OPERATION WALLACEA

STATE OF THE LAMBUSANGO FORESTS 2008

A report on the results of the monitoring programme carried out to assess the effectiveness of the Lambusango Forest Conservation Project that was implemented between 2005 and 2008

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Summary

This report assesses the effectiveness of the Lambusango Forest Conservation Programme (LFCP) in achieving its objectives its 6 main objectives and the 19 performance criteria that were used to quantify progress in these objectives. Table 0.1 summarises progress against each of the objectives and the performance criteria at the end of the LFCP programme in 2008.

The monitoring programmes implemented were sufficient to assess 15 (79%) of the 19 performance criteria. Assessing changes in herpetofauna and bat communities and population levels of tarsiers proved to be unrealistic without substantial additional survey effort than could be achieved during the annual Operation Wallacea survey programmes. In addition it was not possible to recruit the academic input needed to assess the impacts of forest disturbance on fish and stream macro-invertebrate communities.

Of the 15 criteria for which there were sufficient data to assess against the performance criteria 14 (93%) met the targets. Indeed in terms of income generation from forest related activities (objective 1), levels of awareness about the forest and its rules and regulations (objective 2) and reduction in levels of illegal logging (objective 3), the targets were significantly exceeded. One of the most significant findings is that despite 2% of the forests in southern Buton being clear felled in the decade prior to the start of the LFCP, since the start of the Project there has been zero net clearances of the Lambusango forests.

The objective of maintaining biodiversity in the forests appears to have been achieved judging from the bird and butterfly data. There was concern though that overall numbers of birds in both disturbed and undisturbed sections of forest have declined. Maintaining population levels of key species such as macaques and Sulawesi Wild Pig appears to have been achieved although even the existing reduced levels of anoa hunting, will still lead to extinction of this species unless further actions are taken.

These results would indicate that the LFCP has generally succeeded in achieving its objectives. Operation Wallacea are committed to continue annual monitoring of the Lambusango forests to assess how the forests change post the LFCP programme.

Table 0.1 Performance against each of the LFCP objectives and performance criteria

Objective		**Target**	**Assessed**	**Status**	**Objective status**
1. Maximizing income from sustainable forest use.	1.1	5% increase in income from legal forest-based activities.	Y	Met	MET
	1.2	5% increase in people receiving annual income from legal forest-based activities.	Y	Met	
2. Increasing community awareness and involvement in forest.	2.1	90% awareness of forest and associated rules and regulations.	Y	Met	MET
	2.2	60% knowledge of LFMA amongst residents of Buton.	Y	Met	
	2.3	Labundo Forest Centre used as a resource by local schools and universities.	Y	Met	
3. Reducing non-compliance with LFMA regulations.	3.1	10% annual decrease in observed infringements of rules of forest.	Y	Met	MET
4. Maintaining forest structure and coverage in protection forests.	4.1	No decline in forest cover.	Y	Met	MET
	4.2	No anthropogenic change in forest structure.	Y	Met	
	4.3	Ensure sustainable rattan extraction.	Y	Met	
5. Maintaining biodiversity value of the forests.	5.1	No decline in diversity of birds of undisturbed forest.	Y	Met	MET
	5.2	No decline diversity reptiles of undisturbed forest.	N	-	
	5.3	No decline in diversity of insectivorous bats of undisturbed forest.	N	-	
	5.4	No decline in diversity of butterflies of undisturbed forest.	Y	Met	
	5.5	No evidence of pollution or deforestation impacts on freshwater fish and macro-invertebrates,	N	-	
	5.6	Assessing the sensitivity of the chosen indicators in detecting the impacts of anthropogenic change	Y	Met	
6. Maintaining populations of flagship species.	6.1	No decline in Buton Macaque population.	Y	Met	PARTIALLY MET
	6.2	No decline in Tarsier population.	N	-	
	6.3	No decline in Anoa population	Y	Not Met	
	6.4	No decline Sulawesi wild pig population.	Y	Met	

Introduction

The GEF Brief document for the Lambusango Forest Conservation Project contains a number of biodiversity and socio-economic objectives to be achieved by the GEF/World Bank funded management programme. These objectives were then turned into a series of quantified performance criteria against which progress could be monitored by establishment of a biodiversity and socio-economic monitoring programme. Note the late start of the GEF/World Bank funded project meant that all the 2007 target dates in the original GEF Brief have been altered to read as 2008. This monitoring programme was partly funded from the GEF/World Bank funded management project and partly by Operation Wallacea. The various participating scientists have compiled individual reports, but this report brings together the various lines of evidence to review progress against each of the performance criteria. A similar report was prepared in 2006 mid way through the GEF Lambusango project whilst this report reviews the data at the end of the GEF/World Bank project in 2008. Operation Wallacea is continuing to work on the Lambusango forests for the foreseeable future and it is proposed that Annual Reports will continue to be prepared in this format.

1. Management Objective 1

To maximize income to the local communities around the edge of the Lambusango Forest Management Area from sustainable uses of the forest.

Performance criteria for management objective

1.1 Total income received from legal forest-based activities (eg. tourism, rattan collection, exploitation of the production forests) in the Lambusango Forest Management Area is increased by 5% above inflation over the period to 2008.

The objective of this performance criterion was to assess how effectively the Project managed to increase income from the forest or from forest related alternative income streams. The original Brief had planned to develop exploitation rights of the production forests for the various communities but this was abandoned soon after the start of the project in favour of developing businesses in the local communities tied to contracts that committed the whole communities to no hunting, logging or encroachment of farmland into the forest. As a result of this change the performance criteria for 1.1 should really read forest-related rather than forest-based activities. Forest related income should include income earned legally and directly from the forest (eg rattan, timber) and that earned from activities which rely on forest conservation (ecotourism, village based contracts) The increment of total income received from legal forest based activities, except for tourism activity in Labundo-Bundo Village is not therefore relevant

Data collection during July 2005, July 2006 and July 2007 was conducted by Dr Ruth Malleson, whilst at the end of 2007 and end of 2008 were carried out by *Yamin* (see *Table 1.1*). In 2005 and 2006, data were collected from the following villages: (a) Harapan Jaya; (b) Lawele; (c) Watambo and (d) Kabungka. Village business development (Ginger farming) in Harapan Jaya and Lawele Villages were unsuccessful, and the Project decided to move the business facilitation sites to other villages such as Lasembangi (orange farming), Barangka (cashew processing) and Sumbersari (ginger marketing). To respond to this, during July 2007, data were collected from Watambo and Kabungka where there was no business development and in Barangka, Lasembangi and Sumbersari where business development had been undertaken.

From mid 2007 onwards, the Project further developed new types of business on other potential villages such as: (a) Wakaokili (coffee marketing), (b) Wagari (seaweed farming) and (c) Matanauwe (cashew marketing). An independent socio economic assessor (*Yamin*) was contracted to collect data using the same questioners and methodology as developed by Malleson at the end of 2007 and repeated again at the end of 2008 on Watambo and Kabungka (no business development) and Barangka, Lasembangi, Sumbersari, Matanauwe, Wagari and Wakaokili where the business development projects had been undertaken.

In each village the surveys started with participatory household mapping to provide a map locating: individual houses and the households within them; key social and geographical features. The respondents were grouped into: (a) Participating households: those who involved in LFCP (Lambusango Forest Community Project) village business contract activities in the study villages; (b) Non-participating households: those who were not involved in LFCP village business contract activities in the study villages. All participating households were purposively interviewed, while non-participating households were randomly interviewed. About 20-50 households were interviewed in all study villages, around 50% were Participating Households, whilst the rest were Non-Participating Households.

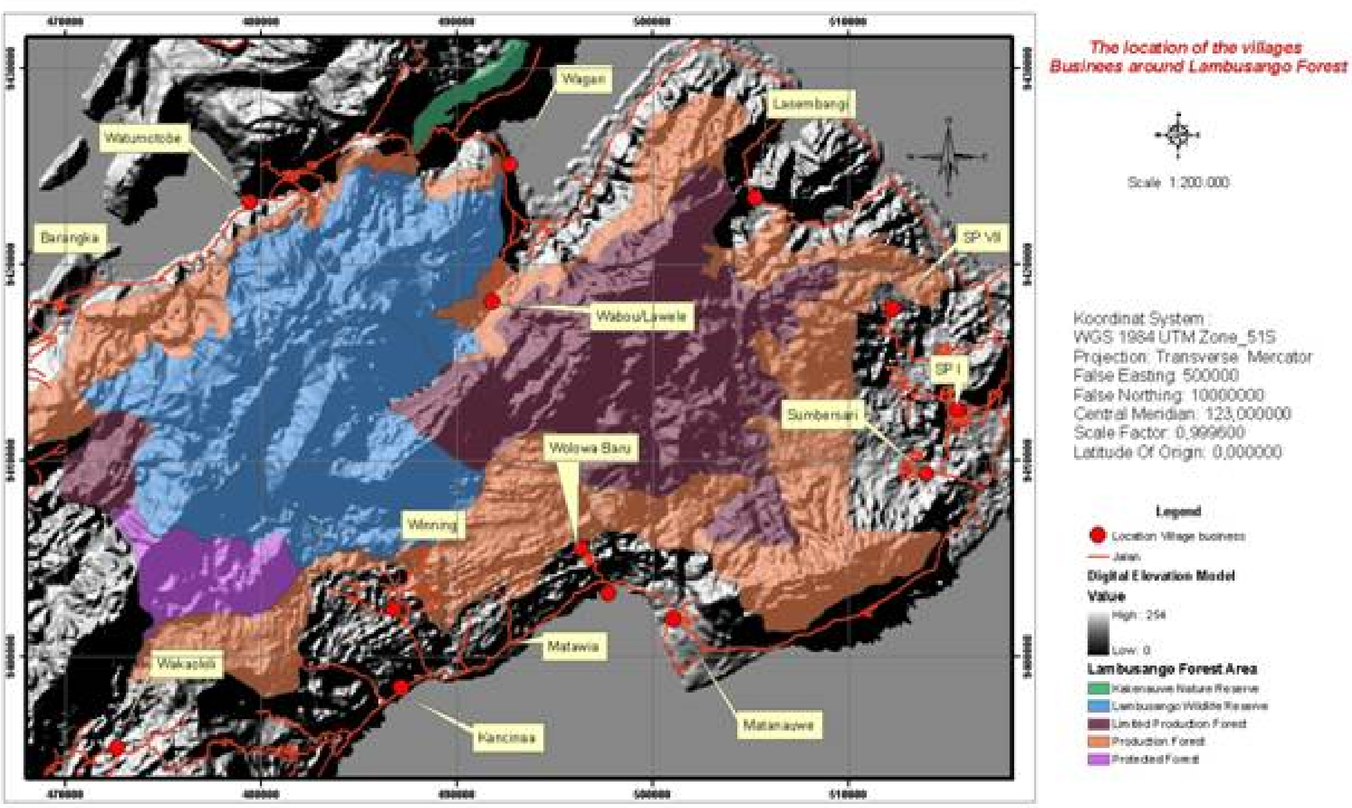

Figure 1.1 Location of the village businesses around Lambusango Forest

Table1.1 Sample sizes on household income surveys

Village Name	2005	2006	2007		2008		Total
			Participating	Non Participating	Participating	Non Participating	
Watambo	30	31	10	20	10	19	120
Kabongka	63	45	11	24	10	24	177
Lawele	63	57	0	0	0	0	120
Harapan Jaya	41	38	-	-	-	-	79
Barangka	-	-	20	25	22	24	91
Lasembangi	-	-	11	25	12	24	72
Sumbersari	-	-	11	25	16	25	77
Matanauwe	-	-	15	16	15	16	62
Wakaokili	-	-	7	6	7	6	26
Wagari	-	-	12	12	12	12	48
Total	197	171	97	153	104	150	872

LFCP facilitated business development in 14 villages (See *Figure 1.1*). In order to judge the effectiveness of these initiatives and since the 2005 and 2006 surveys omitted most of the villages where business development was targeted by LFCP, their impact on raising incomes was assessed by comparing the data between 2007 and 2008 where the surveys did include both villages targeted and those not targeted. The average inflation rate between 2007 and 2008 was 7%, so to achieve the criterion of a 5% increase above inflation the growth in income in those communities must be at least 12%. *Table 1.2* shows the percentage increase in mean income in all of the villages was above inflation with only (Wakaokili) not achieving the additional 5% income needed to achieve the target. This is because the coffee marketing business exercise had only just started June 2007 and had not had time to take effect. On average the two villages were there had been no business development had an average increase in 33% in the incomes over the study period, half that experienced by those villages where investment in businesses had been made by LFCP. Following the introduction of seaweed farming by LFCP in Wagari this activity has now has been replicated by other local communities and now covers large areas in the eastern coast (Matanauwe, Wolowa Baru and Matawia Villages) and has become a strong trigger on income generation beyond project villages' facilitation areas. Clearly the percentage of income increment resulting from the LFCP intervention is much bigger than as illustrated in *Table 1.2*.

Conclusions

Criterion 1.1 has been achieved for those villages where there has been investment based around agreed village conservation contracts but is data deficient for those villages where there was no direct business based intervention. For future surveys the wording needs to be altered to read forest – related activities rather than forest-based activities since it needs to include the financial benefit obtained from businesses in communities where conservation contracts have been agreed.

