Celtis* Forest (Langdale-Brown *et al.* 1964). The mean annual rainfall of 1 457 mm for Ngamba Island (Figure 3.4) falls well between the limits of annual rainfall of 1 270 – 1 524 mm (50 to 60 inches) given by Langdale-Brown *et al.* (1964) for this forest type in Uganda. With 1 160 m Ngamba Island's altitude above sea level (see Chapter 3 – Study sites) also fulfils the observation made by those authors that the *Piptadenestrum-Albizia-Celtis* Forest occurs at an altitude of between 1 128 – 1 280 m (3 700 – 4 200 feet) above sea level at the north-west shores of Lake Victoria (Langdale-Brown *et al.* 1964).

Status of the forest edge on Ngamba Island

Using Langdale-Brown's *et al.* (1964) classification of tropical forest edges (Figure 7.1) the woody vegetation cover on Ngamba Island can be classified as possessing a 'retreating secondary rain forest edge' (compare Figure 7.1 with Figure 3.27 – 3.30). This indicates that while the forest as a whole is still advancing towards the final stage of its climax vegetation a disturbance at the northern forest edge adjacent to the herbaceous vegetation cover is already occurring (Figure 7.1). This disturbance will partly have been caused by the little fishing community which inhabited Ngamba Island before it became a chimpanzee sanctuary (see Chapter 2 – The History of Ngamba Island Chimpanzee Sanctuary). However, part of this disturbance might be caused by the newly introduced chimpanzees who frequent the edge area between forest and herbaceous vegetation quite regularly, especially during the morning and afternoon feeding (see Chapter 2 – The History of Ngamba Island Chimpanzee Sanctuary & Figure 3.27 – 3.30). At the same time they also frequently use the trees at the forest edge for resting, feeding and playing and have caused substantial damage already through the continuing defoliation of branches (Figure 4.8 & 4.12).

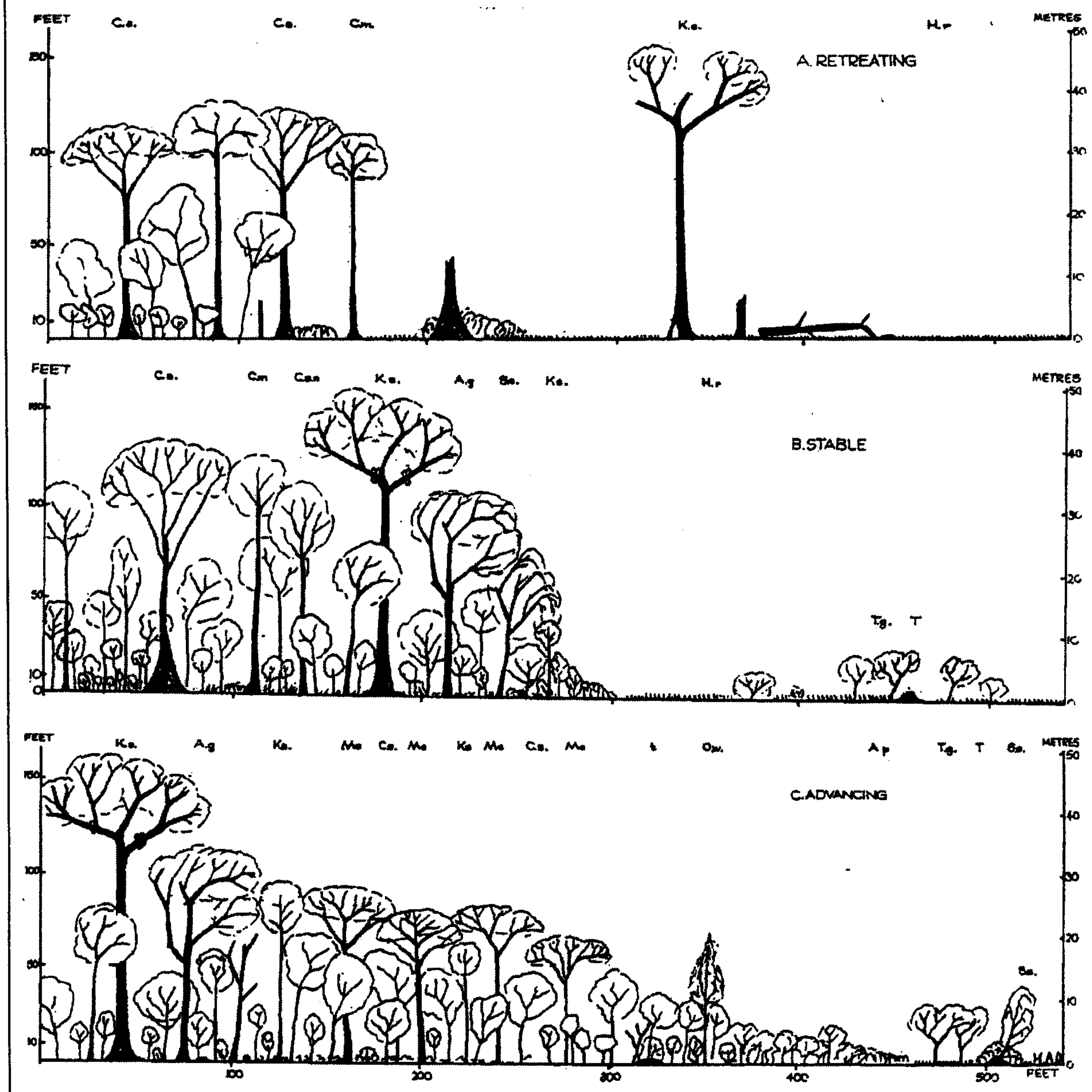

Fig. 4. The forest edge: examples from semi-deciduous forest.

Key

C.a. — Cynometra alexandri
C.m. — Celtis mildbraedii
C.sn. — Chrysophyllum sp. nov.
C. — Celtis zenkeri
K.a. — Khaya anthotheca
A.g. — Albizia grandibracteata
S.e. — Sapium ellipticum
T.g. — Terminalia glaucescens
T — live termite mound
t — dead termite mound
H.r. — Hyparrhenia rufa
M.e. — Maesopsis eminii
C.s. — Caloncoba schweinfurthii
O.w. — Olea welwitschii
A.p. — Acanthus pubescens

Figure 7.1: The three possible forms of forest edges of tropical rain forest (following Langdale-Brown *et al.* 1964).

Recommendation: To evaluate the effect the chimpanzees have on the vegetation cover of the forest edge over time photographs of this area should be taken at regular intervals and compared to any such previous documentation. The GPS coordinates of the forest edge should be regularly checked and compared with previous data as well. A southwards shift of this limit will be a sure indication of a continuing disturbance (Figure 6.1). Comparison with the location of the limits of the control area on Nsadzi Island over time (Figure 6.68) will allow an assessment of how much of the cause of this development might be attributed to the presence of chimpanzees on Ngamba Island. However, the human impact on the vegetation on Nsadzi Island will always have to be considered as well.

