Conservation Comores 2005:

Biodiversity and Resource-use Assessment and Environmental Awareness

Final report

Diagrams, maps and photos removed from this version to conserve file size

A collaborative project organised by the *University of Oxford*, the Comorian *Centre National de Documentation et Recherche Scientifique*, and the Comorian NGOs *Action Comores Anjouan* and the *Association d'Intervention pour le Développement et L'Environnement;* with the support of the *Direction National de l'Environnement et des Forêts* and the *United Nations Development Programme*

Dates: Scoping trip 8th April to 14th April 2005
Main project 30th June to 14th September 2005
Scoping trip for follow-up project 31st August to 9th September 2006

Contact details: hughdoulton@hotmail.com

Doulton, H., Marsh, C., Newman, A., Bird, K. & Bell, M.

The project was marked by a tragedy. Hamidou Ali, one of our key partners in Grande Comore, was killed in a car crash early in the morning of 29th July. As President of the NGO AIDE and Biology Professor at the University of the Comores, Hamidou was a dynamic and successful man. His open, warm manner gained respect and friends wherever he went. He will be greatly missed.
We dedicate the results of our work to his memory.

Doulton, H., Marsh, C., Newman, A., Bird, K. & Bell, M. (2007)
Conservation Comores 2005: Biodiversity and Resource-use Assessment and Environmental Awareness. Final report

Summary

Introduction

The Union of the Comoros is an archipelago of three main islands of volcanic origin situated in the western Indian Ocean. Like most isolated oceanic islands, the Comoros are rich in endemic taxa. These unique taxa are greatly threatened by an expanding population that relies on clearing forest for its livelihood, and the Comoros are therefore classified as part of one of the five 'hottest hotspots' in terms of global conservation priorities. The deforestation also threatens the livelihoods of the Comorian people, with widespread loss of soil fertility and moisture apparent. Despite this, their small size and history of political instability mean that there has been little international conservation intervention on the islands.

Conservation Comores 2005 arose out of the *Oxford University Comoro Islands 1992 & 1994 Butterfly Surveys.* Dr Owen Lewis, leader of those two expeditions, suggested that the surveys be repeated to assess habitat change and consequent changes in butterfly richness. The scope of the project was expanded from there in an effort to reach to the heart of the conservation issues and bring lasting benefit to the Comoros. The final project included butterfly, bird and socio-economic research, and environmental awareness work.

A multi-disciplinary team was recruited and a preliminary plan formulated by the end of October 2004. The University of Oxford team then approached the *Centre National de Documentation et Recherche Scientifique* (CNDRS) and *Action Comores Anjouan* (ACA), both of which committed themselves to the project at an early stage. Hugh Doulton visited the Comoros in April 2005 to meet all partners and aid the last stages of preparation (report available upon request). From there, plans were finalised in full conjunction with ACA and the CNDRS, and with the input of various international advisors and members of the NGO *l'Association pour Intervention en Developpment et l'Environnment* (AIDE), the *United Nations Development Programme-Comoros* (UNDP-Comoros) and the *Direction National de l'Environnement et des Foret* (DNEF). A further week-long visit in September 2006 paved the way for a longer project which is scheduled to begin in October 2007.

Achievements

- Performed over 300 butterfly transect walks and over 200 bird point counts on Grande Comore and Anjouan
- Updated information on the patterns of endemic richness and the status of rare species
- Investigated community attitudes to conservation of the forest and assessed qualitatively the current levels of deforestation and environmental awareness in four villages (two on each island)
- Produced posters and two films to be used in engaging communities in the sustainable use of the forest resource
- Engaged environmental groups from over 30 villages in conservation work
- Established the basis for a longer project by forging strong links with communities, NGOs, and the Governments of the Union and of each island

Results

Bird surveys: On Grande Comore species richness was highest in mature and underplanted forest, where a closed canopy remains, and on the south-eastern slopes of Karthala. Species richness peaks at around 1300m, 500m higher than that found during previous surveys in 1985 and 1989, before decreasing sharply after 1500m at the boundary between mature forest and heath. It therefore appears that the zone of peak species richness has been pushed upward in line with deforestation at lower altitudes. On Anjouan, species richness is highest in areas of forest where large native trees still remain and, again, there is a humped relationship with altitude with species richness peaking at mid-altitudes. The critically endangered Anjouan Scops Owl was found to inhabit even highly degraded areas of forest, suggesting that it may be at less risk than previously thought.