Table 1.2. Mean of Household Income in 2007 and 2008 (in thousands rupiah)

Village	**Year**		**Increment (%)**	**% of increment above inflation rate**
	2007*	**2008+**		
1. Kabongka	5.900	7.000	19	12
2. Watambo	12.800	19.000	48	42
3. Labundo-bundo	19.000	28,000	16	13
4. Barangka	8.500	12.000	41	34
5. Lasembangi	8.500	16.000	88	81
6. Sumbersari	14.000	19.000	36	29
7. Wagari	8.000	21.000	163	156
8. Wakaokili	22.000	25.000	14	7
9. Matanauwe	9.000	12.000	33	26

1.2 Total number of people receiving their annual income from legal forest-based activities (eg. tourism, rattan collection, exploitation of the production forests) is increased by 5% over the period to 2008.

This criterion should also be altered to forest-related income as for 1.1 and the same arguments as for 1.1 that income from businesses in communities that have agreed contracts to conserve the forest should be included in these calculations. The socio-economic survey surveyed households rather than individuals. However, since the average income of households was raised above the target 5% level over inflation for the period 2007 to 2008 then the numbers of individuals benefiting should also have increased by in excess of 5%. This is particularly true since before LFCP none of the individuals in the 14 villages targeted by the project would have had incomes related to forest protection.

Conclusions
Criterion 1.2 has been achieved although the wording needs to be altered to read forest – related activities rather than forest-based activities since it needs to include the financial benefit obtained from businesses in communities where conservation contracts have been agreed.

2. Management Objective 2

To ensure that communities on Buton Island are aware of the importance and uniqueness of the Lambusango Forest Management Area and that facilities are developed and used so that the forests can be used as an educational resource for schools and Universities in SE Sulawesi.

Benchmark performance criteria for monitoring management objective 2

2.1 Knowledge in communities around the edge of the Lambusango Forest Management Area about the rules and regulations applied and the unique flora and fauna of the forests shows an increase to 90% awareness over the period to 2008.

Environmental awareness surveys were carried out at the same time and in the same villages as the economic surveys. In each village the respondents were selected randomly and table 2.1 shows the sample size in each village. Table 2.2 shows that over the LFCP implementation period there was an increasing level of knowledge in the communities around the forest on rules and regulation in forest resources conservation. In 2006, most of respondents (76%) were not aware on such rules and regulation. This sharply changed in 2007 where large proportion of respondents (80%) became aware. The last survey in 2008 was further demonstrated the success of the project in increasing the levels of awareness to the target level. The most effective awareness started in 2007, after the project installed permanent display boards at several strategic sites surrounding the forest showing protected species and sanctions for illegal loggers and forest area encroachment.

Table 2.1. Sample sizes for the Environmental Surveys

Village Name	Year				Total
	2005	2006	2007	2008	
Harapan Jaya	21	49	0	0	70
Kabongka	26	40	24	24	114
Lawele	40	37	0	0	77
Watambo	24	30	25	25	104
Nambo	0	9	0	0	9
Sumbersari	0	0	24	24	48
Lasembangi	0	0	24	24	48
Barangka	0	0	24	24	48
Labundo Bundo	21	0	0	0	21
Wagari	0	0	24	25	49
Wakaokili	0	0	24	25	49
Matanauwe	0	0	24	25	49
Total	132	165	193	196	686

Table 2.2. Change in knowledge relating to forest rules and regulation, all settlements 2006-2008.

Year		Has degree of knowledge change over last year?	
		No	Yes, increased
2006*	n= 161	115	46
	%	71%	29%
2007*	n=120	24	96
	%	20%	80%
2008+	n=194	16	178
	%	9%	91%

Conclusions
This criterion has been achieved and the target exceeded.

2.2 Level of knowledge amongst the general population of Buton Island about the existence of the Lambusango Forest Management Area and the main faunal species it is protecting shows an increase to 60% over the period to 2008.

This criterion was designed to assess wider awareness of the existence of the Lambusango forest and was assessed by completing surveys in Bau Bau and Pasawajo the main towns on Buton Island in 2005 and again in 2008. Table 2.3 shows that the criterion was met and exceeded over the course of the project period. The initial method of socialising the project was by distributing a poster entitled: *'Lambusango Forest: Lung of the World in the heart of Buton Island'*. This poster was distributed to virtually all government offices, schools, restaurants etc. Another poster was produced in 2007 entitled *'Lambusango Forest is home of million life'*, which shows the main faunal species in the forest. Both posters seemed to be very important to raise the knowledge of local community on the LFMA and main protected faunal species in the Lambusango Forest.

Table 2.3. Knowledge on the existence of Lambusango in all settlements

Year	N	No	Yes
2005*	45	67%	33%
2008	93	33%	67%

Conclusions
This criterion has been achieved and the target substantially exceeded

2.3 The Labundo Forest Centre and the Wanda Wolio field centre are used as a resource by most schools in Buton and university students from Kendari and Bau Bau at some point over the period to 2008

A local NGO, Lawana Ecotone has been established to manage educational, research and tourism visits to Lambusango forest. This team now manage the delivery of the Operation Wallacea annual research programme in the Lambusango forests each year. Indeed so skilled have this group become in training in jungle survival and leading wildlife surveys that some of their staff have been used by Operation Wallacea in setting up biodiversity surveys in other countries. In the early drafts of the original LFCP Brief it was the intention to include upgrading the derelict Wanda Wolio house into a field centre. In later drafts this proposal was dropped because of budget restrictions so it was decided to concentrate efforts on the Forestry facilities in Labundo. LFCP completed 8 week training courses for 32 students from Bau Bau, Kendari, Makassar and other Indonesian universities in biodiversity monitoring techniques, so the requirement that most universities utilise the facilities at some point over the implementation period has been met. However, school visits proved not to be possible because of the costs of bringing the groups to the field. Instead efforts were concentrated on developing materials for schools (books, posters etc) and LFCP staff distributing the materials to each of the schools on Buton.

Conclusions
The intention of this criterion was achieved by organising visits by university students from all regional universities and by distributing educational material about the forests to each of the schools on Buton.

3. Management Objective 3

To ensure that the levels of non-compliance with the Lambusango Forest Management Area regulations decreases over the period to 2008.

Benchmark performance criteria for management objective 3

3.1 The level of infringements of rules and regulations observed per unit of patrolling effort by Forest Guardian teams decreases by 10% per year from 2005 over the period to 2008.

This criterion was assessed from monitoring data gathered by the Sub-District Community Forestry Management Forum (CFMF) Coordinator on a monthly basis from June 2006-November 2008. The data were gathered by interviewing at least ten key villagers from every village, which borders the Lambusango Forest. Based on these interviews, when illegal forest extraction activities are found, ground-truthing was then conducted and the following collected on each incident: (a) Description on the activities; (b) Aim of extraction: for subsistence or commercial use; (c) Investigate the field perpetrators and financiers; (d) Dates of when the activities happened; (e) Number of people involved; (f) the origin of field perpetrators (within or outside village under investigation); (g) the exact hotspot site; (h) Types and quantity of equipment (e.g. chainsaw); (i) the vehicles (if any).

Table 3.1 shows the estimated number of illegal loggers based in each of the villages bordering Lambusango from these monthly interviews. Over the 3 year period from 2006 to 2008 there was a 66% reduction in the number of illegal loggers, substantially exceeding the criterion target.

Table 3.1. Decreasing Numbers of illegal loggers from 2006 - 2008

Village	2006	2007	2008
Lambusango Village	3	3	3
Harapan Jaya	3	3	3
Kamelanta	5	3	3
Lasembangi	17	15	3
Sio Manuru	3	3	4
Siotapina (SP 2B)	3	3	3
Wajah Jaya	4	4	4
Wakangka	5	3	1
Waondowolio	24	20	21
Wowoncusu (Lambusango Village)	3	3	3
Wining	12	10	5
Waleona	3	3	4
Wagari	12	13	2
Lawele	10	9	5
Kaumbu	3	3	3
Wolowa Baru	3	3	3
Matawia	15	11	8
Wolowa	4	4	2
Matanawe	6	5	3
Total	138	121	83

Conclusions
This criterion has been achieved and the rates of reduction in illegal logging have substantially exceeded the target levels

Management Objective 4

To ensure the effectiveness of the proposed management plans for Lambusango and Kakenauwe in maintaining forest structure and coverage.

Benchmark performance criteria for management objective 4

4.1 To ensure forest coverage of the LFMA does not decline by 2008

Landcover change was assessed using a combined maximum likelihood classification and NDVI-differencing approach with Landsat Thematic Mapper imagery (30m resolution) from 1991, 2004, 2006 and 2008. Most images contained some cloud cover, and those used for analysis were carefully selected to ensure that the focal areas for assessing forest change in the LFMA were largely cloud free. There was no substantially cloud-free imagery for 2008 so two images were combined. Nevertheless, there remained extensive cloud cover (28% of area) obscuring a substantial part of the LFMA. This affects the strength of conclusions that can be drawn from the results as cloud is frequently mis-classified as forest loss. Classification accuracy for the four time periods was between 88 and 96%. Full details of analysis and an in-depth discussion of the results are given in Carlisle (2009)

Rates of forest change were analysed separately for the four categories of forest protection: Conservation forest (C); Limited Production forest (LP); Production forest (P); Non-forest (i.e. under no regulation). Forested area declined in limited production, production and non-forest and remained stable in conservation forest from 1991 to 2006 (Fig.4.1). The rate of forest loss was slower in Limited Production Forest than the other categories where loss occurred. Between 2006 and 2008 the rate of forest loss increased in Conservation and Limited Production forest, stayed steady in Production Forest and was reversed in the non-forest zone. It is difficult to separate true forest losses from mis-classification of cloud covered land in the forest zones; forested zones were disproportionately affected by cloud cover compared to non-forest zone (30-40% cloud cover versus <20% cloud cover respectively). The increase in the non-forest zones' forested area may be due to development of tree-based farming being mis-classified as regenerating forest.

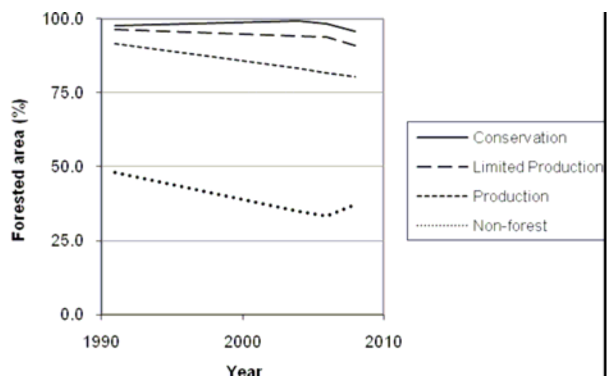

Figure 4.1. The changing proportion of forest for each Forest Management Zone

Rates of forest change were related to the forest protection status: least change occurred in the conservation forest, followed by limited production and production forest. Within the bounds of likely misclassification errors, there was no substantial change in forest between the early LFCP and late LFCP periods; although forest loss has occurred, regeneration has also occurred at a similar rate.

	No Change			Loss			Regeneration		
	C	LP	P	C	LP	P	C	LP	P
1991-2004	97.1	92.7	80.7	0.5	3.7	10.8	2.1	1.4	2.6
2004-2006	97.7	92.1	78.8	1.3	1.6	3.8	0.4	1.6	3.1
2006-2008	94.4	89.3	77.4	3.2	3.9	3.5	1.4	1.6	3.0

Table 4.1 The changes in percentage of forest in Conservation Forest (C), Limited Production Forest (LP) and Production Forest (P).