Pioneer and persistent woody vegetation species on Ngamba Island

When applying Martinéz-Ramos & Alvarez-Buylla's (1986) classification of pioneer and persistent tree species (see Chapter 4 – The significance of seed dispersal) the tree species on Ngamba Island with an abundance of ≥ 100 plants per hectare (Figure 6.8 & 6.9) can be classified as outlined in Table 7.1 (*Commelina capitata* has not been considered).

Table 7.1: *Classification of tree species on Ngamba Island with an abundance of ≥ 100 plants per hectare into pioneer and persistent species[1] and giving their mean abundance as plants per hectare*

Species [plants per hectare]	Pioneer tree (many seeds < 50 mm)	Persistent tree (few seed > 50 mm)
Aframomum angustifolium	2 931	
Albizia gumnifera	1 238	
Dracaena fragrans	2 209	
Dictyandra arborescens	113	
Galinera saxifraga		178
Guarea cedrata		1 078
Ouratea hiernii	244	
Oxyanthus speciosus		666
Pachystela brevipes		163
Palisota mannii	200	
Tetrorchidium didymostemon		129
Total	6 935	2 214

[1] Sources: Eggeling 1951, Lind & Tallantire 1962, Langdale-Brown *et al.* 1964, Lind & Morrison 1974, Katende *et al.* 1995, Katende *et al.* 1999.

There is nearly equilibrium between the number of pioneer (6) and persistent (5) tree species on the Island (Table 7.1). It is hence shown by the high number of pioneer species present that this forest is still in its young to intermediate stage of climax vegetation. This finding furthermore supports the observation by Langdale-Brown *et al.* (1964) that the *Piptadenestrum-Albizia-Celtis* Forest is characterized by a mixture of genera usually represented by only one species. Here 11 species represent nine different genera (Table 7.1 & Annex – Table 1). The pioneer species are about three times as abundant as the persistent species – another indication for the young to intermediate age of the forest successional stage (Table 7.1).

Recommendation: As part of the monitoring programme on Ngamba Island the ratio and abundance of these single pioneer and persistent tree species should be determined regularly. A steady increase in the number and abundance of persistent species would indicate that the forest cover progresses undisturbed towards its mature climax stage. Major disturbances, such as tree fall gaps, might eventually lead to an increase in the number and ratio of pioneer species to persistent species when over the years the gaps are covered again by woody vegetation. These gaps might be caused by wind as well as by the destructive influence of the chimpanzees (Figure 4.8 – 4.17).

Pioneer and persistent woody vegetation species on Nsadzi Island

When classifying tree species on Nsadzi Island with abundance ≥ 100 plants per hectare into pioneer and persistent species a picture different to that of Ngamba Island emerges. Only two species in these groups are the same on both islands, namely *Dictyandra arborescens* and *Ouratea hiernii* (Table 7.1 & 7.2). Also on Nsadzi Island 11 different species representing 6 different genera belong to this category of abundance (Table 7.2), but the ratio of pioneer species to persistent species is 9:2, i.e. higher than on Ngamba Island (Table 7.1 & 7.2).

Table 7.2: *Classification of tree species on Nsadzi Island with an abundance of ≥ 100 plants per hectare into pioneer and persistent species*[1] *and giving their mean abundance as plants per hectare*

Species [plants per hectare]	Pioneer tree (many seeds < 50 mm)	Persistent tree (few seed > 50 mm)
Calycosiphonia spathicalyx	150	
Coffea eugenioides	450	
Dictyandra arborescens	350	
Funtumia africana	350	
Menisorus pauciflorus	700	
Oncinotis species 1		650
Ouratea hiernii	1 400	
Oxyanthus speciosus var. *stenocarpus*		150
Rhytigynia species 1	1 600	
Turrea vogellioides	750	
Uvaria angolensis	550	
Total	6 300	800

[1] Sources: Eggeling 1951, Lind & Tallantire 1962, Langdale-Brown *et al.* 1964, Lind & Morrison 1974, Katende *et al.* 1995, Katende *et al.* 1999.

Recommendation: This rather pronounced difference between the two islands forecloses a meaningful comparison of the future fate of their pioneer and persistent tree species as a result of the impact of chimpanzees. When monitoring the future development of pioneer and persistent tree species on Ngamba Island it will therefore only be possible to make an assessment of the impact the chimpanzees might have on them, since a direct comparison with a similarly structured control forest is not possible.

COMPARISON OF CANOPY COVER AND HEIGHT CLASS DISTRIBUTION OF PLANT SPECIES PRESENT ON NGAMBA AND NSADZI ISLAND

A comparison of the mean number of trees per hectare according to height class on both Ngamba and Nsadzi Island also shows a rather different forest structure (Table 7.3). While the number of trees on Ngamba Islands declines fractionally from the lowest to the highest height class, as predicted by Langdale-Brown *et al.* (1964) for tropical rain forest vegetation, no such pattern is visible on Nsadzi Island (Table 7.3). Here, the 1.0 m height class shows the highest number of trees followed by the 0.5 m height class, while the remaining four height classes show about the same mean number of trees per hectare (Table 7.3). The mean total number of trees is higher on Ngamba Island than on Nsadzi Island (Table 7.3). At this stage therefore the forest structure on Ngamba Island still looks healthy, but it does not look like it is healthy on Nsadzi Island (Table 7.3).

Table 7.3: *Mean number of trees per hectare according to height class on Ngamba and Nsadzi Island*

Height class	Mean number of trees per hectare	
	Ngamba Island	Nsadzi Island
> 6 m	304	600
4 – 5 m	772	750
3 m	1 141	650
2 m	1 703	850
1 m	2 100	3 000
0.5 m	2 509	1 350
Total	8 529	7 200

Recommendation: It is postulated that the chimpanzees' impact on the forest structure will in the short to medium term mainly be evident on the density of the lower height classes. Here, younger saplings and trees will be bent and broken and uprooted by displaying male adults and by youngsters during their infant walks (see Chapter 2 - The History of Ngamba Island Chimpanzee Sanctuary, Chapter 4 – Destructive behaviour & Figures 4.8 – 4.11). To evaluate this impact and the above hypothesis the sample plots on Ngamba Island should regularly be monitored using the "Varying quadrat plot method".