Butterfly surveys: On Grande Comore, there had been a significant upwards shift in abundance across six endemic species since 1992, showing that deforestation at low altitudes is restricting the range of the threatened endemic species. Individual transects where habitat had degraded from underplanted to secondary forest had also suffered a significant decrease in endemic richness compared with transects that had remained underplanted since 1992. The south-eastern slopes of the island were the highest in endemic richness. On Anjouan, endemic richness peaked at around 800m. Some endemic species preferentially inhabit plantations and peak in abundance below the start of the forest, whilst others are virtually confined to what little remains of the forest. It therefore appears that some of the endemic species on Anjouan have been able to adapt to non-forest habitats and so are unlikely to be under threat, whilst those restricted to forest habitats should be considered highly threatened.

Socioeconomic surveys: The economic situation and population pressure were the most often-cited reasons for ongoing deforestation in all four villages where we worked (Djoumoichongo and nKourani-Sima on Grande Comore; Mjumvia and Lingoni on Anjouan). The scale of deforestation varies from constant timber removal on the south-eastern slopes of Grande Comore, to gradual degradation of the little remaining forest on Anjouan as new fields are gazetted. Environmental awareness differed markedly between the two islands. The lack of previous environmental awareness work on Grande Comore meant that most people were unaware of the long-term problems deforestation might be causing and many believed that the forest was an infinite resource. However on Anjouan, the problems caused by deforestation are all too evident to the people, and there was also a more positive attitude towards forest protection. The general consensus across both islands was that the government did not have the capacity to enforce forest protection, and the view that government action would ignore community needs was also widespread. Community-led action was thought to be a better option, with the most frequent suggestions being tree planting and generation of incomes not dependent on forest exploitation. Detail on the substance and implementation of these solutions was, in general, lacking.

Awareness work: Posters and films showing the value of the forest were produced with the input of local communities and all partners. These will be used as part of a community engagement strategy envisaged for the longer-term project. A training day was held on each island for members of a total of about 30 village environmental groups (Ulangas) drawn from villages impacting directly on the forest. The problems caused by deforestation and the possible solutions were discussed in detail and the participants urged to work to transmit the messages to their communities.

Conclusions and Recommendations

- The situation on Anjouan is urgent as deforestation continues and ensuing problems mount. There is far more forest left on Grande Comore, but deforestation is advancing at a rapid pace. Forest protection measures must be implemented soon if biodiversity and ecosystem functions are to be maintained.

- One aim of protection would be to conserve as full a complement of the Comorian fauna and flora as possible. We base recommendations on three months of bird and butterfly surveys and a study of the literature of earlier surveys of these two taxa – further focal taxa research is needed before concrete biodiversity recommendations can be made.

- On Grande Comore, an exclusion reserve would best be located on the south-eastern flanks of Karthala, where a large amount of relatively intact native forest remains and species richness is at its highest for birds and butterflies. On Anjouan, a reserve would most easily be located around Mt. Ntingui, but there is such a small amount of native forest left that any remaining patches should be considered for protection.

- More detailed socioeconomic research is needed to investigate the attitudes of all stakeholders to conservation, and the levels of deforestation and environmental awareness. A public engagement strategy can then be devised, using the materials of this preliminary project as a starting point.

- Maps of land ownership are necessary if a system of land-use zoning is to be devised. These can then be used to discuss plans for management of forest under each community's control. Community plans can then be merged into island forest management plans.

- Effective long-term efforts to reduce deforestation will have to include consideration of alternative economic options (both livelihood and direct payment), the population issue, agricultural improvements, afforestation options, improving and enforcing forestry legislation and land tenure arrangements, and the best protected area options. Much time will have to be invested in conflict resolution and in tailoring solutions to the specific circumstances of different situations.

- These recommendations form the basis of a long-term project fronted by Bristol Zoo Gardens that will begin in October 2007 as a direct outcome of this expedition. The project will be supported by academics from the University of Oxford and will work in partnership with the World Bank, the UNDP, the Comorian government and local NGOs.

Contents

Team members

University of Oxford

Leader	Hugh Doulton	Biological Sciences student
Photographer	Charles Marsh	Biological Sciences student
Translator	Anneke Newman	Human Sciences student
Treasurer	Katie Bird	Human Sciences student
Medical and Safety Officer	Mark Bell	Politics & Philosophy student
Home Agent and Advisor	Dr Owen Lewis	Department of Zoology

Grande Comore

Ibrahim Yahaya	Head of Biodiversity Research at the CNDRS
Hachime Abderemane	Focal point for UNDP biodiversity project

AIDE

President	Hamidou Ali	Biology professor at the University of the Comoros
Secretary	Said Ahamada	
Technician	Mouhoutari Ahamada	