In order to better investigate the possibility that forest loss had occurred, eleven 'Hotspots' of forest change in and around conservation forest, where there had been significant variation in NDVI between imagery, were identified (Fig.4.2)

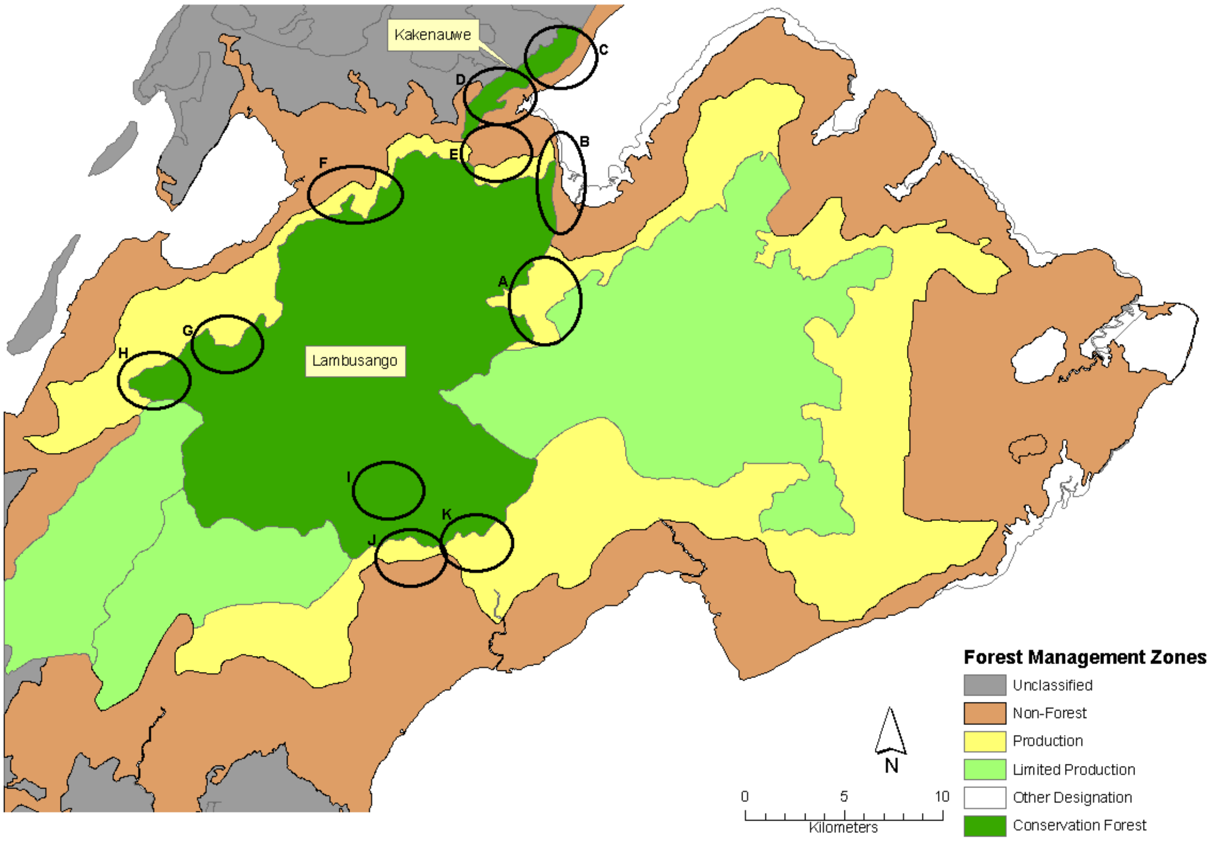

Figure 4.2 Forest management zones and forest change hotspots.

For most of the periods studied, hotpots were not affected by cloud cover, however conservation forest was obscured for 3 of the 11 hotspots (G, I, K) in the 2006 to 2008 period. Considering the changes in the previous time periods, it seems likely that two of these hotspots (G, K) have not experienced negative impacts during 2006 to 2008. Hotspot I has been classed as having negative impacts for all time periods, although this may not be due to human activities, the fact that it is in the heart of the Lambusango conservation forest means it ought to be investigated in detail. In general, there is an increase in forest regeneration and a decline in evidence of negative impacts through the LFCP period.

Table 4.2. Summary of Hotspot changes in Conservation Forest.

Hotspot	Pre-91	91-04	04-06	06-08
A	—	—	▼	▲
B	▼	▲	—	—
C	—	▼	▼	▼
D	▼	▼	▼	▲
E	—	—	—	—
F	—	—	—	—
G	—	▼	▲	? ▲
H	▼	—	—	—
I	▼	▼	▼	?
J	—	—	—	—
K	—	▼	▲	? ▲

Red cells indicate occurrence of forest loss or degradation, or persistence of degraded or cleared land. Green cells indicate an absence of such negative impacts.
▼ indicates forest loss or degradation.
▲ indicates forest regeneration.
— indicates no change.
? indicates cloud cover.

The only evidence of forest clearance in the Conservation forest during 2006 to 2008 is in Kakenauwe at Hotspot C. Forest regeneration is evident in a single Conservation forest hotspot (B) between 1991 and 2004, but at 2 (G, K) then 4 (A, D, G, K) in 2004-2006 and 2006-2008 respectively. In comparison, the number of hotspots with clearance of non-Conservation forest is 9, 9, 6 and 5 for pre-1991, 1991-2004, 2004-2006 and 2006-2008 respectively. These results give encouraging evidence that there has been a reduction in negative impacts in the first 2 years of the LFCP, followed by further improvement in 2006-2008. This improvement contrasts with the changes happening outside the Conservation Forest.

Four hotspots show trends that require further field investigation and perhaps enforcement effort from the authorities:

- C – cleared forest within Kakenauwe
- D – forest degradation within Kakenauwe
- H – cleared forest within Lambusango
- I – degraded or cleared forest within Lambusango

Landsat data has recently been made freely available. Continued monitoring of forests in the LFMA based on remotely sensed data and using the protocols established during the work presented here will leave a lasting legacy for regional forest management authorities.

Conclusions
Taking into account the uncertainty associated with poor quality imagery from 2008, the weight of evidence suggests that there has been no substantial change in forest cover over the LFCP period. Deforestation over the LFCP period has been wholly or in part matched by forest regeneration. Detailed analysis of hotspots of forest change indicate that forest loss has decreased and regeneration increased in the LFMA during the LFCP period. Some areas of concern remain; the work done has allowed these to be identified. This criterion has therefore been achieved.

4.2 To ensure that the structure of the forest in the conservation and limited production forests shows no significant anthropogenic impacts over the period to 2008.

Anthropogenic impacts include a wide range of activities: clear felling to use the land for agricultural purposes, selective logging and rattan collection, hunting and disturbance by the presence of humans.

Clear felling
Clear felling of patches of forest is covered in section 4.1 above and there was no evidence of a net loss of forest in the LFMA to agricultural usage.

Selective logging
Classification of satellite imagery could not reliably distinguish between selectively logged and unlogged areas, though decreases in NDVI between images suggest a loss of forest density and highlight areas for field investigation. Such areas are limited to hotspots D and I identified in section 4.1.

Anoa hunting
Hunting of anoa is a key concern of the Lambusango forest management project. No further data are available since the findings of the interim report in 2007. This extensive survey dealt with 173 respondents from 43 villages, questioning them on anoa meat consumption over the 20 years from 1986 to 2006. Among them, 70 (41%) reported eating anoa in at least one year while the rest (59%) claimed never to have eaten anoa. 60% of people who had eaten anoa (20% of respondents) paid for the meat while 21% said they had hunted it. 11 hunters from various villages were reported to be active in the period 2004 to 2006. The survey also recorded a minimum of 24 anoa hunted during this 3 year period: two in 2004, 14 in 2005 and 8 in 2006. It is possible that the small number recorded from 2004 and higher number from 2005 are simply due to inaccurate memory of respondents and can not reliably be taken to indicate a change in hunting effort. The average annual take (8 individuals) might be regarded as representative of hunting effort. The highest hunting level occurred in the Lawele area with six anoa killed in 2005 and four in 2006. (Table 4.3).

Table 4.3. The minimum number of anoa reported hunted in Lambusango from 2004 to 2006.

Adjacent forest study sites	2004	2005	2006	Total
Lapago	1	0	1	2
Lasolo	1	5	2	8
Lawele	0	6	4	10
Wahalaka	0	2	0	2
Wabalamba	0	1	1	2
Total	2	14	8	24

Fewer anoa were reported killed in 2006 than in 2005 at all but one site. A VORTEX population simulation incorporating information on hunting, abundance and distribution from data collected in Lambusango demonstrated that reducing or stopping hunting in the Lawele area alone would substantially increase the expected population size of the Lambusango anoa population as a whole (Fig 4.3).

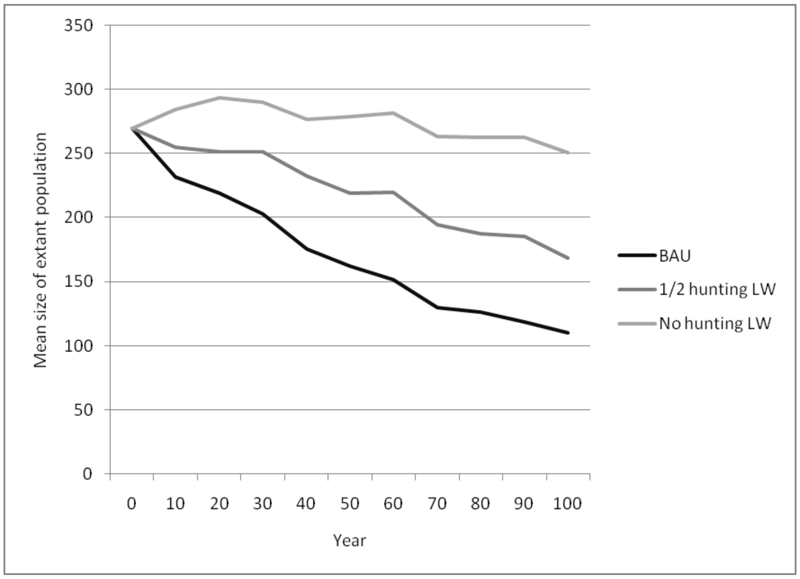

Figure 4.3 Lambusango anoa population status under Business as usual (BAU), a reduction in hunting rate of half in the Lawele area, and a complete cessation of hunting in Lawele

However, only a complete halt to hunting is likely to allow the population to grow to anything like its natural carrying capacity.

Human activity

The numbers of forest trails in each of the years is a reasonable proxy for forest usage on the study grids. Human trails were found in the forests crossing the transect lines and were recorded as part of the large mammal monitoring programme. The number of trails counted varied considerably from year to year and from camp to camp. While all camps showed an increase in trails from 2004 to 2005 that might indicate a change in counting method or observer ability, these increases were not consistently large across camps, so are probably valid and associated with an increase in rattan collection in the study grid areas during that year. The clearest general trend is the marked decline in trails from the 2004-2005 period to the 2006-2008 period. There was a substantial increase in trails between 2006 and 2008 in only one camp – Wabalamba, which had, at the time of the 2008 survey, already seen nearby cutting of lines for seismic surveys. It is likely that this affected human access to this part of the forest.

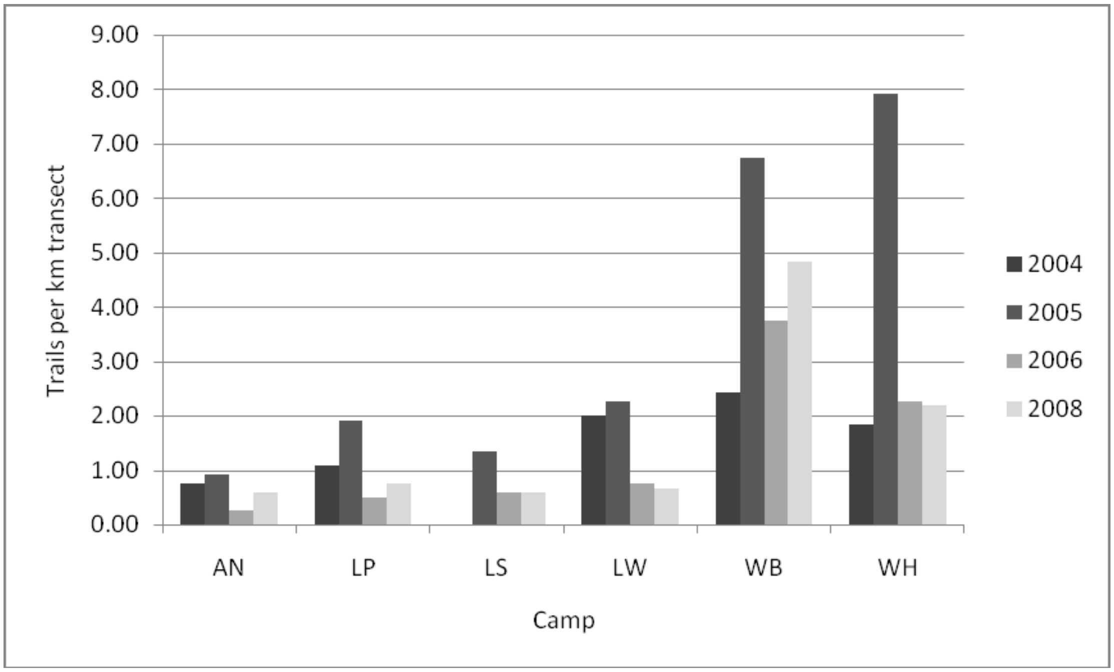

Figure 4.4 Number of trails per km at each camp and overall in Lambusango

The level of forest use, as indicated by the number of human trails was highest in the Wabalamba and Wahalaka areas. The fact that Wahalaka is an important area for rattan collection and Wabalamba is the only area where extensive selective logging is apparent (as well as recent seismic exploration) probably account for this. Both of these sites are in or on the edge of the conservation forests, and it may therefore be necessary to focus some information dissemination on rules governing forest access and enforcement in these sites.

Conclusions
The weight of evidence suggests that the LFCP has been effective in reducing improper human use of the forest. Uncertainties remain over the trend in illegal hunting of anoa and decisive focussed action should be taken to reduce this.

4.3 To ensure that rattan extraction in the limited production and conservation forests is being carried out sustainably

The sustainably of rattan extraction is being considered from 3 different perspectives, in terms of:

- Rattan biology: the persistence of the rattan plants
- Forest ecology: absence of long-term impacts on forest
- Sustainable livelihoods: a stable and valuable additional household income source

Surveys of the amount of rattan cane have been used to examine the possible impact of harvesting on the rattan plants. In 2006, field surveys recorded the number of rattan species and standing crop at 45 sites each 50m X 10m and covering all 6 node camps. This survey was repeated in 2007, but only at 23 sites at 4 node camps because a permit to work in the conservation forest was not granted. Results from this survey have to be treated with caution as the one-year duration of the study does not allow reliable estimates of growth rate. Also, exactly relocating the survey sites proved difficult due to limited GPS accuracy when working in the forest. So the 2007 survey sites are not completely coincident with those of 2006.