Comparison of growth form abundance and species richness on Ngamba and Nsadzi Island

Growth form abundance

The main difference between the percentage contribution of growth forms to overall density on Ngamba and Nsadzi Island is the more or less complete absence of a shrub layer on Nsadzi Island (1%), while it shows about the same abundance as the sparse shrub (6%, 7%) layer on Ngamba Island (Figure 6.4 & 6.69). With a mean total number of 7 800 plants per hectare (Table 6.15 & Figure 6.69) Nsadzi Island also possesses a lower density of woody vegetation than the secondary rain forest cover on Ngamba Island with a mean total of 9 820 plants per hectare (Figure 6.69).

Recommendation: The regular monitoring of the mean density of woody vegetation of the sample areas on both islands will indicate a possible impact of the chimpanzees on the Ngamba Island woody vegetation density. This density will decrease over time through the destructive behaviour of the chimpanzees (see Chapter 4 - Island chimpanzees + - Destructive behaviour). Should a decrease of density also occur on Nsadzi Island a comparison of the degree of decline on both islands will allow a conclusion on the percentage of decline attributable to the chimpanzees' impact on the woody vegetation on Ngamba Island. This percentage can then be used to make and adjust predictions for the future development of forest density over time according to number of chimpanzees present on Ngamba Island.

Importance of Aframomum angustifolium *and* Dracaena fragrans

The contribution of the shrub layer to overall woody vegetation density on Ngamba Island is mainly caused by high mean densities of *Aframomum angustifolium* and *Dracaena fragrans* (see Chapter 6 - Tree density corrected for *Aframomum angustifolium*,

- Distribution of plant species according to growth form & Figure 6.8, 612, 6.17, 6.22, 6.23, 6.27, 6.28, & 6.32). Both of those species are also Ngamba Island chimpanzees' food plant species (see Chapter 4 – Terrestrial herbaceous food + Feeding techniques, Chapter 6 – Ngamba Island chimpanzees' food plant species & Table 6.4).

Recommendation: Regular monitoring of the density of these two species will show whether the use by the chimpanzees - while also acting as possible seed dispersers - will increase or decrease the abundance of those two plant species on the island. The chimpanzees have also quite a destructive influence on those two p lant species simply through bending and uprooting of stems (see Chapter 6 - Sample plots on Ngamba Island).

Species richness

In the eight sample plots on Ngamba Island a total of 41 different woody vegetation species has been found (Annex – Table 1). Species richness in the sample plots on Ngamba Island varies from 9 to 17 different species (Figure 6.6), while it is 16 for the two plots on Nsadzi Island (Table 6.14). The two sample plots on Nsadzi Island contain altogether 24 different species (Annex – Table 7). Some of the plots on Ngamba Island are species poor with a high density of a selected number of species, e.g. plot 7 and 8 which show a high abundance of *Dracaena fragrans* and *Aframomum angustifolium*, respectively (see Chapter 6 – Density according to height class and growth form).

Recommendation: Regular monitoring of the eight sample plots on Ngamba Island will indicate whether a change in the species richness and species diversity in the eight plots on the island occurs. Special emphasis should be put on the monitoring of *Aframomum angustifolium* and *Dracaena fragrans* (see above) as well as on the other Ngamba Island chimpanzees' food plant species (see below).

Height class and mean percentage canopy cover of tree species on Ngamba Island with an abundance of ≥ 100 plants per hectare

When comparing the mean number of plants per hectare with the mean percentage canopy cover it becomes obvious that the three most abundant tree species are pioneer species or typical representatives of the shrub layer of the *Piptadenestrum-Albizia-Celtis* Forest (Langdale-Brown *et al.* 1964) (Table 7.1 & 7.4), while the three tree species with the highest mean percentage canopy cover are persistent tree species (Table 7.1 & 7.5). The former tree species have their highest abundance in the lower and younger height classes which still possess a limited degree of foliage (Table 7.4 & 7.5). The latter tree species have their highest abundance of plants and canopy cover in the higher height classes (Table 7.4 & 7.5).

Table 7.4: *Mean number of plants per hectare according to height class for species with an abundance of ≥ 100 plants per hectare*

Species [plants per hectare]	Height class						
	0.50m	1.00 m	2.00 m	3.00 m	4.00 – 5.00 m	> 6.00 m	Total
Aframomum angustifolium F	575	900	956	463	13		2 907
Dracaena fragrans F	1 400	475	225	75	38		2 213
Albizia gumnifera F	263	438	166	291	216	16	1 390
Guarea cedrata F	166	188	284	144	138	147	1 067
Oxyanthus speciosus F	78	175	38	200	153	23	667
Ouratea hiernii	6	13	213	13			245
Palisota mannii	175	25					200
Galinera saxifraga		38	25	63	53		179
Pachystela brevipes F	38	13	13	25		75	164
Tetrorchidium didymostemon F			38	31	56	4	129
Dictyandra arborescens F		25	63	13	25		126

□ Pioneer tree species

■ Persistent tree species

F Ngamba island chimpanzees' food plant species

Table 7.5: *Mean percentage canopy cover for species with an abundance of ≥ 100 plants per hectare*

Species [Percentage canopy cover]	Height class						
	0.50m	1.00 m	2.00 m	3.00 m	4.00 – 5.00 m	> 6.00 m	Total
Guarea cedrata F	0.84	2.48	6.82	8.69	11.42	64.27	94.52
Oxyanthus speciosus F	0.60	3.14	11.81	15.15	6.63	5.52	42.85
Pachystela brevipes F	0.23	0.58	0.23	3.25	12.28	18.76	35.33
Dracaena fragrans F	10.89	6.13	4.13	0.73	0.30		22.18
Aframomum angustifolium F	1.23	5.75	6.96	2.91	0.01		16.86
Terorchidium didymostemon F	0.02	0.39	2.00	2.41	6.20	3.93	14.95
Ouratea hiernii	0.95	2.87	9.74	0.22			13.78
Albizia gumnifera F	0.55	0.76	0.96	1.27	1.71	2.90	8.15
Galinera saxifraga F	0.03	0.32	2.37	3.63	1.54		7.89
Palisota mannii	2.80	0.50					3.3
Dictyandra arborescens F		0.07	0.28	0.24	1.03		1.62

□ Pioneer tree species

■ Persistent tree species

F Ngamba island chimpanzees' food plant species

Tetrorchidium didymostemon is a persistent tree species which seems the one most likely to disappear from Ngamba Island over time. It has no more young seedlings and saplings which could eventually replace old dying trees (Table 7.4). Other persistent tree species which might follow at a later stage are *Galinera saxifraga* and *Oxyanthus speciosus* (Table 7.4). Overall, all persistent tree species seem to be having a problem recruiting new trees. Those being food species for chimpanzees will face an additional pressure – apart from *Galinera saxifraga* that are all of them (Table 7.4). The pioneer species most likely to disappear seems to be *Dictyandra arborescens*, followed by *Ouratea hiernii* (Table 7.4).