Anjouan

Action Comores Anjouan

Co-ordinator	Mohammed Fahar Eddine Moutui
Assistant Secretary	Hamid Ahmed
Assistant Co-ordinator	Halidi Ahmed
Statistician	Mahamoud Boina
Driver	Bacar Halifa
Secretary	Said Azilani Musbahou
Head Research Technician	Ishaka Said
Research Technician	Abdou Salim
Assistant Secretary	Assiate Salim
Administrator	Nassuri Toilibou

Abbreviations used in the text

A: Anjouan

ACA: Action Comores Anjouan

AIDE: Association d'Intervention pour le Développement et L'Environnement

BA: British Airways

BP: British Petroleum

CBD: Convention on Biological Diversity

CNDRS: Centre National de Documentation et Recherche Scientifique

DEFRA: Department for Environment, Forestry and Rural Affairs (UK government)

DNEF: Direction National de l'Environnement et des Forêts

EEP: Environmental Education Programme

FADC: Fonds d'Appui au Développement Communautaire

GC: Grande Comore

GDP: Gross Domestic Product

GEF: Global Environment Facility

GIS: Geographical Information System

GLM: General Linear Model

GPS: Global Positioning System

IMF: International Monetary Fund

IUCN: International Union for the Conservation of Nature

KMF: Comorian Franc

LFF: Livingstone's Flying Fox

NGO: Non-Governmental Organisation

PRA: Participatory Rural Appraisal

RGS: Royal Geographical Society

UN: United Nations

UNDP: United Nations Development Programme

WHO: World Health Organization

Background

1. Geography

The Comoros archipelago consists of four main islands of volcanic origin situated in the Mozambique Channel, approximately 300km equidistant between Madagascar and Mozambique. They lie between the southern latitudes of 11º20' and 11º4', and 43º11' and 45º19' longitude (Battistini and Verin, 1984). Grande Comore, Anjouan and Mohéli today from the Union of the Comores, whilst Mayotte remains under French administration as the 'Collectivité départementale de Mayotte'. The population of the islands excluding Mayotte was estimated at 768000 in 2003 (UN, 2003). Conservation Comores worked on two of the islands: Grande Comore and Anjouan.

Figure 1. Location of the Comoro Islands © Google Earth

Grande Comore, with a surface area of 1148km^2 and a highest point at 2361m, is the youngest, largest and highest island in the archipelago. Annual rainfall rises from 1500m on the dry north coast to 5900mm in the forest on the west slopes of Mount Karthala (Battistini and Verin, 1984). Three vegetative zones exist: (i) in the hot and humid coastal zones below around 800m the land is dominated by exotic plantations, such as coconut *Cocus nucifera*, degraded forest and coastal scrub. (ii) Above 800m tropical rainforest remains, although much is underplanted by bananas at lower altitudes and occasionally up to a height of 1400m. Pristine forest remains only at high altitudes. (iii) Above approximately 1750m the forest is replaced by giant heath, *Phillippia comorensis*, to the summit of Karthala. The latest population census from

1998 gives a population of c. 300,000 at a density of just over 260 people/km^2 (Louette et al., 2004). The population continues to expand, pushing agriculture and timber extraction further and further up the slopes.

Figure 2. Map of Grande Comore showing an approximation of remaining forest cover. Taken with permission from Louette et al. (2004).

Anjouan has a much smaller surface area of 424km^2, culminating at an altitude of 1595m with some very steep mountain slopes. Rainfall ranges from 1400mm on the south-east coast to 2700mm on the south-west coast (Battistini and Verin, 1984). A population estimate of c. 260,000 means that population density is over double that of Grande Comore, and pressure on natural habitats and resources is severe (Louette et al. 2004). It thus has the smallest remaining area of primary forest, restricted to inaccessible mountain slopes. Much of the rest of the forest is very heavily degraded and plantations and overexploited, infertile soils cover most of the island.

The islands have a tropical climate, with a hot, wet season from November to April and a slightly cooler, drier season from May to October. Monthly mean temperatures on the coast vary from 23 to 27^{o}C (Battistini and Verin, 1984).

Figure 3. Map of Anjouan showing an approximation of remaining forest cover. Taken with permission from Louette et al. (2004).

2. Political situation

Ngazidja (Grande Comore), Mwali (Mohéli) and Ndzuani (Anjouan) gained their independence from France in 1975 to from the Federal Islamic Republic of the Comoros. A substantial number of actual and suspected coups, and disagreements regarding the balance of administrative power across the three islands have resulted in years of political turmoil since independence (Pitcher and Wright, 2004). These culminated in August 1997 with Anjouan’s declaration of secession from the Comoros. The then President of the Republic of the Comoros responded with an armed invasion of Mutsumudu and over 100 people were reportedly killed in the fighting. The invasion failed to restore Anjouan to the Comoros and only extensive talks organised by the Organisation for African Unity and the UN eventually brought agreement three years later in August 2000 (Harrison Church, 2005).