Table 4.5 summarises the rattan survey results for the 4 main commercial species. For each species, the sites have been classified as experiencing growth if total cane length increased, or undergoing harvest if total cane length decreased. The minimum, maximum and total values shown are for just those sites experiencing harvest or growth respectively. For *Calamus* sp. (kabe) no sites are classified as undergoing harvest. This could be because this species has not been harvested, or harvesting has occurred but total cane length growth exceeds the amount harvested. For *C. zollingeri*, the total harvested exceeds the total growth, indicating that for the 2006 to 2007 period there has been a net reduction in the amount of cane. For the other 2 species, total growth exceeds total harvested, giving a net increase in cane length across Lambusango.

Table 4.5 Change in rattan cane length in metres in 50m x 10m plots from 2006 to 2007

	Calamus zollingeri	*C. sp. (kabe)*	*C. ornatus*	*C. symphisipus*
Number of harvest sites	8	0	7	5
Number of growth sites	5	17	14	5
Minimum harvested	-2	---	-11	-9
Maximum harvested	-76	---	-164	-47
Total harvested	-260	---	-569	-215
Minimum growth	2	23	3	1
Maximum growth	99	3,562	343	110
Total growth	153	17,015	1,576	367

Conclusions
Since overall the growth exceeded the harvesting rates then it appears that rattan extraction is being undertaken sustainably and that this criterion has been achieved.

Management Objective 5
To ensure the effectiveness of the proposed management plans for the Lambusango Forest Management Area in maintaining biodiversity value of the forests.

Performance criteria for management objective 5

5.1 ***To ensure the diversity of bird species indicative of undisturbed forest does not decline in the conservation and limited production forests over the period to 2008.***

Bird communities were surveyed using the Variable Circular Plot methods (point counts with distance estimates to each contact) following Bibby et al. (2000) at 6 different node camps across Lambusango forest. Three node camps (Anoa, Lapago, Bala) were in the least disturbed habitats while the other three (Sumba Sari, Wabalamba, Wahalaka) were in the more disturbed habitats (Figure 5.1).

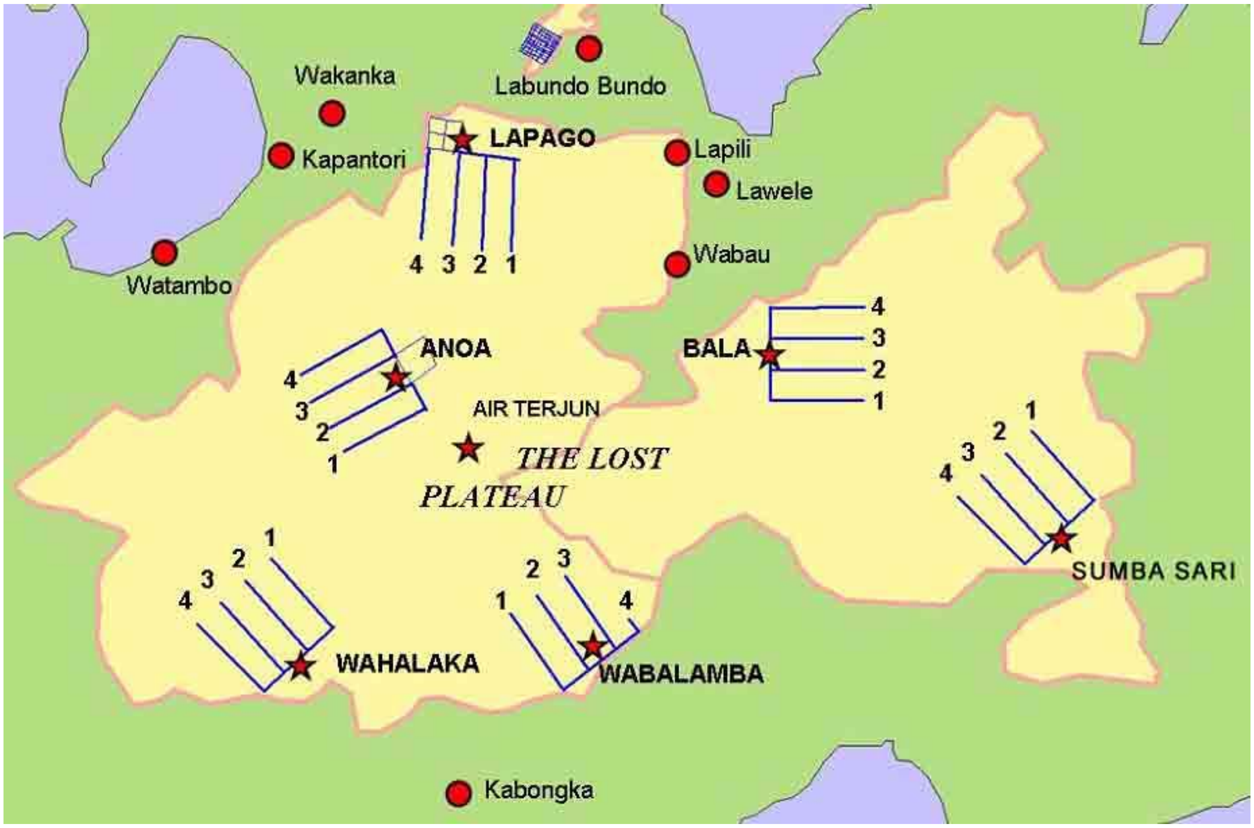

Figure 5.1 Location of the survey camps

Points were located at 150-m interval along each of the transects at each node camp giving a total number of point counts of 168 (6 camps x 4 transects X 7 point counts) and were visited between 0600 and 0800 hours. Groups consisting of 2-3 recorders stayed at each point and recorded any birds detected around the central point for 10 minutes without the use of a settling down period. Each group visited different points each day and did counts only once at each point with two replicates completed on each transect. All birds heard and seen were recorded (those flying over were noted but not used for the subsequent analysis) and an estimate of distance was made to each contact. Surveys were conducted twice a year covering the wet season (May-June) and the dry season (July-August) in 2006 and 2007 but only in the dry season in 2005. In 2007 refusal by the Forestry department to allow access to the Anoa and Lapago camps meant that only a partial data set was obtained and in 2008 the dry season only survey comprised data from only Bala, Anoa and Wahalaka. The surveys from 2005 – 2007 were completed and analysed by Nurul Winarni (Manchester Metropolitan University). Tom Martin

(Lancaster University) completed the surveys in 2008 and has compared these data with those collected by the teams in 2005 of which he was also a part.

In the period 2005 – 2007 a total of 61 bird species were recorded on transect surveys. The performance criterion requires the diversity of bird species indicative of undisturbed forest not to decline. However, a comparison between the bird communities in the least disturbed with the more disturbed habitats indicated very similar communities. The use of diversity indices could not detect any significant differences either between communities in the differing levels of disturbance. Moreover comparison of diversity indices over the 3 year study showed no significant changes. Multiple regression analysis suggested that the level of disturbance as characterized by the vegetation structure variables recorded at each count station did not seem to affect the total number of species ($R^2_{9, 155} = 0.04$, $F = 0.87$, $P = 0.55$) or individuals ($R^2_{9, 155} = 0.08$, $F = 1.46$, $P = 0.17$). However, when the bird species were analysed individually then some species had a significant relationship between abundance and disturbance levels (as measured by the number of pandans and palm vegetation, lianas, ferns, canopy openness, number of recently fallen trees and intermediate well-rotten trees). Bay coucal, Green imperial pigeon, Black-naped monarch, Black-naped oriole, Citrine flycatcher, Sulawesi black pigeon and Pied cuckoo-shrike had a positive relationship with increasing levels of disturbance . On the other hand, Black-naped fruit-dove, White-bellied imperial pigeon, Ashy Woodpecker and Red-knobbed hornbill showed a negative relationship to disturbance level. Of the 21 commonest species, 6 species had estimated densities higher in less disturbed sites – the Black-naped fruitdove, Sulawesi hornbill, Red-knobbed hornbill, White-bellied imperial pigeon, Ashy woodpecker, and Red junglefowl but only Red-knobbed hornbill was significantly more abundant. In addition sunbirds, which are an amalgam of 4 species (black, olive backed, brown throated and crimson) all of which may have differing habitat requirements were also more abundant in less disturbed sites. The Hair-crested Drongos were only just more numerous in less disturbed forests and the Sulawesi Whiteye whilst more numerous in these samples is normally found in undisturbed habitats. Estimated densities of all the other species were higher in the more disturbed sites with 3 species significantly more abundant - Sulawesi babbler, Drongo cuckoo (both insectivores) and one frugivore, Green imperial pigeon.

Table 5.1. A comparison of the densities of the 21 commonest bird species and their associations with vegetation structure

English name	Endemic status	Observations		Estimated density		z-test		Multiple regressions vegetation structure		
		Least disturbed	Most disturbed	Least disturbed	Most disturbed			R^2	P value	Vegetation characteristics
Bay coucal	E	316	460	0.19	0.27	-1.54		0.17	0.00	Disturbance (+), undulations (-)
Green Imperial pigeon		458	689	0.58	0.82	-2.65	*	0.08	0.00	Disturbance (+)
Sulawesi babbler	E	247	339	0.71	0.91	-2.06	*	0.03	0.02	Undulations (-)
Black-naped monarch		239	318	0.50	0.62	-1.08		0.04	0.01	Disturbance (+)
Sunbirds		203	192	1.00	0.88	1.24		0.04	0.63	
Black-naped oriole		325	456	0.37	0.48	-1.03		0.14	0.01	Ferns (-), disturbance (+)
Hair-crested drongo		247	339	0.44	0.36	1.18		0.04	0.72	
Pied cuckoo-shrike		156	213	0.15	0.19	-0.58		0.06	0.03	Intermediate fallen trees (+), disturbance (+)
Black-naped fruit-dove		205	146	0.16	0.11	0.46		0.21	0.04	Treevines (+), ferns (-), disturbance (-)
Citrine flycatcher		176	218	0.31	0.35	-0.62		0.09	0.00	Treevines (+), disturbance (+)
Sulawesi dwarf hornbill	E	112	97	0.04	0.03	1.49		0.03	0.83	
Flowerpeckers		100	139	0.64	0.83	-0.71		0.04	0.62	
White-bellied imperial pigeon	E	191	115	0.10	0.06	0.54		0.09	0.02	Disturbance (-), pandans (-)
Sulawesi cicada bird	E	128	173	0.09	0.12	-0.90		0.03	0.02	Undulations (-)
Red-knobbed hornbill	E	115	21	0.07	0.01	4.65	*	0.23	0.03	Disturbance (-), ferns (-)
Ashy woodpecker	E	85	76	0.19	0.15	0.94		0.16	0.03	Undulations (-), treevines (-), ferns (-), disturbance (-)
Sulawesi black pigeon	E	39	120	0.02	0.07	-1.28		0.13	0.00	Disturbance (+)
Sulawesi white-eye	E	66	57	0.18	0.14	0.96		0.10	0.06	
Drongo cuckoo		52	90	0.04	0.06	-1.93	*	0.07	0.20	
Red junglefowl		79	53	0.03	0.02	1.80		0.06	0.44	
Spot-tailed goshawk	E	60	66	0.04	0.05	-0.09		0.11	0.01	Pandans (+), ferns (-)

* Correlation is significant at the 0.05 level (2-tailed)

(+)/(-) Positive or negative correlations to vegetation characters

Given that the overall diversity of bird communities in the range of forest disturbance encountered in the Lambusango forests does not vary significantly, then it is proposed that this performance criteria would be better assessed from whether the density of species indicative of relatively undisturbed forest is constant or declining. This would give a better measure of whether anthropogenic impacts are affecting bird communities than use of diversity indices, which may mask underlying changes in species or species richness, which is affected by variable survey effort.

It is therefore proposed that the densities of Black-naped Fruit Dove, Sulawesi Dwarf Hornbill, White-bellied Imperial Pigeon, Red-knobbed Hornbill, Ashy Woodpecker and Red Jungle Fowl are monitored over time. Table 5.2 shows that over the period 2005 to 2006 the density of two (Red-knobbed Hornbill and Ashy Woodpecker) of the target six species declined significantly in all sites, whilst in 2007 the density of two (the two hornbill species) of the six declined significantly. The data for 2007 though is only a partial data set so should be viewed cautiously.

Table 5.2 Density estimates (pairs/ha) of most common bird species during 2005-2007 and associated standard errors (SE) and Z-tests. Guild category comprised of frugivores (1), insectivores (2), partial frugivores/insectivores (3), nectarivores (4), predators (5), omnivores (6), and insectivores/piscivores (7). Yellow highlighted species are those indicative of undisturbed forests with red highlighted cells indicating significant declines of undisturbed forest species. Pink highlighted cells indicate significant declines of disturbed forest species.