Two of the three species with the highest mean percentage canopy cover, namely *Guarea cedrata* and *Oxyanthus speciosus*, have been classified as *indifferent species* using the Braun-Blanquet classification (Table 6.3). This indicates that they are distributed ubiquitously throughout the island (see Chapter 5 – Analysis of woody vegetation data). *Pachystela brevipes* is a companion species (Table 6.3) and occurs only in confined areas throughout Ngamba Island (see Chapter 5 – Analysis of woody vegetation). This species belongs to the family Sapotaceae, members of which characterize, according to Langdale-Brown *et al.* (1964), the final stages of the climax vegetation in a *Piptadenestrum-Albizia-Celtis* Forest. This climax vegetation can be compared to the 'tree stage of succession' of secondary rain forest succession described by Richards (1966) and Ewel (1980) and can again be divided into three different phases.

Based on the canopy cover values it is currently definitely the group of persistent tree species which is giving the character and appearance of the woody vegetation cover on Ngamba Island (Table 7.5).

Recommendation: As part of the vegetation monitoring programme possible changes in these patterns should be determined and evaluated. The forest cover on Ngamba Island seems to be in a transition period from the young to the intermediate stage of climax vegetation (Langdale-Brown *et al.* 1964). It will be interesting to see whether and if so to which extent the impact of the newly introduced species of chimpanzees onto the island will interfere with this natural progress in forest development. It is postulated that through continuing destruction of the existing vegetation cover and simultaneous destruction of upcoming plant seedlings and saplings the chimpanzee population on Ngamba Island will eventually bring this development to a complete standstill.

Comparison of the seven tree species present on both Ngamba and Nsadzi Island

Figures 6.60 – 6.66 summarize the mean percentage canopy cover of the seven tree species, namely *Dictyandra arborescens*, *Eugenia capensis*, *Ouratea hiernii*, *Oxyanthus speciosus*, *Peddiea fischeri*, *Tetrorchidium didymostemon and Trichilia species 1*, present on both, Ngamba and Nsadzi Island (Table 6.14). Of those seven species only *Oxyanthus speciosus* and *Trichilia species 1* show a similar pattern in their mean percentage canopy cover at different height levels (see Chapter 6 – Mean percentage canopy cover of selected plant species) with it still being considerably higher for both species and at all height levels on Ngamba Island (Figure 6.63 & 6.66).

Because of these varying patterns in mean percentage canopy cover a direct comparison of the seven tree species on both islands over time will be inconclusive. It will be worthwhile, though, to compare trends in the development of the canopy cover of the single species. It is predicted that the mean canopy cover of the individual species on Nsadzi Island will increase over time, while that of the same species on Ngamba Island will decrease.

Recommendation: As part of the regular vegetation monitoring special emphasis should be put on the evaluation of the development of the mean canopy cover of the seven plant species present on both, Ngamba and Nsadzi Island. If an opposite trend in the mean percentage canopy cover on both islands can be detected, as predicted above, the destructive impact of the chimpanzees on the woody vegetation of Ngamba Island will be directly demonstrated.

Food plant species

There are only three Ngamba Island chimpanzees' food plant species present on both, Ngamba and Nsadzi Island, namely *Dictyandra arborescens*, *Oxyanthus speciosus var. stenocarpus* and *Tetrorchidium didymostemon* (see Chapter 6 – Woody vegetation on Nsadzi Island, Table 6.14). Being part of the seven species present on both islands they will be especially monitored as outlined already above.

The mean total projected canopy cover of Ngamba Island chimpanzees' food plant species is presented in Figure 6.67. It is predicted that this canopy cover will decrease over time in all 11 species shown through the destructive feeding techniques applied by the chimpanzees (see Chapter 4 – Chimpanzee feeding behaviour). Since the chimpanzees and their destructive impact are confined to a limited fenced-off area the trees may have no chance to recover. Especially, as long as the tree is fruiting, each individual tree will be regularly exposed to visiting chimpanzees. The animals have no other chance but to return over and over again to the same fruiting trees in their limited forest refuge.

Recommendation: Regular monitoring of the mean percentage canopy cover of these species, especially in comparison with the three chimpanzees' food plant species also present on Nsadzi Island, will allow this prediction to be tested, and to assess the degree of destruction caused by the Ngamba Island chimpanzees on the canopy cover of those selected species.

EVALUATION OF "DEAD TREE" ABUNDANCE ON NGAMBA ISLAND

When applying Skorupa & Kasenene's (1984) 1.3% to 1.4% annual rate of natural tree fall for mature tropical forests (see Chapter 4 – Logging and natural tree mortality) the mean percentage of 0.84% of "Fallen dead" trees for Ngamba Island (Figure 6.41) falls well below this threshold. The mean percentage of 0.71% of "Fallen dead" trees on Nsadzi Island (Figure 6.75) hence also falls below this threshold. The mean percentage fallen trees determined for both islands is (incorrectly) assumed here to be an *annual* tree fall rate. The real value of the latter will therefore be even lower for both islands. It can therefore be concluded that the mean annual natural tree fall rate for Ngamba and Nsadzi Island falls well below the mean rate determined by Skorupa & Kasenene (1984). There need therefore not be any concern for the long term survival of the secondary rain forest cover on either of the islands when considering the natural tree fall rate alone.

There are two sample plots on Ngamba Island (plot 4 & 8) with a significantly higher density of "Fallen dead" trees. The highest percentage occurs in plot 8 and with 2.59% exceeds the annual natural tree fall rate by more than one percent. The second highest percentage occurs in plot 4 with 1.97% and hence lies about 0.5% above the annual natural tree fall rate. In both plots the 10 – 15 cm stem diameter class contributes between two to three times the number of trees compared to any other stem diameter class (Table 6.8). It therefore seems evident that it is the youngest group of trees which mainly falls victim to influences preventing them from maturing. The main cause of uprooting trees might be wind as postulated by Skorupa and Kasenene (1984). Plot 8 is the southernmost of the sample plots (Table 6.1 & Figure 6.1). Furthermore, with 8 386 plants per hectare it has the fourth lowest density of woody vegetation of all eight sample plots (Figure 6.3). It has also though more than 150% of canopy cover in the 3.0 m height level and above (Figure 6.56), which would indicate a canopy cover sufficiently closed to act as an efficient wind brake (Fons 1940). Considering though the moderate slope of the plot combined with the rather open stand of trees the canopy does not form a closed and uniform cover and is hence not efficient enough to brake the incoming partly high winds sufficiently (Fons 1940) to prevent them from damaging weak and young, feeble trees. Plot 4 on the other hand is the plot with the highest elevation (Table 6.1). With 9 150 plants per hectare (Figure 6.3) it has a similarly low density of woody vegetation as plot 8 and is dominated by a canopy cover in the 2.0 m height level (Figure 6.52). It furthermore has a marked northern slope (Table 6.1). Its woody vegetation will therefore be fairly unprotected (Fons 1940) from the heavy storms which occur about twice-yearly, coming from the north (Figure 3.16) and hitting this fairly high and unprotected plot situated north of the highest elevation on Ngamba Island (Table 6.1 & Figure 6.1).