The accord drawn up provided for the implementation of a new constitution that would allow the three islands considerable control of their own affairs, but with the central government retaining overriding control of foreign affairs, external defence, currency, nationality and religion. In 2001 three quarters of the electorate voted in favour of the proposed new constitution and the islands became the Union of the Comoros (Harrison Church, 2005). The situation has been much calmer since then, and peaceful elections in 2006 voted in a second government.

3. Economic situation

Agriculture is the dominant economic activity in the Comoros, making up 39.9% of GDP in 2004 (IMF, 2004), with the major export crops being vanilla, cloves and ylang ylang. The majority of production occurs in Anjouan and has been significantly hampered by the political unrest. The price of vanilla has been negatively affected by competition from Madagascar and Indonesia and from synthetic substitutes, whilst the world clove market virtually collapsed in the mid 1980s although prices increased substantially in 2000. Prices for ylang ylang have remained generally favourable although ageing plantations and inadequate processing equipment means that the industry is not working to its full capacity (Harrison Church, 2005).

In general the recent political instability, poor infrastructure, erratic power and water supplies, limited road systems and a lack of reliable transportation links between the islands and the outside world all impede economic development, and the World Bank currently only funds through community initiatives. These problems also mean that the islands have only a small and fragile tourist industry, although restaurants and hotels make up 24.6% of GDP (IMF, 2004).

The Government's failure to adhere to the IMF and World Bank structural adjustment programme in 1994 resulted in France suspending budgetary assistance, although it later agreed to provide aid for projects in social and education sectors. Various other aid projects have been funded by the USA, Britain, and a number of states in the Middle East. However, political instability continues to discourage international investment and aid (Harrison Church, 2005).

All of this means that the Comoros are struggling with poverty and the Human Development Index of 2002 ranked the Comoros at 136 out of 177 countries (UNDP, 2002). The population continues to expand rapidly, exacerbating the problems: total fertility rate (the number of births a woman can expect to have throughout her reproductive years) in 2002 was estimated to be 4.9 (WHO World Health Report 2003).

4. The Biodiversity

The Comoros contain an extremely high concentration of endemic fauna and flora (Myers et al., 2000), and the islands are designated as a hotspot of bird endemicity by Birdlife International (Birdlife International, 2004). There are 47 species listed in the Red Data Book, including 12 birds and butterflies, three of which are classified as critically endangered (the three Scops Owls, *Otus sp.*), and four of which are classified as endangered (two butterflies, *Graphium levassori* and *Papilio aristophontes*, and two birds, *Dicrurus fuscipennis* and *Humblotia flavirostris*) (IUCN, 2004). It is likely that many more endemics are severely threatened, as they tend to inhabit the depleted rainforest habitat (Lewis et al., 1997, Louette et al., 2004). It is crucial that conservation action on the Comores is improved very soon if these species, and as yet undiscovered species, are to be saved from extinction (Louette et al., 2004).

5. The threats

All fertile land in the Comoros is already under use, and the needs of a rapidly growing population mean that further agriculture encroaches upon remaining forest (UNDP et al., 2000; Louette et al., 2004). Forest area, already vastly depleted, receded at an annual rate of 5.8% between 1990 and 1995, the fourth highest of any country (Mohammed Said 2000). With a lack of economic alternatives, the Comorian people have no option but to cut down the remaining forest either to make new fields or to sell timber for money. The deforestation is putting at risk the many endemic and IUCN Red List species and Louette et al. (2004) note that the 'environmental situation is urgent, and needs to be addressed if significant areas of natural habitat are to remain'. All of which means that the islands are designated as part of one of the five 'hottest hotspots' regions in terms of global conservation priorities (Myers et al., 2000).

6. Conservation plans

Despite the severe nature of the problems, international conservation or development intervention has been lacking. In 2000, the Comorian Ministry for the Environment, in collaboration with major global conservation bodies such as the IUCN and the UNDP, and all the environmental organisations on the Comoros, published a report highlighting the urgent need for conservation on the islands and proposing measures to prevent biodiversity loss. Forest depletion is causing severe erosion and greatly affecting water retention, causing major agricultural problems (UNDP *et al*., 2000). The National report to the Convention on Biological Diversity (CBD) notes the efforts being made by the Environment ministry, the CNDRS and various NGOs to protect the forest environment, but goes on to say that these efforts are inadequate due to 'severe financial and material constraints' (Mohammed Said 2000 and 2005).