English name	Guild	Density estimates (D)			SE Density			Z test			
		2005	2006	2007	2005	2006	2007	2005-2006		2006-2007	
Green Imperial pigeon	1	0.75	0.69	0.61	0.13	0.12	0.10	0.30		0.53	
Black-naped fruit-dove	1	0.21	0.15	0.09	0.08	0.06	0.04	0.56		0.83	
Sulawesi dwarf hornbill	1	0.05	0.04	0.02	0.01	0.00	0.00	1.11		2.85	*
White-bellied imperial pigeon	1	0.11	0.08	0.06	0.09	0.06	0.04	0.31		0.28	
Red-knobbed hornbill	1	0.09	0.04	0.02	0.02	0.01	0.00	2.73	*	2.14	*
Sulawesi black pigeon	1	0.04	0.07	0.03	0.02	0.04	0.02	-0.70		0.79	
Sulawesi white-eye	1	0.21	0.16	0.12	0.04	0.03	0.02	0.93		1.14	
Bay coucal	2	0.24	0.24	0.16	0.07	0.07	0.05	-0.01		0.99	
Sulawesi babbler	2	1.44	0.62	0.72	0.12	0.05	0.06	6.38	*	-1.28	
Black-naped monarch	2	0.85	0.60	0.33	0.13	0.09	0.05	1.62		2.76	*
Hair-crested drongo	2	0.63	0.40	0.27	0.08	0.05	0.04	2.39	*	2.20	*
Pied cuckoo-shrike	2	0.18	0.17	0.15	0.06	0.05	0.05	0.17		0.29	
Citrine flycatcher	2	0.50	0.33	0.23	0.09	0.05	0.04	1.64		1.39	
Sulawesi cicada bird	2	0.13	0.12	0.07	0.03	0.02	0.01	0.22		1.84	
Ashy woodpecker	2	0.28	0.15	0.13	0.05	0.02	0.02	2.69	*	0.40	
Drongo cuckoo	2	0.06	0.06	0.03	0.01	0.01	0.01	-0.23		2.93	*
Black-naped oriole	3	0.52	0.46	0.33	0.10	0.08	0.06	0.45		1.21	
Spot-tailed goshawk	5	0.07	0.03	0.05	0.02	0.01	0.02	1.59		-1.24	
Red junglefowl	6	0.02	0.02	0.02	0.01	0.00	0.00	0.32		0.03	

*asterisks indicated significancy

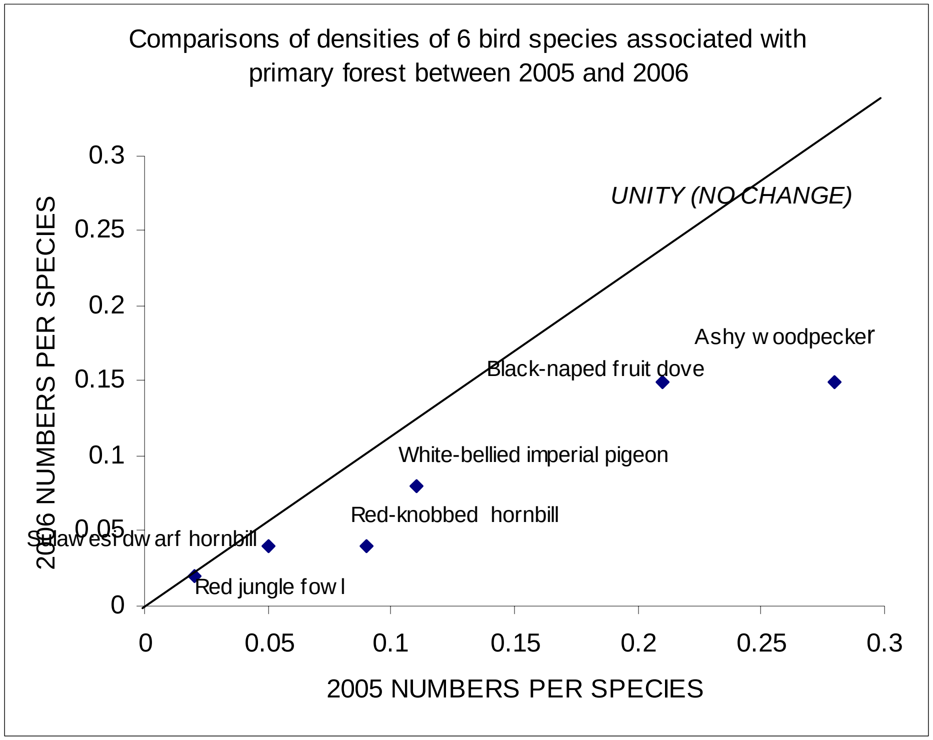

Figure 5.2

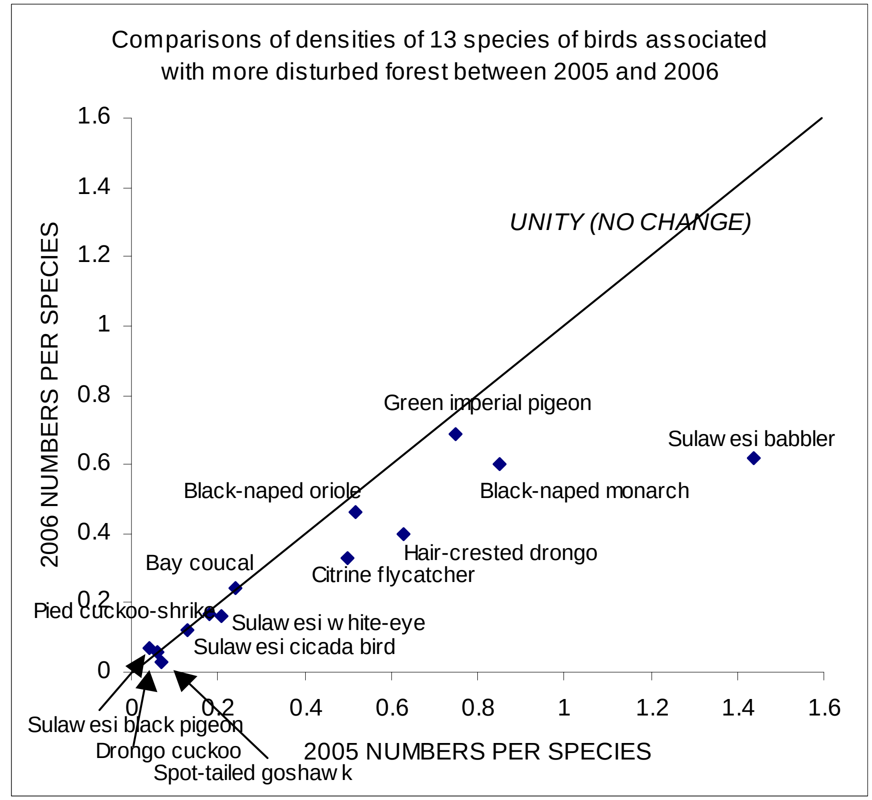

Figure 5.3

The densities of five of the species undisturbed forest indicators declined over the 3 year study period with only Red Jungle Fowl maintaining population levels (Fig 5.2). This may indicate that the forest was becoming more disturbed. However, two of the species, which showed a positive correlation with increasing disturbance (Hair-crested Drongo and Sulawesi Babbler) also declined significantly. Indeed all of the species which were more abundant in disturbed as opposed to undisturbed forest in 2005 had declined by 2006 (Fig 5.3).

The apparent decline in densities of most of the 19 commonest species continued into 2007. However, since this was only a partial data set these figures may not be as reliable. A comparison of the data from Bala and Anoa (undisturbed forest) and Wahalaka (disturbed forest) in 2008 with the same camps in 2005 did not show such a clear pattern for the six indicator species of undisturbed forest (Fig 5.4). The Red-knobbed Hornbill had declined markedly however as shown in the 2005 – 2007 data set. Trapping of Red-knobbed Hornbills using nooses or lime in the Lambusango forest for the pet trade is a problem and this trapping may well have exacerbated any underlying declining trend. The Dwarf Hornbill seems to have increased in numbers over the 2005 – 2008 period in direct contradiction to the 2005 – 2007 data set. Interestingly though 10 of the 13 species used as indicators of disturbed forest had also declined in the 2005 – 2008 data sets (Figure 5.5) with only Sulawesi White-eye, Sulawesi Cicadabird and Sulawesi Black Pigeon showing any increases.

The density of the commoner bird species (both those indicative of undisturbed and disturbed forest) appears to have declined over the study period. This is unlikely to be a sampling bias since a different team collected the data for the 2005 – 2007 comparison to the team that gathered the data for the 2005 – 2008 comparison. It is difficult to explain why such an overall decline in bird abundance across both frugivore and insectivore guilds has occurred over the study period. The 2005 – 2008 data sets showed similarities to the 2005 – 2007 data sets in that all of the 6 undisturbed forest species were more abundant in the undisturbed than the disturbed sites. However, the picture was not so clear with the 13 species identified as preferring more disturbed sites from the 2005 – 2007 data set. Table 5.1.3 shows that Spot-tailed Goshawk, Green Imperial Pigeon, Pied Cuckoo Shrike, Hair-crested Drongo, Black-naped Monarch and Sulawesi White-eye were all more abundant in undisturbed sites in the 2005 and 2008 data sets. It may be that by categorising the forest into such broad categories as undisturbed and disturbed is resulting in some species dropping either side of the line when many of the forests being surveyed are of an intermediate nature. What is clear though is that there is an overall decline in abundance of the commoner birds over the study period. Whether this can be attributed to increasing disturbance fo the forest, environmental cycles such as rainfall patterns affecting fruit production and insect levels is difficult to decide without longer data sets, which will continue to be gathered by the Operation Wallacea survey teams in subsequent years.

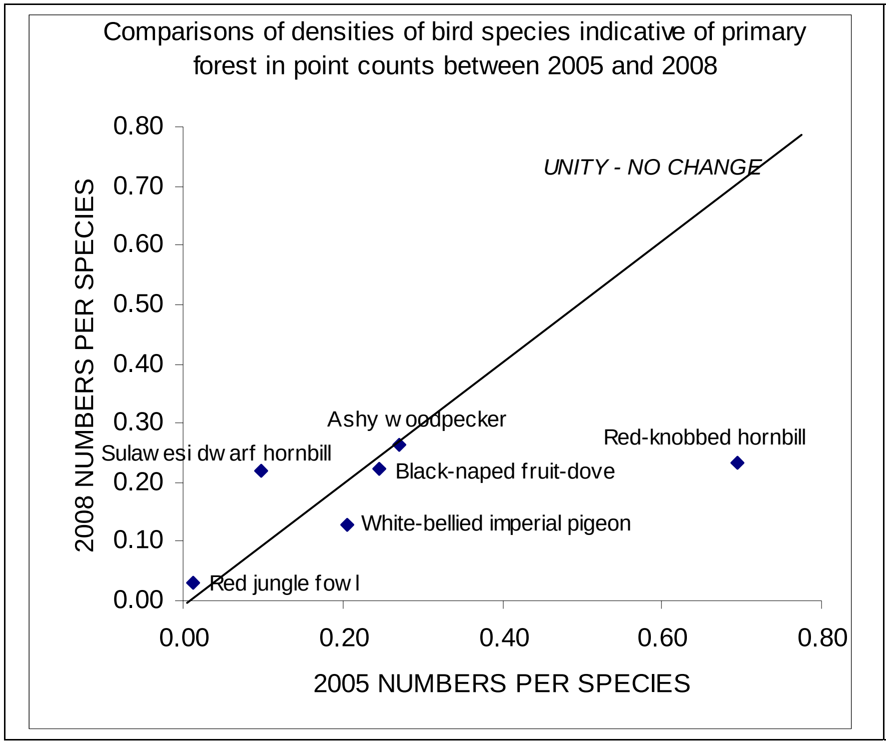

Figure 5.4

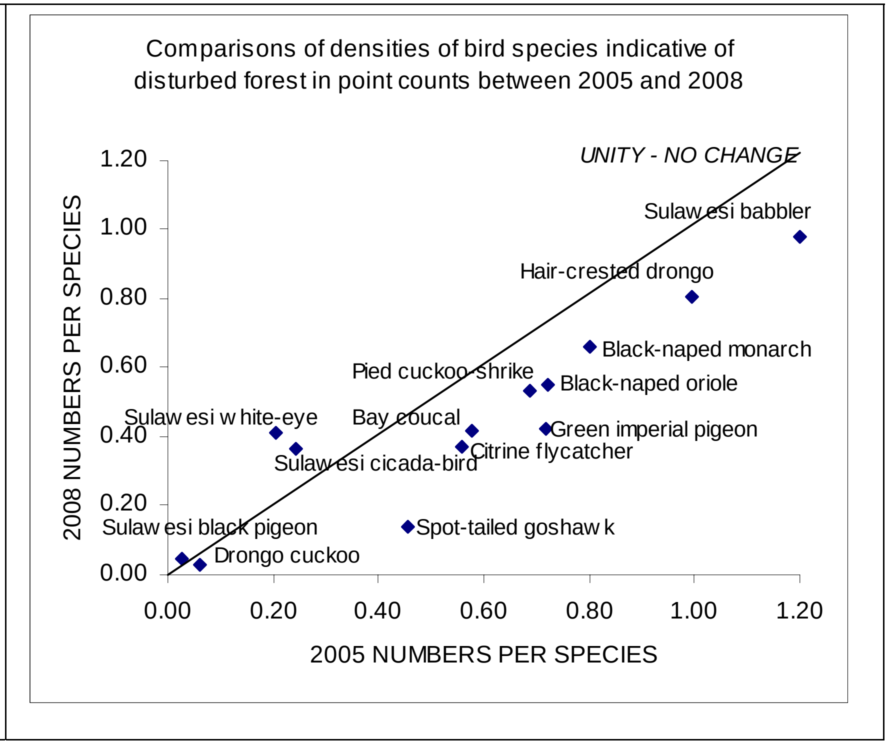

Figure 5.5

Table 5.3 Density estimates of the 19 commonest forest bird species identified by Nurul Winarni in her analysis of the 2005 – 2007 data estimates. The figures in this table were from Tom Martin's comapriosn of bird communities in Bala, Anoa and Wahalaka Camps in 2005 and 2008