A second influence causing tree mortality especially in young, slim trees might be the destruction through displaying chimpanzees (see Chapter 4 – Destructive behaviour + Feeding techniques & Figures 4.8 – 4.11). They might not necessarily uproot these trees but might bend them and shake them and even defoliate them when sitting, resting, playing and building nests in them (Figure 4.8). This might result in a rather high number of "Standing dead" trees present in a confined area inhabited by chimpanzees. The mean percentage of "Standing dead" trees is 0.24% for Ngamba Island (Figure 6.41) and 0.05% for Nsadzi Island (Figure 6.75). This difference between the two islands is marked and might be an indicator of a disturbance and destruction of the woody vegetation cover caused by the chimpanzee inhabitants of Ngamba Island. The trend of this development will in future have to be measured and compared between the sample plots of the two islands. It will then become possible to assess and furthermore predict the impact per chimpanzee and per year on defoliation followed by destruction of the woody vegetation cover of Ngamba Island. Three (plot 3, 7 + 8) of the eight plots on Ngamba Island show an above average percentage of "standing dead" trees: plot 8 shows with 1.16% the highest percentage followed by plot 7 (0.45%) and plot 3 (0.23%) (Figure 6.40).

The high percentage of standing dead trees in plot 8 might partly again simply be caused by the constant impact of southerly winds on the rather open stand of trees on a moderate slope defoliating and subsequently killing a number of standing trees (Fons 1940, Figure 3.12 – 3.16). It is assumed that the trees might be defoliated partly by the often moderate to strong southerly winds as well as partly also by adult chimpanzees who might use the exposed trees as lookouts and at the same time defoliate them as shown in Figure 4.12. Plot 7 and plot 8 have a very different woody vegetation structure (Figure 6.27 – 6.30). While plot 7 has a high abundance of trees in the three lower height classes (Figure 6.29) and a high percentage of "Standing dead" trees in the 10 – 15 cm stem diameter class mainly representing young trees (Table 6.9); plot 8 has the highest abundance of trees in the 2.0 m height class (Figure 6.30) while its high percentage of "Standing dead" trees is recruited only from the > 20 – 25 cm and the > 25 – 30 cm stem diameter classes mainly representing more mature trees (Table 6.9). Also the distribution of total projected canopy cover shows a concentration in the 0.50 m height level for plot 7 (Figure 6.55) and in the four highest height levels in plot 8 (Figure 6.56).

There seems to be no correlation between the distribution and abundance of Ngamba Island chimpanzees' food species (Table 6.4) and the percentage of "Standing dead" trees (Table 6.10) in the sample plots.

Recommendation: To assess whether there is an impact by the chimpanzees additionally to wind on the occurrence and hence percentage of "Standing dead" trees (on the sample plots) on Ngamba Island the following should be observed in the future:

1. Does the mean percentage of "Standing dead" trees increase over time?
2. Does the mean percentage of "Standing dead" trees increase in comparison with that on Nsadzi Island?
3. Does the percentage of "Standing dead" trees increase in the single sample plots?
4. Does the percentage of "Standing dead" trees change between sample plots?
5. Is the percentage of "Standing dead" trees in the different sample plots correlated with the movement patterns of the chimpanzees on the Island and with the "time-spent" by (certain) chimpanzees in different areas of the island?

THE ROLE OF WIND ON NGAMBA ISLAND

As outlined above and in Chapter 3 – Wind, the wind on Ngamba Island mainly originates from the south. Heavy storms however, mainly come from the north and occur about twice a year (Figure 3.12 – 3.16).

A major impact chimpanzees have on the woody vegetation cover of Ngamba Island is that they defoliate trees of all height classes (see Chapter 4 – Island chimpanzees, Destructive behaviour + Feeding techniques & Figure 4.8 & 4.12 – 4.16). An intact tree canopy is of major importance in reducing the impact of wind velocity and hence the destruction caused by wind in a forest habitat (Fons 1940).

With increasing defoliation the destructive effect especially of heavy storms on the woody vegetation cover of Ngamba Island is likely to increase. This will result in an increase of the number of "Fallen dead" trees over a period of time. It is therefore postulated that the number of "Fallen dead" trees will increase firstly in the northern part of the Island where the impact through heavy storms is greatest. This effect will though only become noticeable after a number of years. Monitoring the woody vegetation cover following the recommendations given above (see Evaluation of "Dead tree" abundance on Ngamba Island) will eventually allow this hypothesis to be tested (and hopefully substantiate it).

ASSESSMENT OF THE IMPACT OF NGAMBA ISLAND CHIMPANZEES ON THE VEGETATION COVER OF THEIR FOREST REFUGE

Using different approaches and calculations to estimate the necessary home ranges for chimpanzees in a confined habitat the results given in Table 7.6 vary considerably. These areas are calculated under the condition that the chimpanzees have to live self sustainable on the area available to them (see Chapter 4 – Island chimpanzees + Chimpanzee ranging pattern & Figure 4.6). For a confined habitat in a sanctuary or zoo, where food is often provided for chimpanzees, their required home range would be smaller (see Chapter 4 – Factors affecting food choice + Provisioning). Only regular monitoring of the vegetation cover of a confined habitat, like on Ngamba Island, will show, which of the calculated home ranges (Table 7.6) comes closest to the area required by chimpanzees under such circumstances. At present it is therefore postulated that the required home range for each chimpanzee lies in between the areas calculated using Jenkins' (pers. comm.)[1] and Ghiglieri's (1984) estimates (Table 7.6). Since there is an 11.2-fold difference between these estimates they can only be considered to be rather broad guidelines. They indicate nevertheless, that Ngamba Island with an area of 42.40 ha of secondary rain forest cover and 16 adult and 17 juvenile chimpanzees is already highly overstocked (Table 7.6 & Figure 4.6).

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[1] Jenkins, P. 2001. Pandrillus, Calabar, Nigeria.