In 2004 a proposal was submitted to open GEF funding for the Comoros. The large-scale project aimed to create a network of six terrestrial and marine reserves on the Comoros (one marine park already exists on Mohéli) and improve food security and sustainability of natural resource-use. However, the proposal was shelved as the international community was then unwilling to fund through the Comorian government and it was felt that there was a lack of community involvement in the plans. It is thought that the proposed project will not be implemented for, at the least, several years, yet the situation is so urgent on Anjouan that such a delay in action could be critical if any worthwhile areas of natural habitat are to be preserved.

7. Aim

To contribute to conservation efforts and the development of conservation plans in the Union of the Comores, through biological and resource-use surveys and environmental awareness work, in order to address the problem of rainforest degradation and potential species extinction.

8. Original Objectives

1) To identify the habitats and localities richest in birds and butterflies on Grande Comore and Anjouan, focusing on endemic and Red Data Book species. We will investigate whether patterns in species richness can be related to vegetation type, land use and altitude, and whether the results for the two taxa are consistent.

2) To provide distribution data for endemic butterflies to international conservation bodies and the Comorian government, so that areas of highest richness and or Red Data Book taxa can be considered for inclusion within proposed reserve boundaries; and to provide data on endemic bird ranges to Dr Michel Louette (Royal Museum for Central Africa, Belgium), as a contribution to an important bird area atlas of Comorian birds, to be published in 2007.

3) To quantify changes in the abundance of birds (since 1985), and butterflies (since 1992) on Grande Comore, in relation to changes in vegetation-type and land-use.

4) To train Comorians in survey techniques with a view to establishing a long-term monitoring scheme.

5) To interview local farmers and villagers to assess factors affecting agricultural yields and land-use, with a view to providing data and ideas to support sustainable use of forest around future reserve areas.

6) To raise conservation awareness by working with, and providing resources for, grass-roots environmental organisations known as Ulanga, and by collaborating with the University of the Comoros.

Of these, we were unfortunately unable to repeat the exact bird surveys of 1985 due to time constraints, nor to include students in the work as we felt that would have overstretched our capacity. Development of plans for the resource-use surveys and the awareness work are detailed in the Participatory Rural Appraisal section and environmental awareness sections respectively.

Bird Surveys

1. Introduction

The birds of the Comoro Islands were largely unstudied until the first major scientific expedition was carried out by Benson in 1958 (Benson, 1960). This expedition took great steps in determining the taxonomic status of many species. Since then, work has focussed mainly on Grande Comore, with the majority of data collected in two expeditions by the Belgian Royal Museum for Central Africa (Louette *et al.*, 1988 and 1989). These expeditions did much to identify patterns of distributions and abundances of key endemic species, distinguishing critical areas for conservation (Bijnens *et al.*, 1987; Louette, 1988, 2000; Louette *et al.*, 1988, 1989, 1992, 2004; Stevens *et al.*, 1993, 1995).

The birds of Anjouan have been even more neglected than those of Grande Comore. Most work has focussed on the critically endangered Anjouan Scops Owl, *Otus capnodes*, since its rediscovery in 1992 (Safford, 1993; Moorcroft, 1995). Whilst the avifaunal list is thought to be largely complete, patterns of species richness and distributions of endemic species remain unknown.

The work of this report therefore sought to fill in some of the gaps in our knowledge of the birds of the Comoros: identifying the patterns of current species richness on Grande Comore and Anjouan, and comparing these with those found on previous expeditions and with those of butterflies. The results could then be combined to suggest appropriate strategies for conserving the avifaunal biodiversity of the Comoros.

Grande Comore is the centre of endemism of the four islands. Five island endemics exist, of which four are confined to the slopes of Karthala: *Otus pauliani, Humblotia flavirostris, Zosterops mouroniensis* and *Dicrurus fuscipennis*. *Nesillas brevicaudata* can also be found on La Grille, a 1087m crater to the north of Karthala. There are a further four species endemic to the Comoros archipelago and 16 endemic subspecies (*Butorides striatus,* a coastal species, and *Cyanolanius madagascarinus* which has not been observed since 1982 are not included). The endemic species are thought to have arrived in a double invasion, the first from mainland Africa, followed by a second wave of Madagascan origin (Louette, 2000). There are also 16 resident non-endemic species which are largely confined to the non-forested lower slopes, and are thought to have colonised the islands only after the arrival of humans.