Disturbed forest species	Primary 2005	Secondary 2005	2005	Primary 2008	Secondary 2008	2008
Spot-tailed Goshawk	**0.65**	**0.07**	**0.46**	**0.2**	**0.02**	0.14
Green Imperial Pigeon	**0.86**	0.43	**0.72**	0.49	0.29	0.42
Sulawesi Black Pigeon	**0.03**	**0.02**	**0.03**	**0.03**	**0.07**	0.04
Drongo-cuckoo	**0.00**	0.18	**0.06**	0.02	0.05	0.03
Bay Coucal	**0.50**	**0.73**	**0.58**	**0.47**	**0.30**	0.41
Pied Cuckoo-shrike	**0.88**	**0.30**	**0.69**	**0.73**	**0.14**	0.53
Sulawesi Cicadabird	**0.23**	**0.27**	**0.24**	**0.43**	**0.23**	0.36
Hair-crested Drongo	**1.09**	0.80	**0.99**	0.94	0.54	0.81
Black-naped Oriole	**0.71**	0.75	**0.72**	0.63	0.39	0.55
Sulawesi Babbler	**1.11**	**1.38**	**1.20**	**0.98**	**0.98**	0.98
Citrine Flycatcher	**0.57**	0.54	**0.56**	0.38	0.36	0.37
Black-naped Monarch	**0.95**	0.50	**0.80**	0.71	0.57	0.66
Sulawesi White-eye	**0.27**	**0.07**	**0.20**	**0.45**	**0.34**	0.41
Primary forest species						
Red Junglefowl	**0.02**	0.00	**0.01**	0.03	0.04	0.03
White-bellied Imperial Pigeon	**0.31**	**0.00**	**0.21**	**0.19**	**0.00**	0.13
Black-naped Fruit-dove	**0.34**	0.05	**0.24**	0.22	0.23	0.22
Sulawesi Dwarf Hornbill	**0.13**	**0.04**	**0.10**	**0.23**	**0.20**	0.22
Red-knobbed Hornbill	**0.91**	**0.27**	**0.70**	**0.33**	**0.04**	0.23
Ashy Woodpecker	**0.30**	**0.21**	**0.27**	**0.36**	**0.07**	0.26

Conclusions

Objective 5.1 has been achieved in terms of changes in diversity of bird communities not being observed over the study period. However, it is proposed that for future years this objective should be modified to assess changes in the density of the commonest 19 species. If this objective had been set at the outset of the project it would have been clear that bird densities have been declining (particularly the Red-knobbed Hornbill) but whether this could be attributed to increasing forest disturbance or other factors is at present unclear.

5.2 To ensure the diversity of reptile species indicative of undisturbed forest does not decline in the conservation and limited production forests over the period to 2008.

Initial studies on herpetofauna communities at the node camps in 2005 suggested that the diversity of this group was not sufficient for changes to be attributable to changes in levels of forest disturbance. In addition a minimum of 8 weeks survey effort with pitlines and standardised searches was needed at each of the sites to characterise the herpetofauna communities and this level of effort could not be encompassed within the Operation Wallacea annual survey programme. In 2006 efforts were made to examine in more detail the herpetofauna communities in disturbed forest adjacent to Labundo and at the less disturbed Lapago site. The objective was to identify relatively abundant species (eg skinks) that were indicative of less disturbed forest, so that the abundance and distribution of these target species could be monitored at each of the node camps in future years in much shorter time periods. Unfortunately this exercise did not result in being to identify species clearly associated with levels of disturbance and this criterion had to be abandoned. Annual monitoring of the herpetofauna between Labundo and Lapago has continued annually from pitline surveys and standardised searches over an 8 week period in June to August each year. These data do not indicate any significant changes in the herpetofauna community over the study period.

Conclusions
The monitoring programme did not produce the data needed to assess performance against this criterion because of the difficulty in achieving sufficient survey effort at each of the node camps to characterise the community and the failure to identify indicator species that could have been used to characterise the sites more rapidly. Indications from the constantly monitored Labundo to Lapago camps suggest that there have been no significant changes in the herpetofauna communities.

5.3 To ensure the diversity of insectivorous bat species indicative of undisturbed forest does not decline in the conservation and limited production forests over the period to 2008

For annual monitoring from 2000 to 2008 of bat numbers and assemblage composition in the Kakenauwe Forest Reserve adjacent to Labundo village, bats were captured in six to ten harp traps, positioned along forest trails positioned around 50 metres apart. Traps were moved to new positions each night. Trapping effort has varied from year to year, depending on logistical constraints. Rarefaction plots from these data survey effort needs to be sufficient to capture around 130 bats before the species community of a site could be characterised. This level of survey effort could not be achieved at each of the node camps within the Lambusango forest within the Operation Wallacea annual survey programme. Monitoring of the bat communities has continued at the Kakenauwe site.

Conclusions
It is not possible to collect sufficient data to use bats as indicators of forest change without a substantial investment to run survey programme at each of the node camps. This criterion is therefore data deficient.

5.4 To ensure the diversity of butterfly species indicative of undisturbed forest does not decline in the conservation and limited production forests over the period to 2008

The data for this section were obtained from the report on butterfly communities prepared by Nurul Winarni and Dr Martin Jones, Manchester Metropolitan University. Butterfly species were surveyed using a modification of the 'Pollard walk' (Pollard 1977), combining both point count and transect walks. Surveys focused on families Papilionidae, Nymphalidae, and Pieridae, excluding Hesperiidae and Lycaenidae which were too small to identify directly in the field. Points were located at 150m intervals along each transect (the same as those used for bird recording). Observers walked along the 900m transect and identified individual butterflies. At each survey point, the observer stood and recorded any butterfly detected within a spherical area of 5m radius (vertical and horizontal) for approximately 10 minutes. All butterflies seen were identified to species if possible, otherwise to genus or family. During the surveys, binoculars were used to aid identification. Unidentified butterflies were caught by net and then released after identification. Species identification was based on Vane-Right and de Jong (2003), and the reference collection provided by Willmott (2000).

Surveys were conducted in 2006 and 2007 (familiarisation with the fauna took place in 2005). Surveys were carried out twice a year covering the wet season (May-June) and the dry season (July-August). Administration difficulties during 2007 restricted the surveying so only 3 node camps (Lawele, Lasolo, Wabalamba) were visited during the dry season in that year. The data from these three sites are used for the between year comparisons. Although butterflies were surveyed using both line transect and point count, only point count data were analysed for the subsequent analyses as the butterfly data could then be associated with the vegetation sampling plots.

71 butterfly species were identified, 34 of which were endemic. 11 of 13 species regarded as common or intermediate in abundance were endemics, further highlighting the inherent biodiversity value of the Lambusango area for this group. During 2006, the highest diversity (Shannon-Weiner's index) was demonstrated by Lapago and the lowest was in Lasolo whereas Anoa was the highest and Lasolo was the lowest during 2007 (Table 5.4). During 2006, Lawele had the highest evenness score and Lasolo the lowest. Focussing on the three sites with complete data sets (Lasolo, Lawele, Wabalamba, visited during dry and wet seasons in 2006 and 2007), the patterns of diversity and evenness were consistent - highest in Lawele and the lowest in Lasolo. Over two years using data from these 3-sites, number of Nymphalids, Papilionids, and Pierids recorded per sampling point did not show significant differences.

Table 5.4. Butterfly species diversity and evenness at each node camp during 2006-2007.

Node camps	Total Species		Shannon-Wiener		Simpson	
	2006	2007	2006	2007	2006	2007
Anoa	22	27	2.49	2.81	9.80	13.40
Lapago	37	25	3.03	2.65	15.18	11.46
Lasolo	23	27	2.39	2.45	7.41	7.84
Lawele	31	31	2.90	2.67	15.30	10.32
Wabalamba	31	27	2.73	2.47	10.55	7.79
Wahalaka	29		2.69		11.04	

Conclusions
This criterion has been achieved and there is no evidence that butterfly populations overall are declining. The Lambusango forest remains an important location for a number of endemic species.

5.5 To ensure the freshwater fish and macro-invertebrates in rivers flowing through the limited production and conservation forests do not show evidence of de-forestation or intermittent pollution incidents over the period to 2008.

This was intended to be part of the Operation Wallacea annual survey programme. However, repeated attempts to attract academic from universities have failed to enable this work to be undertaken.

Conclusions
No monitoring has been completed to assess the whether this performance criterion has been achieved.

5.6 To determine the impacts on these indicator groups in areas of exploited production forests to assess the sensitivity of the chosen indicators in detecting the impacts of anthropogenic change.

Herpetofauna and bats were eliminated from the analysis since the survey effort needed to characterize their communities at each of the sites across the forest was far too great to encompass with the agreed funded programme. Birds and butterflies seemed to be the most cost effective groups to use as indicators of levels of forest disturbance. The bird and butterfly data were therefore analysed by dividing the 6 study sites into two levels of disturbance: less disturbed (Anoa, Lapago, Lawele) and more disturbed (Lasolo, Wabalamba, Wahalaka). To compare the bird and butterfly communities between different disturbance levels, species diversities were compared using Shannon-Wiener and Simpsons Indicies (Magurran 2004) and rank-abundance models (Magurran 2004, Hill and Hamer 1998). Diversity indices were analysed using EstimateS 8.0 (Colwell 2006), goodness of fit of species abundance models was assessed with chi-square goodness of fit tests (Magurran 2004) in R 2.4.1 with biodiversity R functions (http://www.r-project.org/).

Birds
To determine the impact of disturbance on bird feeding guilds, the species were categorized into seven feeding guilds (frugivores, insectivores, partial frugivores/insectivores, nectarivores, predator, omnivores, insectivores/piscivores) following Coates *et al.* (1997) and Walker (2007). Only two guilds, frugivores and insectivores were included in the analysis because they constitute the majority of bird species in Lambusango. Mann-Whitney U tests were then carried out on rank abundance of frugivore species, insectivores, and partial frugivores/insectivores for differences between the less disturbed and more disturbed areas. Similar analyses were carried out on butterflies, specifically on major families (Nymphalidae, Papilionidae, Pieridae).

Multiple regressions were used to determine whether vegetation structure (and thus disturbance level) at each point was related to the number of species, total number of individuals, number and abundance of frugivorous, insectivorous, and partial frugivorous/insectivorous. Parameters entered were vegetation structures that characterized degree of disturbance - canopy openness (mean), *Pandanus* trees—

Pandanaceae (count), ferns (count), palms—Palmae (count), undulations (1-3 scale), tree vines (1-3 scale), fresh fallen trees (count), and intermediate-rotten fallen trees (count). Multiple regressions were also used to identify whether abundance (number of observations) of the most abundant species was related to vegetation structure. Similar analyses were carried out on butterflies (number of observations, total number of individuals) as number and abundance of Nymphalidae, Papilionidae, and Pieridae.

Bird densities were estimated by distance sampling with programme DISTANCE v.5.0 (Thomas *et al*. 2006). Only the densities of the most abundant (mean observations > 100) and rather less abundant (mean observations 20-100) bird species were estimated as sample sizes for some of the others were too small. Earlier analysis demonstrated that observer heterogeneity and season did not greatly impact upon on density estimations and hence data from different observers and different seasons during 2005-2007 were pooled. Densities for different disturbance levels were estimated by post-stratification. A range of suitable models were fitted to the data and the best selected based on the minimum AIC (Akaike's Information Criterion) values (Buckland *et al*. 2001). Differences in density estimates between disturbance regimes were tested for using Z tests (Buckland *et al*. 2001).

Disturbed and undisturbed sites supported similar numbers of bird species (N = 54 and 56 respectively). Species richness and diversity were slightly but significantly higher in the less disturbed than the more disturbed forest (Shannon-Wiener H' = 3.23 and 3.13 respectively, t = 52.43, P < 0.05; Simpson's index = 19.4 and = 16.16). Frugivores contributed 22 species (36.1% of overall number of species) to the community and insectivores 17 (27.9 %); partial frugivores/insectivores were represented by 6 species (9.8%). Significantly more frugivore species were recorded in the less disturbed forest than the more disturbed forest (Mann-Whitney U test, N = 84, U = 2897, P = 0.04) whereas number of insectivores were higher in the more disturbed forest (N = 84, U = 2320.5, P < 0.01). Number of partial frugivore/insectivore species were not significantly different between the two forest categories (N = 84, U = 3069.5, P = 0.12). Proportions of frugivore species recorded were higher in less disturbed forest (21.3% in less disturbed, 14.7% in more disturbed) whereas insectivores were more prevalent in the more disturbed forest (0.08% in less disturbed, 19.6% in more disturbed).