Table 7.6: *Chimpanzee home ranges in a tropical rain forest habitat*

Home ranges for self sustainability required by chimpanzees in a confined tropical rain forest habitat / sanctuary [ha]					
Number of Chimpanzees[1]	**McNab (1963)[2] Food hunters**	**Milton & May (1976)[3] Primate hunters**	**Ghiglieri (1984)[4] Ngogo chimpanzees**	**Jenkins (2001)[5]** Boki Ogi Chimpanzees	**Destruction / year [ha]**
1	70	34	56	5	0.05
5	350	170	280	25	0.25
10	700	340	560	50	0.50
15	1 050	510	840	75	0.75
16	1 120	544	896	80	0.80
17	1 190	578	952	85	0.85
18	1 260	612	1 008	90	0.90
19	1 330	646	1 064	95	0.95
20	1 400	680	1 120	100	1.00
25	1 750	850	1 400	125	1.25
30	2 100	1 020	1 680	150	1.50
35	2 450	1 190	1 960	175	1.75

1. For the mean body mass of an individual chimpanzee 28.7 kg is used as estimated by Ghiglieri (1984).
2. McNab (1963) uses the equation: $R_h = 0.20$ M for Food hunters, with M = basal metabolic rate [Kcal/day.), Rh = Home range [acres].
3. Milton & May (1976) use the equation: Log HR_i = 0.83 Log BW – 2.17, with HR_i = size of home range [ha] of the individual, BW = body mass [g].
4. Ghiglieri (1984) calculates a mean home range of 30.5 km² for the 55 chimpanzees in Ngogo, Kibale Forest, Uganda, i.e. 0.56 km² / Chimpanzee.
5. Jenkins (*pers. comm. 2001*) estimates an area of at least 4 – 5 ha of tropical rain forest habitat per chimpanzee for self sustainability.

■ Cut-off limit for stocking density of chimpanzees on Ngamba Island.

Table 7.6 also gives an indication of the destruction caused by chimpanzees in a confined habitat depending on their density. When using Jenkins' (pers. comm.) description of the destruction of the secondary rain forest cover by chimpanzees kept in a confined habitat as a guideline a mean destruction of 0.05 ha (= 500 m^2) of rain forest cover per chimpanzee per year can be calculated (see Chapter 4 – Destructive behaviour). Applying this value Table 7.7 gives an overview of the future destruction of the secondary rain forest cover on Ngamba Island depending on chimpanzee stocking density.

Table 7.7: Destruction of the secondary rain forest cover on Ngamba Island depending on chimpanzee stocking density

Number of Chimpanzees	Time until destruction [Years]	Destruction per year [%]
1	844	0.12
5	169	0.59
10	84	1.19
15	56	1.78
16	53	1.90
17	50	2.01
18	47	2.13
19	44	2.25
20	42	2.37
25	34	2.96
30	28	3.55
35	24	4.15

Considering the maximum life span of a chimpanzee to be about 50 years it becomes obvious that only a stocking density ≤ 17 chimpanzees can, while not being sustainable, ensure a safe habitat for one generation of sanctuary chimpanzees while still resulting in the complete destruction of the secondary rain forest cover of the island. This would also mean that breeding by individual chimpanzees confined in any sanctuary should be controlled or prohibited completely, at least as soon as the maximum stocking density has been reached (see Chapter 2 – Origin of the Ngamba Island chimpanzees & Cox *et al.* 2000).

There will be a "cut-off" limit for stocking density where the destruction caused by a number of chimpanzees in a confined habitat can still be restored by natural forest regeneration and hence allow sustainable use of such a refuge. Using Jenkins' (pers. comm.) values this density lies between 5 to 10 chimpanzees for Ngamba Island (Table 7.6). When applying Ghiglieri's estimate it would be about 1 chimpanzee (Table 7.6).

Might this dark picture of the continuing and unavoidable destruction of the secondary rain forest cover of Ngamba Island perhaps be enlightened by the fact that chimpanzees also act as efficient seed dispersers (see Chapter 4 – Chimpanzees as seed dispersers)? Sadly, the answer here also seems to be "no". Following De Steven & Wright (2002) and Chapman & Chapman (1996) the number of mature trees that a parent tree produces per fruiting period might often be as little as ≤ 1. As stated by a number of authors the impressive number of seeds dispersed by each individual chimpanzee is put into perspective by the very low final recruitment rate (Janzen 1970, 1982, 1986, Augspurger 1984a+b, Janzen 1986, Estrada & Coates-Estrada 1986, Popma & Bongers 1988, Schupp 1988a, Chapman 1989, Wrangham *et al.* 1994a+b, Chapman & Chapman 1996, De Steven & Wright 2002). It is therefore also doubted that the presence of the chimpanzees on the island will increase the number of fig trees over time, even though they are an important food source for this species (see Chapter 4 – The importance of *Ficus* species & Chapter 6 – Distribution and density of *Ficus* spp.).

In consequence of the above it is postulated that the impact of the Ngamba Island chimpanzees as seed dispersers for selected woody vegetation species is of low importance if not negligible. It is by far outweighed by the destruction caused to the secondary rain forest cover of the island by this newly introduced species.

CONCLUSION

In summary, the impact the newly introduced species of chimpanzee will over time have on the secondary rain forest cover of their forest refuge on Ngamba Island is that of continuing destruction. Using a rate of destruction of about 0.05 ha per chimpanzee per year the secondary rain forest cover of Ngamba Island will be completely destroyed in 53 years with a stocking density of 16 adult chimpanzees, in 39 years with a stocking density of 22 adult chimpanzees and in 26 years with a stocking density of 33 adult chimpanzees. Regular and intensive monitoring of the vegetation cover will allow the evaluation and, if necessary, the adjustment of these values predicting the rate of destruction.

Overall, increasing stocking density - also through maturing of the juvenile chimpanzees currently present on the island into adulthood - will increase the rate of destruction of the woody vegetation cover of Ngamba Island proportionally.

CHAPTER 8

MANAGEMENT RECOMMENDATIONS

A number of management recommendations are proposed for Ngamba Island Chimpanzee Sanctuary. As outlined in detail below they can be divided into three broad categories, namely (1) chimpanzee management, (2) vegetation monitoring, and (3) climate monitoring.

CHIMPANZEE MANAGEMENT

The following seven major recommendations for the management of the chimpanzees on Ngamba Island are proposed (Table 8.1):

Abandon the track system inside the forest

The track system inside the forest should be reduced to a minimum or better, be abandoned completely (see Chapter 5 – Selecting sample plots for the woody vegetation survey). The woody vegetation cover is already rather small. A constantly maintained grid system of man-made tracks covering the island additionally opens up the vegetation. It hence facilitates access for the chimpanzees also into the denser areas of the rain forest cover (see Chapter 6 – Sample plots on Ngamba Island). Furthermore, the chimpanzees create their own track system which adds further to the destruction of woody vegetation. Letting the vegetation on the tracks recover will increase the density of and the area covered with woody vegetation inside the secondary rain forest cover (Table 8.1).