In contrast Anjouan has only one island endemic species, *O. capnodes*, which was rediscovered in 1992 (Safford 1993), and a further three Comorian endemics: *Columba polleni*, *Turdus bewsheri*, and *Alectroenas sganzini*. A population of *A. sganzini* also exists on Aldabra, however here it will be considered as a species endemic to the Comoros.

2. Methods

Bird surveys

Surveys were carried out using point counts modified from Louette *et al.* (1985). All birds seen or heard within a fixed 50m radius were recorded over a fifteen-minute period. Individuals at a distance greater than 50m or which were judged to be simply passing through the point were disregarded in order to minimise the chances of double counting. Furthermore, points were located at least 200m, or 300 paces apart. Individuals were placed into four distance zones: 0-5m, 5-15m, 15-30m and 30-50m. Surveys were carried out between 06:00 and 10:00 when weather conditions were dry and calm.

The Madagascar Fody, *Foudia madagascariensis*, and the closely related Comoro Fody, *F. eminentissima*, were distinguished only to genus-level. The two species are very similar in non-breeding plumage and could not always be separated in counts. Additionally, Moorcroft observed individuals intermediate between the two on Anjouan, and hypothesised that hybridisation may be taking place, as is known to occur with *F. madagascariensis* and *F. omissa* in Madagascar (Moorcroft 1995). They are treated here as an endemic subspecies, as *Foudia eminentissima* dominates in forested areas and so it is expected that the majority of fodies recorded represented this species. Nocturnal species (*Otus spp*.) were not surveyed in this study, unless seen roosting within the point count.

Habitat type, canopy height, altitude, weather, cloud cover, time and GPS coordinates were all recorded.

On Grande Comore, habitat was classified into seven categories:

(i) Mature forest;

(ii) Underplanted forest, where banana trees have been planted beneath a primary canopy;

(iii) Regenerating forest Type A, which is dominated by the invasive shrub *Psidium cattleianum*;

(iv) Regenerating forest Type B, which is dominated by the invasive shrub *Clidemia hirta*;

(v) Pioneer forest on old lava flows;

(vi) Tree heath, dominated by the giant heather, *Phillipia*;

(vii) Plantations, where a native canopy no longer remains.

127 surveys were carried out from 17th to 28th July and 1st to 12th September at seven locations around Karthala and La Grille, limited by the difficulty of access to the forest. At least 15 points were carried out at each location over several days and every habitat was surveyed. Efforts were concentrated within the remaining forest, and habitats found immediately above or below.

On Anjouan, four habitat categories were identified:

(i) Mature forest;

(ii) Affected forest, which included both underplanted forest and regenerating forest, as *P. cattleianum* and *C. hirta* were rarely encountered;

(iii) Plantations;

(iv) 'Padza' (over-exploited agricultural land, turned arid with little fertility and few or no trees).

109 surveys were carried out between 5th and 27th August from sea-level to 1600m in all habitats at eight locations around the island.

Extensive pre-expedition training took place using *Birds of the Indian Ocean Islands* (Sinclair and LanGrand, 2003) and audio training from *Guide sonores des Oiseaux nicheurs des Comores* (Herremans, 2001). In addition, there was one week of familiarisation before surveys were started.

Comparisons with butterflies

109 of the bird points (61 on Grande Comore and 48 on Anjouan) were situated near to the middle of a 170m butterfly transect. These crossovers were as far as possible distributed evenly through habitats and altitudes, but due to difficulty in access and navigation some clumping occurs.

For the comparison analyses, where there were discrepancies between the habitat category for birds and butterflies, the habitat category chosen for the butterfly surveys was chosen as it is based upon the transect as a whole and so is assumed to be more representative than the bird points. The altitude recorded for the bird surveys was chosen as a mid-point for the transect.

Statistical analyses

Grande Comore and Anjouan were treated separately in all analyses. Species accumulation curves were determined for each habitat to ensure that there had been appropriate levels of sampling effort. On Grande Comore, points in the Regenerating B forest were discarded due to insufficient sampling effort. Bird and butterfly species richness were transformed via square rooting before statistical analysis. The General Linear Model (GLM):

$$\sqrt{(Y + 0.5)} = \text{Altitude}|\text{Altitude} + \text{Habitat} + \text{Location}$$

was fitted for three different response variables, each a different level of species richness using the Sequential Sum of Squares:

(i) **Total Endemics** - Total number of all endemic species and subspecies.

(ii) **Non-endemics** - Total number of species not endemic to the Comores

(iii) **Total Species** - Total number of all species recorded.