Multiple regression analysis suggested that the level of disturbance as characterized by the vegetation structure variables recorded at each count station did not affect number of species ($R^2_{9,\,155}$ = 0.04, F = 0.87, P = 0.55) or individuals ($R^2_{9,\,155}$ = 0.08, F = 1.46, P = 0.17). However, when the bird species were analyzed individually 14 species showed significant relationships with vegetation structure. Species associated with increased disturbance were: Bay coucal, Green imperial pigeon, Black-naped monarch, Black-naped oriole, Citrine flycatcher, Sulawesi black pigeon and Pied cuckoo-shrike. Those associated with low disturbance were: Black-naped fruit-dove, White-bellied imperial pigeon, and Red-knobbed hornbill.

Forward multiple regression analyses demonstrated that the vegetation structure variables did not correlate with number of frugivore species and number of partial frugivores/insectivores or with their total abundance at each point. Only insectivores were affected by vegetation structure. Number of insectivore species as well as their abundance was positively related to increases in disturbance level.

Butterflies

The less disturbed habitats supported a slightly higher number of species (N = 59) than the more disturbed ones (N = 57). Diversity of butterflies was higher in less disturbed sites than the more disturbed (Shannon-Wiener H' = 3.00 and 2.72 respectively, t = 150.76, $P < 0.05$; Simpson's Index = 13.28 and 9.03), though rank abundance models suggested there was little difference between the communities at the two sites. The abundance of two common species, *Lohora opthalmica* and *Cupha maeonides* was positively related to disturbance while two others, *Eurema alitha* and *Idea blanchardi* were significantly more abundant in less disturbed sites.

Multiple regression analyses relating abundance and species richness to habitat variables revealed that the number of butterfly species was positively related to *Pandanus* vegetation and intermediate sized well-rotten fallen trees ($R^2_{1, 162} = 0.10$, F = 9.05, P = 0.001) and total abundance was positively related to intermediate sized well-rotten fallen trees ($R^2_{1, 163} =$ 0.052, F = 8.93, P = 0.003). At this microhabitat level three common species, *Cupha maeonides, Faunis menado* and *Lohora ophthalmica,* were associated with variables of disturbed forest while two common species*, Idea blanchardi* and *Moduza lymire* were positively associated with variables of less disturbed forest.

Conclusions

The research and analysis for this criterion has been completed.. With knowledge gathered from research it is possible to use certain species as indicators of local and regional disturbance and others as indicators of reduced disturbance. Insectivorous birds as a guild appear to be associated with disturbance. Many of the species of birds and butterflies that demonstrate positive or negative responses to habitat disturbance are endemics.

Management Objective 6

To ensure that populations of flagship species such as Anoa, Sulawesi Wild Pigs, Tarsiers and Macaques are maintained in the forests.

Benchmark performance criteria for management objective 6

6.1 Ensuring the population of the Buton Macaque shows no long term trend of decline over the period to 2008.

Macaque surveys were completed as part of the anoa transect line surveys which were completed on each of the node camp transects during the months of July and August 2005 and 2008. In total 42 encounters with Macaques (where individuals were sighted) were made in the 2005 survey and 44 in 2008 (Table 6.1). There was considerable variation in both number of encounters and mean group size between the two time periods.

Table 6.1 Distribution of Macaque sightings

Camp	No. Encounters		Mean group size	
	2005	2008	2005	2008
AN	7	1	6	1.0
LP	6	12	6.7	4.3
LS	9	4	4.1	6.3
LW	6	10	11.7	3.2
WB	12	8	9.3	2.1
WH	2	9	8	5.2
Total	42	44	7.5	3.7

Mean overall group size was 7.5 individuals in 2005 and almost half that (3.7) in 2008. In both years there was substantial skew in the distribution of group size, with this being most pronounced in 2008 (Figure 6.1). Since the overall number of encounters over the field season was roughly the same, it is entirely possible that these differences in mean group size and group size distribution indicate differences between observers, especially since none of the very large groups observed in 2005 were recorded in 2008. It is possible that this decline in group size reflects a real reduction, but it would be very surprising for an impact to be so severe as to substantially affect groups of this species across a wide area in only three years. Studies of troops in forest and forest edge environments indicate that those in more disturbed areas are larger than those in less disturbed areas, possibly because of the increased availability of resources in disturbed land and adjacent farmland. There was no obvious large-scale disturbance, forest regeneration or increase in human activity throughout the study area or over the study period, so an effect of these factors seems unlikely.

Detection probability and effective strip width (two related parameters) increased significantly over the survey period suggesting that macaques were more readily observed, and further into the forest in 2008 than 2005 (Fig 6.2). This may be because of inter-observer differences, or because macaques had modified their behaviour, remaining more active at distance in the second survey period than the first, perhaps suggesting a long-term modest habituation effect. However, this latter seems unlikely given the short time period that survey teams are in the field each year. Detailed behavioural studies elsewhere in Lambusango require re-habituation on an annual basis after three months constant contact and a nine month period of no contact. It is possible that an increase in general human activity in the forest would increase detection probability, but there is no evidence that this occurred as the number of trails present declined in most sites from 2005 to 2008.

There was no difference in estimated group density based on distance analysis between 2005 and 2008 (Fig.6.3). These group densities, assuming a modal group size of that in 2005 (4 individuals) translate to a total population over the 600km^2 of Lambusango of 6,240 individuals.

There were some extremely large groups recorded, and it is likely that these are representative of true group size while the smaller groups that are more frequently observed are sub-groups that break away from the large group for foraging. Such fission-fusion behaviour is typical of a number of species of group-living primates. Detailed behavioural studies elsewhere in Lambusango have recorded troops of more than thirty individuals and one troop of more than seventy.

Conclusions

The Lambusango macaque population appears to be stable so this criterion has been met, though there are uncertainties over actual population size because of the difficulties in assessing mean group size.

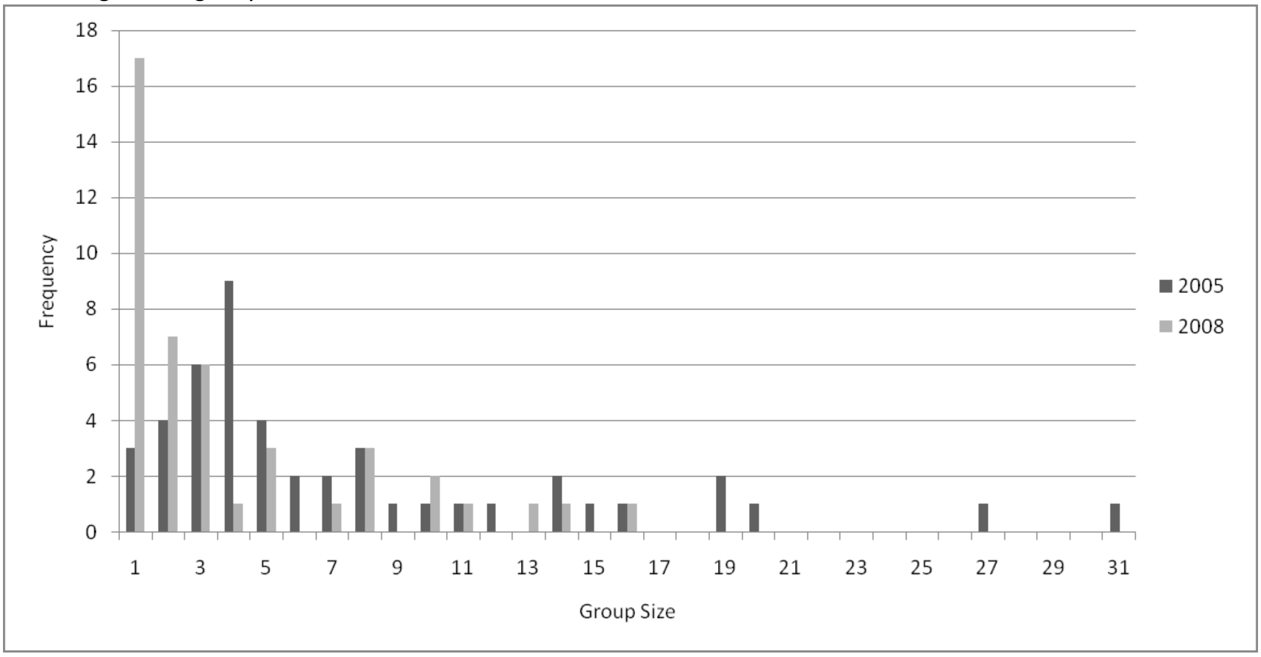

Figure 6.1 Frequency distribution of Macaque group sizes

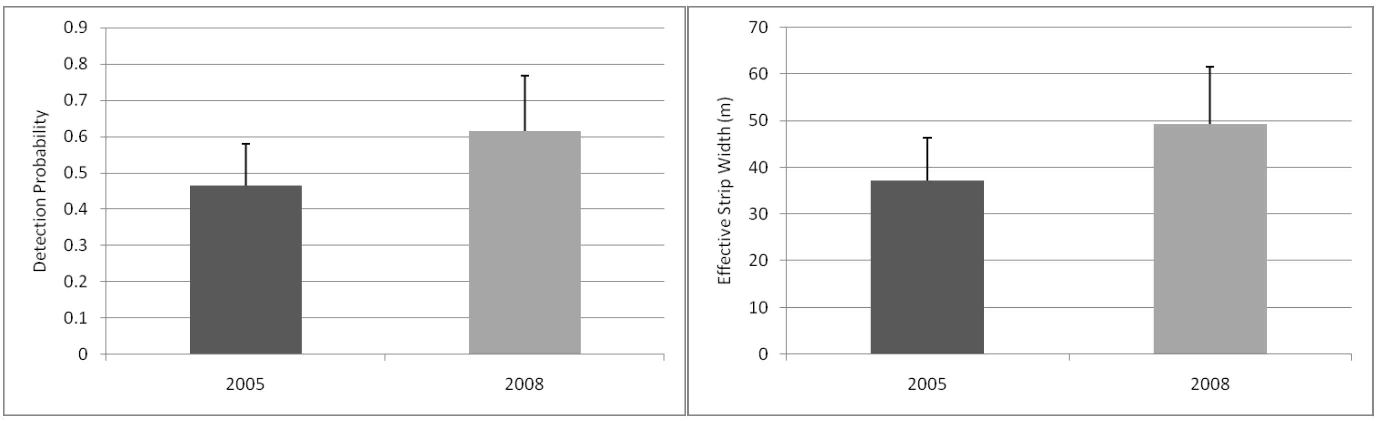

Figure (6.2) Detection probability and effective strip width for macaques in 2005 and 2008.

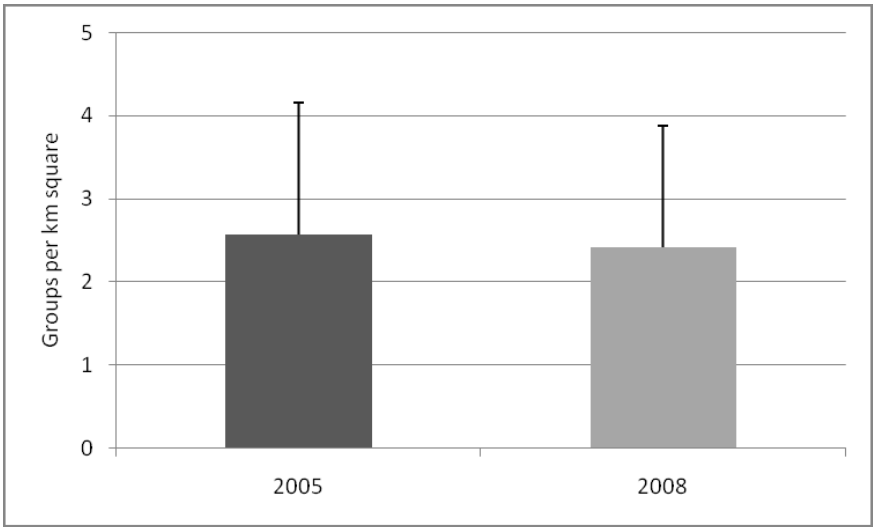

Figure 6.3 Estimated density of macaque groups in 2005 and 2008.

6.2 Ensuring the population of the new Tarsier species shows no long term trend of decline over the period to 2008

No data have been gathered on this criterion because of the difficulties in determining a methodology for estimating population size. It is unlikely that this criterion can be monitored effectively.

Conclusions
This criterion is data deficient and cannot be assessed.

6.3 Ensuring the population of Anoa shows no long term trend of decline over the period to 2008.

The occupancy and detection probability of anoa and wild pigs was determined from the presence of their tracks across the study area. Anoa and pig tracks can be readily distinguished from each other and those of other ungulates (feral cows, occasional deer) that exist in the study area on the basis of their size and shape. Tracks were recorded every 50 metres along the transect lines during the months of July and August 2004-2008. Every year, each transect line was walked once at a pace of approximately 800 m per hour to look for anoa tracks.