Restrict area of infant walks

The chimpanzee infants cause a considerable destruction of selected trees during their infant walks inside the forest area in the morning and the evening (see Chapter 2 – Previous research on flora and fauna of Ngamba Island, Chapter 3 – Data collection on Ngamba Island & Chapter 4 – Destructive behaviour). The tree in Figure 4.8 was a healthy young plant in May 2000. In November 2000, after only six months, it had been completely defoliated and destroyed by the playing infant chimpanzees during their forest walks. By reducing the area of the infant walks to the small open grassland area in the east of the island (Figure 6.1 & 3.34 - arrow) the destruction caused by these infants is also limited to a rather small area (Table 8.1).

Provide "Playground"

To further reduce the destructive impact of the infants, some playground-like structures should also be erected in this open grassland area. Those can also be used by the adult chimpanzees during their ventures inside the fenced off area (Figure 8.1 & 8.2). This will give them the chance to test their - mainly unintended - destructive strength also on other features besides healthy woody vegetation (Table 8.1).

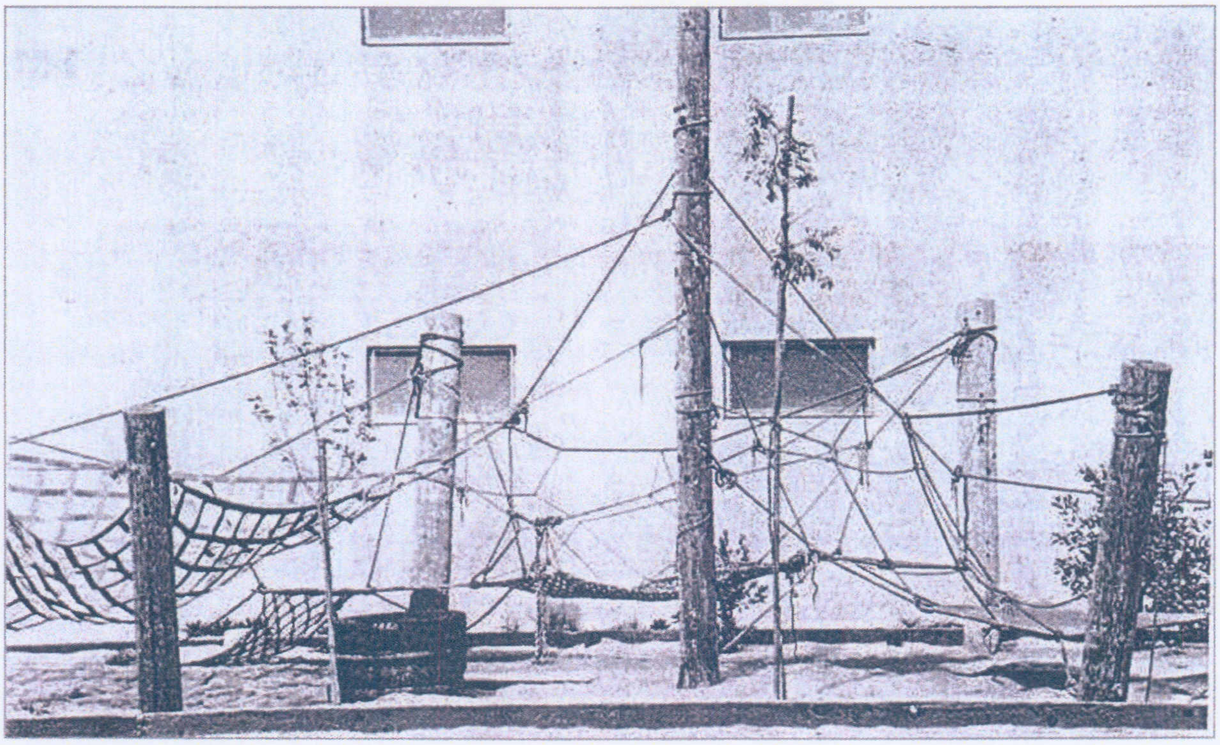

Figure 8.1: Example of a playground structure which could be erected on Ngamba Island (following Hewes 1975).

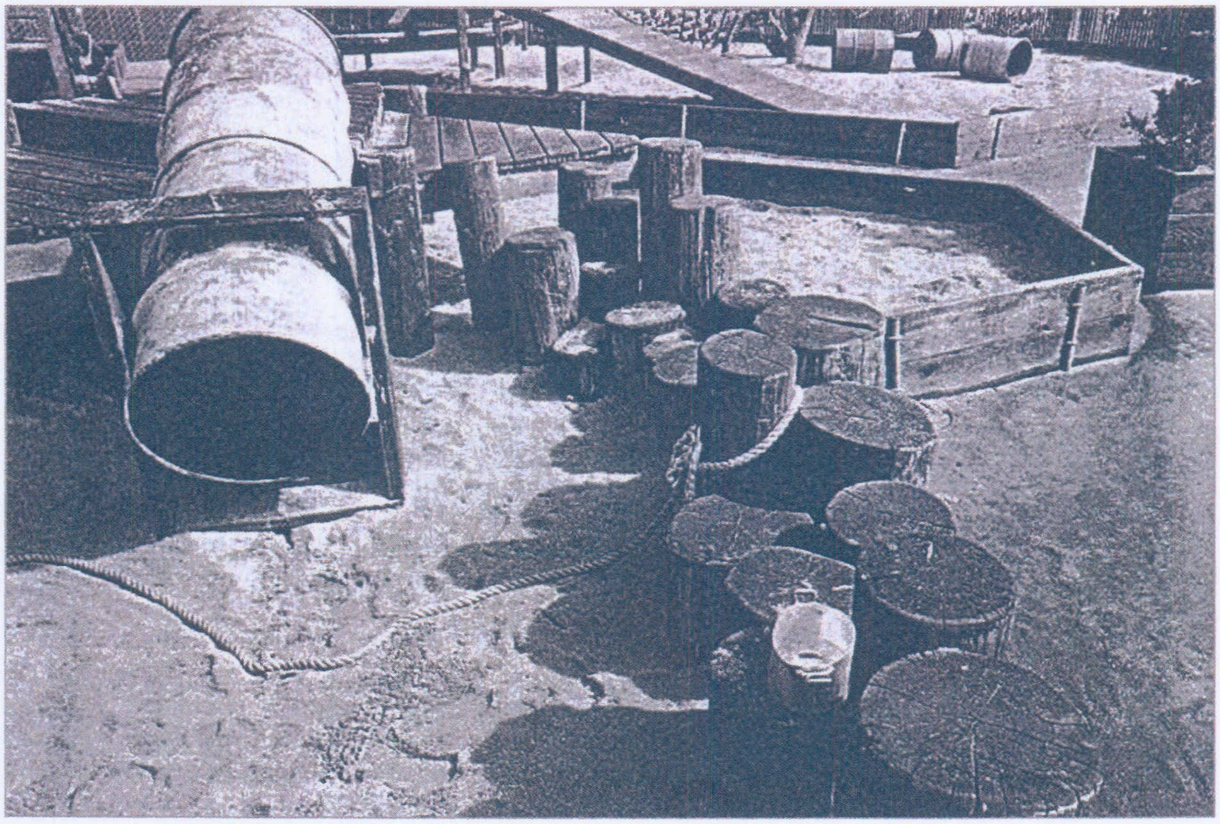

Figure 8.2: Example of a playground structure which could be erected on Ngamba Island (following Hewes 1975).