Total species is most commonly used as the variable of interest in this report even though only the endemics species are of conservation importance, as this is consistent with previous work on the Comoros. However, in forest habitats total species richness is equivalent to endemic richness due to the negligible occurrence (if at all) of non-endemic species. It can therefore be used as a reliable variable to assess conservation priorities.

Habitat and location were compared separately for species richness using *post hoc* Tukey pairwise comparison tests. Patterns of total species richness, endemic richness and non-endemic richness were determined by plotting the fitted values from the GLM analyses against altitude. Bird and butterfly total species richness and endemic richness were compared using Pearson Correlations.

Carroll and Pearson (1998) outline a technique for accounting for problems associated with spatial autocorrelation in collecting data. For this study, it was decided that although some clumping inevitably occurred due to the difficulty in accessing the forest, point counts were located far enough apart to be reasonably independent.

3. Results

Grande Comore

The quadratic term for altitude was found to be a highly significant predictor of species richness. Habitat and location were also significant in all cases. The F-ratios and p-values for the three level of species richness are summarised in Table 1.

Table 1 – A summary of F-ratios and P-values for the three different levels of species richness for each explanatory variable in the GLM for Grande Comore. Grey squares indicate non-significant results in the model.

		Total Endemics	**Non-Endemic**	**Total Species**
Alt	$F_{1,96}$	3.35	54.51	0.17
	P-value	0.070	<0.0005	0.679
Alt*Alt	$F_{1,96}$	70.98	28.08	57.39
	P-value	<0.0005	<0.0005	<0.0005
Habitat	$F_{3,96}$	8.10	6.37	6.12
	P-value	<0.0005	<0.0005	<0.0005
Location	$F_{7,96}$	2.98	3.93	3.96
	P-value	0.010	0.001	0.001

Species Richness and Altitude

There is a significant quadratic relationship between species richness and altitude. Total species richness increases with altitude, peaking around 1300m (as does endemic species richness), then decreasing sharply after around 1500m at the boundary between mature forest and heath (Figure 1).

Non-endemic species richness is greatest at the lowest altitude surveyed, 400m. Non-endemic richness subsequently decreases non-linearly with altitude. No non-endemics were recorded above 1000m (Figure 2).

Species Richness and Habitat

Underplanted forest has the highest endemic richness and the highest total species richness, although not significantly greater than the other habitats (Figure 3). Mature forest also has high species richness. The total species richness is comprised entirely of endemics with no non-endemics recorded in the mature forest. Although lower than that of underplanted forest, species richness is still considerably higher than that of the other forest habitats (pioneer, regenerating and plantation) and heath. Heath, pioneer forest, regenerating forest, and plantation all have similar total species richness.

In contrast, non-endemic species are significantly more abundant in more open habitats: pioneer, regenerating forest, and plantation (Figure 4). Plantation has the greatest richness of non-endemics, while also having the lowest richness of endemic species. Non-endemics were completely absent from heath and mature forest, and mostly absent from underplanted forest.

Fig. 1 – Plot of fitted values against Altitude for Total Species richness on Grande Comore

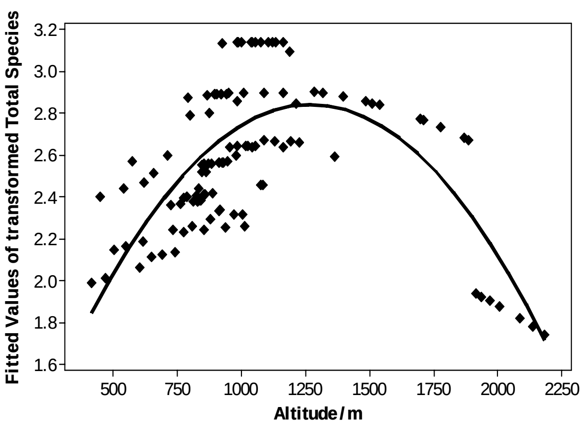


Fig. 2 – Plot of fitted values against Altitude for Non-endemics on Grande Comore

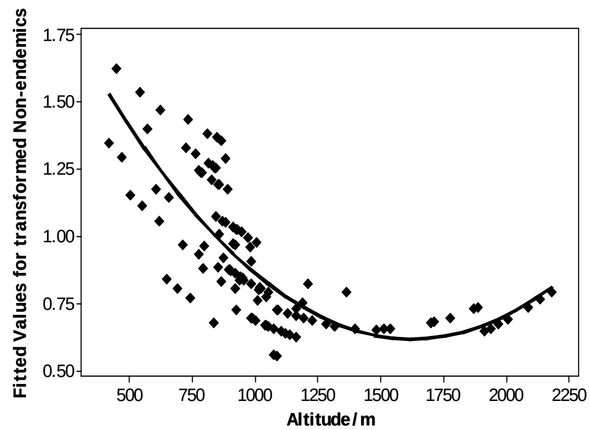


Fig. 3 – Interval Plot for Total Species against Habitat for Grande Comore with 95% CI for mean