For analysis, 3km transects were divided into 500m sections. To avoid spatial autocorrelation, only alternate 500m sections were used in the analysis. Within each section alternate 50m sections were used as independent replicate sampling points since anoa were never observed to follow the transect for more than 50m. The presence (1) or absence (0) of tracks was recorded within each 50 m sampling point. Thus each year, a maximum of 72 sampling sites each with 5 replicate sampling points were surveyed from 6 node camps. A failure to survey some parts of the transect lines was regarded as missing data. Problems with access to protection forest in 2007 and occasional illness of surveyors meant that not all transects were surveyed in all years (Table 6.2). Missing data points are not problematic for occupancy analysis.

Table 6.2 Transects not surveyed over the study period because of access problems and surveyor illness

Year	Transects not surveyed
2004	WB T1,T4
2005	-
2006	-
2007	All transects at AN, LP, LS, WH
2008	LW T4, WB T2.

Data were analysed using program PRESENCE V.2 (MacKenzie et al. 2006). Changes in probability a site is occupied (ψ) and probability of detection (p) across the study sites should be a reflection of changes in distribution and abundance respectively. Royle and Nichols (2003) suggest that variations in abundance at different times and places are probably the most important reason for variation in detection probability. Lower number of animals usually result in lower detection probability during surveys (Bayle et al. 2004).
For the anoa track data a number of multiple season models relevant to management questions were fitted to the data. Covariates incorporated into these models were:
LFCP: a coding variable delimiting between the pre-LFCP period (2004-2005) and the LFCP period (2006-2008). CAMP: a series of 0-1 coding variables identifying each forest camp.

Occupancy analysis using PRESENCE requires that different states of a categorical variable be defined as separate covariates. Having many states therefore results in fitting models with many parameters which can reduce the strength of inference. Condensing the 'year' variable into Pre-LFCP and LFCP reduces the number of parameters to be fit from five to two. This also has the advantage of reducing the impact of gaps in the data resulting from problems with forest access and fieldworker illness.

Models were fitted with probability of occupancy (ψ), probability of local patch extinction (ε) and probability of detection (p) as parameters. All combinations of these covariates for all parameters were included in the models, in additive and multiplicative fashion. Additive models included LFCP and CAMP as separate variables, i.e. fitting the model assuming a variable has consistent effect on the parameter; multiplicative models combined LFCP and CAMP, i.e. modelling the situation where the variable 'CAMP's effect on the parameter can change with time period. Models were selected based on Akaike's Information Criterion with lower values of AIC being preferred. Models were assessed based on ΔAIC, the difference between the AIC value of a particular model and the AIC value of the best fitting model. As some models involved fitting a large number of parameters, model output was inspected and those that had failed to reach an adequate convergence were discarded (Mackenzie et al. 2006).

Variability of parameter estimates was relatively low (Fig. 6.4) and indicates that the methods employed here can provide high quality monitoring data for elusive large ungulates. There was no significant change in probability of occupancy (ψ) between the two periods. However, local patch extinction (ϵ) increased significantly between the two periods (Fig. 6.4). This is consistent with stable occupancy as extinction relates to the number of patches occupied in one year that were unoccupied the following year. In this case extinction Pre-LFCP is from sites occupied in 2004 and not occupied in 2005 and occupied 2005 but not occupied 2006 while extinction LFCP relates to those occupied in 2006 but not occupied 2007 and occupied 2007 but not 2008. Recolonisation of patches can occur between these periods and is estimated by the derived parameter γ. γ also increased significantly between the two periods. The implication is that while the overall occupancy of the population remained stable, the population became much more fluid in its distribution during the LFCP period. Why this might be is unclear, but it may represent a population that is increasingly moving into unoccupied territory, perhaps in response to increased forest access in some areas.

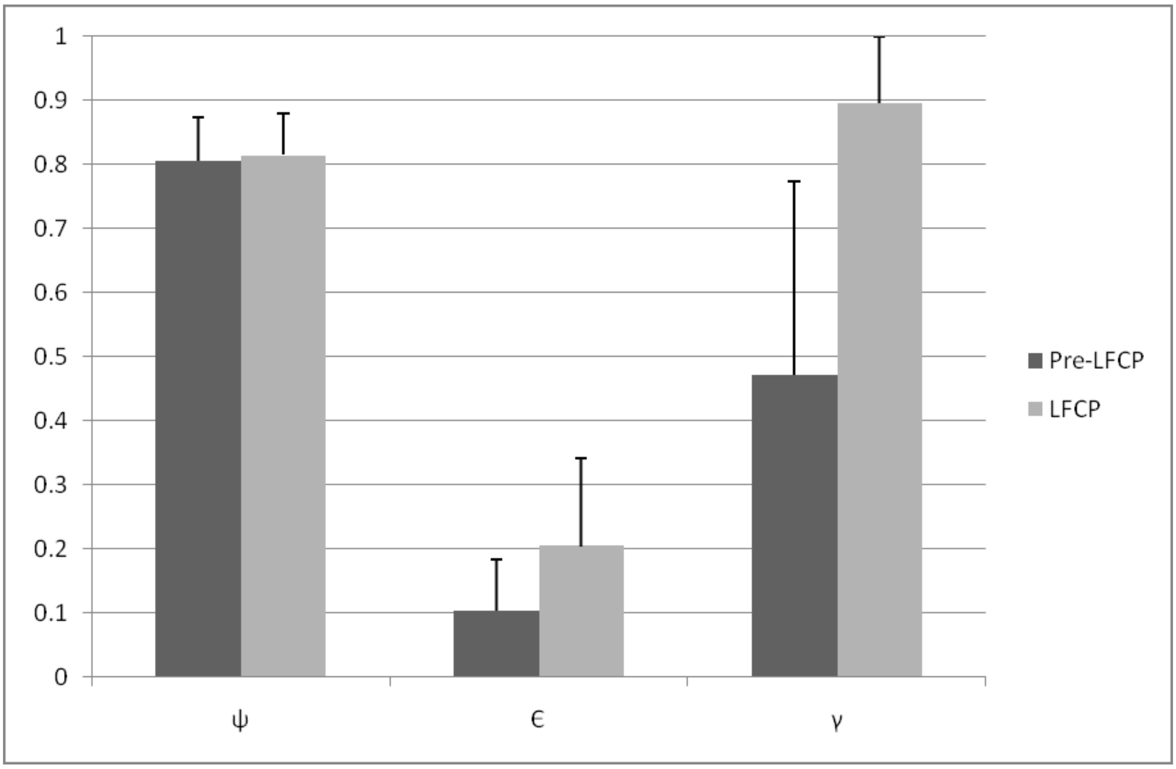

Figure 6.4 Modelled parameter values for probability of occupancy (ψ), probability of extinction (ε) and derived value for probability of recolonisation (γ) based on multi-season occupancy models. Pre-LFCP period is years 2004 and 2005, LFCP period is years 2006-2008 inclusive. Error bars are 95% confidence limits.

Detection probabilities (p) were estimated on a camp-by-camp basis for pre-LFCP and post LFCP periods (Fig.6.5). Error bounds are larger because each estimate is based on a maximum of 12 landscape units as opposed to 72 across all camps. Nevertheless standard errors were relatively small. There were notable declines in p in four of the six camps though these were only significant in the case of Lapago and Lawele, with Wahalaka approaching significance. The largest decline (49%) was in Lapago.

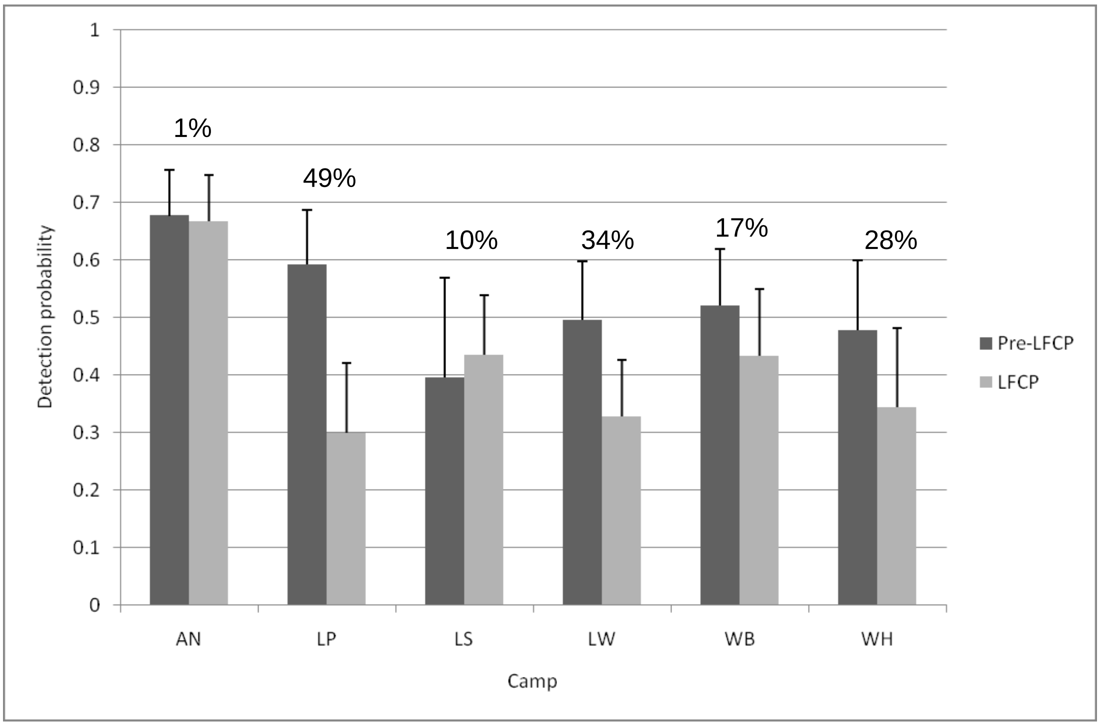

Figure 6.5. Detection probability (p) of anoa in each camp in Pre-LFCP and LFCP periods. Error bars are 95% confidence limits

The relationship between detection probability and abundance is not clear. However, all other things being equal it ought to relate to population density, and the fact that detection probability appears to have declined over the survey period in some areas, but not all suggests that these changes are not simply a response to the increased human presence brought by the biological monitoring teams. It is likely that they represent real declines in the anoa population.

Conclusions

The distribution of anoa in Lambusango appears to be stable, however there is good evidence that the population has declined in the LFCP period. This decline is particularly associated with certain parts of the forest and the work presented here illustrate areas that should be the focus of enforcement efforts.

6.4 Ensuring the population of the Sulawesi Wild Pig shows no long term trend of decline over the period to 2008

The distribution of pig tracks proved extremely variable with some areas having large numbers and others devoid of them. This resulted in substantial variation in occupancy estimates. The best fitting model from a series of candidates (selected as for anoa) was the null model with parameter estimates constant over all camps. There was no evidence for a significant change in either ψ or p (Fig.6.6) though there was a small decline in p over the study period.

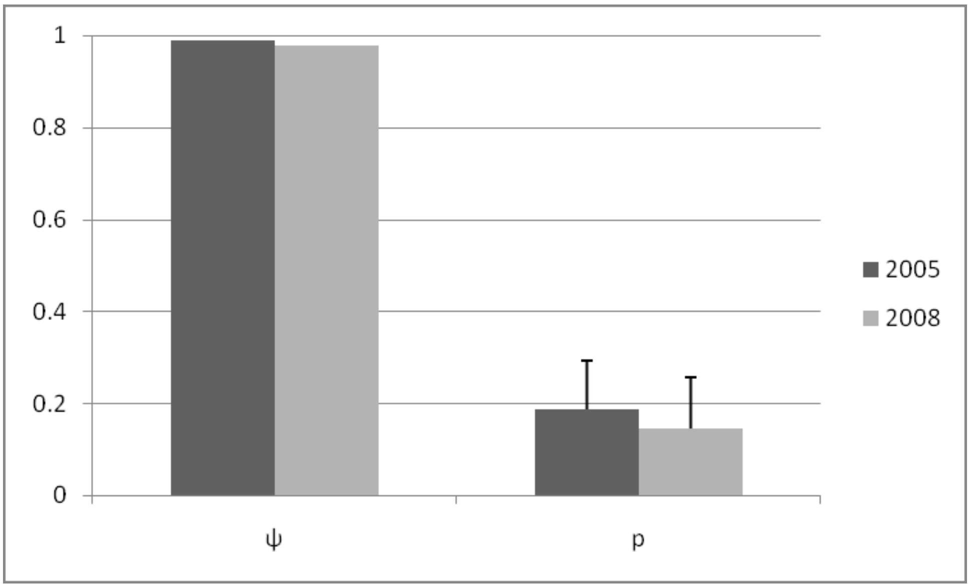

Figure 6.6 Occupancy probability and detection probability of Sulawesi Wild Pig

Occupancy probability remained high, indicating that the species remains ubiquitous though patchy in Lambusango.

Conclusions

The population and distribution of wild pigs appears to be stable in Lambusango. Continued monitoring of hunting is important to ensure that this currently abundant endemic species does not start to decline.