A separate playground area only for infant chimpanzees (Montgomery pers. comm.)[1] could be constructed outside the fenced-off area close to the landing area (Figure 2.2). This would allow reducing the number of infant walks and their destruction inside the forest (Table 8.1).

Provide toys

Toys like tyres, different sized boxes, sticks, etc., could be distributed throughout the Island (and also in the holding facility) to offer further entertainment and distraction from the use of the woody vegetation cover as toy and display material (Table 8.1).

Keep chimpanzees in enclosure during the night

To prevent destruction through the building of night nests (see Chapter 4 – Destructive behaviour + Chimpanzee nest-building behaviour) the chimpanzees should generally be kept inside the enclosure during the night (Table 8.1).

Provide hammocks in trees inside the forest

To reduce the number of day nests that are built (see Chapter 4 – Chimpanzee nest-building behaviour) by the Ngamba Island chimpanzees during their time spent in the forest hammocks like those used in the enclosure (Figure 8.3) could be provided in a number of trees inside the fenced-off area (Table 8.1).

[1] Montgomery, C. 2002. Jane Goodall Institute Uganda, Entebbe, Uganda.

Figure 8.3: Type of hammock provided for Ngamba Island chimpanzees inside the holding facility. The same type could also be provided in a number of trees inside the forest area.

Rotate chimpanzees between "used" and "empty" island

All management recommendations suggested above cannot sustainable and successfully reduce the destructive influence of the current number of chimpanzees on the secondary rain forest cover of Ngamba Island in the long run. They can only assist in reducing this impact and hence prolonging the time until complete destruction of the woody vegetation cover occurs.

It is therefore postulated that the only way how Ngamba Island can be sustainable managed as a chimpanzee sanctuary without finally destroying the vital habitat for the species at the same time is through the introduction of a rotation system. The chimpanzees have to be rotated between two or three islands (see Chapter 2 – Future plans) one of which is always kept void of chimpanzees at any given time.

This surely is a cost- and labour-intensive exercise and brings with it a number of risks also for the health and well being of the chimpanzees. The latter is mainly caused by the fact that at least all adult chimpanzees will have to be immobilized before they can be transported. Since all anaesthesia also always carry a fatal risk, though minimal, the possibility that an immobilized chimpanzee might not survive such anaesthesia always needs to be considered.

On the other hand the introduction of such a rotation system is the only chance to give the rain forest vegetation a chance to recover and hence to use Ngamba Island sustainable as a chimpanzee sanctuary. It furthermore gives the chance for thorough health checks of all individuals and to implant hormone contraceptives at regular intervals. Without chimpanzees on the island thorough vegetation monitoring can be performed as well in a short period of time.

The rotation should take place about every two to four years considering actual chimpanzee density and destruction caused per year (Table 7.7). Evaluation of the results of the intense vegetation monitoring will allow adjusting this interval if necessary (Table 8.1).

VEGETATION MONITORING

The management recommendations for the regular monitoring of the vegetation cover of Ngamba and Nsadzi Island have been outlined in detail in Chapter 7 – *Recommendations* (Table 8.1).

CLIMATE MONITORING

The following two major recommendations for the monitoring of climate on Ngamba Island are suggested:

Continue measuring daily temperature, relative humidity and precipitation

All necessary equipment for such measurements has been put in place on Ngamba Island (see Chapter 5 – Daily temperature, relative humidity and precipitation). Furthermore, respective data can be collected from the Meteorological Department based in Entebbe. It should be assured that at least monthly daily minimum and maximum values as well as the monthly mean for temperature and relative humidity can be obtained and compared to previously collected data. Precipitation should be measured several times daily at the same time of the day if appropriate (Table 8.1).

Determine wind direction and wind velocity

This information also has to be obtained from the Meteorological Department in Entebbe. It should be collected once per month and also compared to data previously collected.

Table 8.1: Management Recommendations for Ngamba Island Chimpanzee Sanctuary

Management recommendation	Time period	Comments
Chimpanzee Management		
Abandon the track system inside the forest.	Immediately & Constantly	Reduce the track system inside the forest to two parallel tracks from north to south and west to east, or better: abandon completely.
Restrict area of infant walks.	Immediately & Constantly	Use only the open grassland area and forest edge in the east of the island.
Provide "Playground".	Immediately & Constantly	Inside the fenced-off area in the open grassland area in the east of the island. Outside the fenced-off area in a confinement next to the landing area, to be used only by infant chimpanzees.
Provide toys.	Immediately & Constantly	Distribute tyres, different sized boxes, sticks, etc., throughout the forest, especially to give adult males a chance and tools to display without destroying the woody vegetation cover.
Keep chimpanzees in enclosure during the night.	Immediately & Constantly	To prevent further destruction through the building of night nests.
Provide hammocks in trees inside the forest.	Immediately & Constantly	To prevent chimpanzees from building day nests in trees.
Rotate chimpanzees between "used" and "empty" island.	Every two to four years (Adjust time span according to results of vegetation monitoring.)	Though tedious and expensive this is the only chance to give the vegetation a chance to recover and to use Ngamba Island sustainably as a chimpanzee sanctuary. It furthermore gives the chance for thorough health checks of all individuals and to implant hormone contraceptives. Without chimpanzees on the island thorough vegetation monitoring can be performed in a short period of time.

Table 8.1: Management Recommendations for Ngamba Island Chimpanzee Sanctuary (continued)

Management recommendation	Time period	Comments
Vegetation Monitoring		
Monitor woody vegetation on Ngamba and Nsadzi Island using the "Varying quadrat plot" method.	Every two years at the end of the long rainy season in June / July	Concentrate especially on dead tree density, plant species with a density ≥ 100 plants per hectare, the seven plant species present on both islands and Ngamba Island chimpanzees' food plant species (as outlined in Chapter 7 and 8).
Monitor forest edge.	Yearly at the end of the long rainy season	Take photographs and GPS readings of the forest edge and compare to previous data to evaluate if edge keeps retreating.
Climate Monitoring		
Continue measuring daily temperature, relative humidity and precipitation.	8:00 14:00 18:00	Compare regularly with historical data to detect possible climate changes.
Determine wind direction and wind velocity.	Daily	Collect data from Entebbe Meteorological Station.