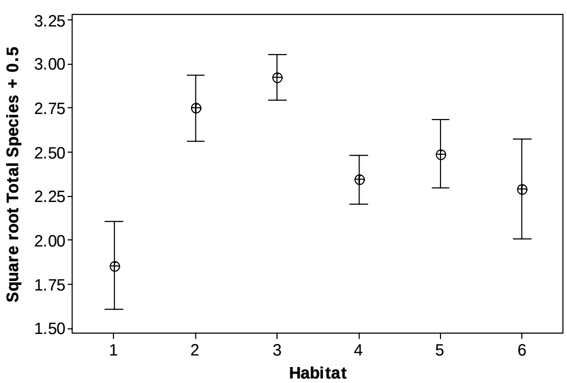
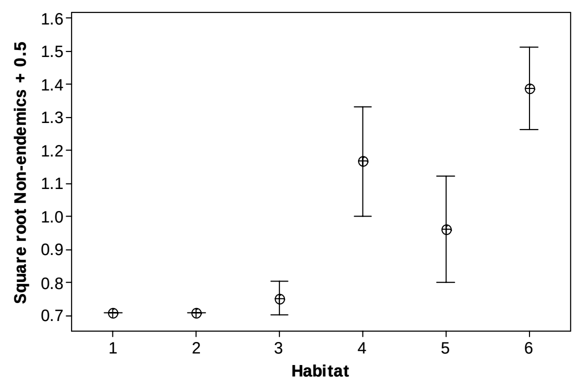


Fig. 4 – Interval Plot for Non-endemic Species against Habitat for Grande Comore



Key: 1 - Heath (n = 7), 2 - Mature (n = 20), 3 - Underplanted (n = 35), 4 - Pioneer (n = 23), 5 - Regenerating A (n = 23), 6 - Plantation (n = 11)

Fig. 5 – Interval Plot for Total Species against Location for Grande Comore with 95% CI for mean

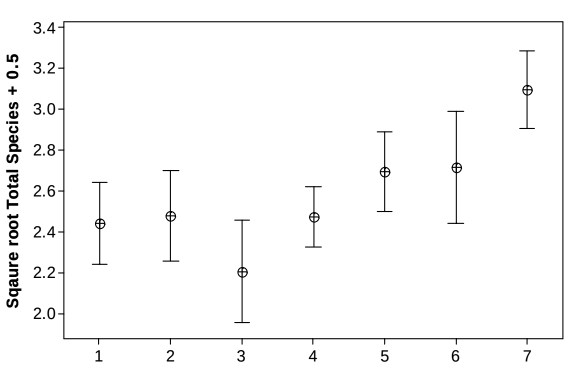
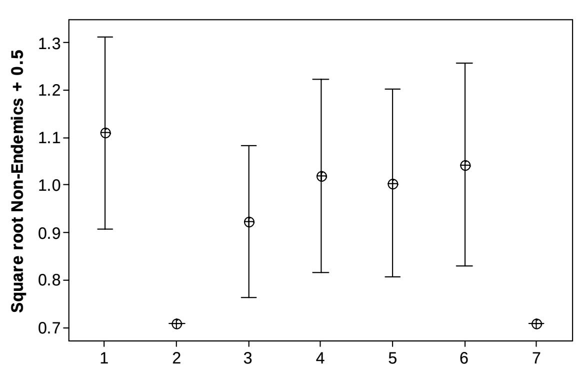


Fig. 6 – Interval Plot for Non-endemic Species against Location for Grande Comore with 95% CI for mean



Key: 1 - Bahani (n = 18), 2 - Convalescence (n = 25), 3 - Nioumbadjou (n = 16), 4 - Kourani (n = 15), 5 - La Grille (n = 17), 6 - Mvouni (n = 18), 7 – Tsinimouapanga (n = 16)

Species Richness and Location

Tsinimouapanga, on the wetter south-east slope of Karthala has the greatest total species richness and endemic richness, although the difference is only significantly greater than for Bahani and Kourani (Figure 5). La Grille and Mvouni, which both have a large amount of underplanted forest also have a high total species richness. Nioumbadjou, which is dominated by pioneer forest, has the lowest total species richness. Convalescence is an important site for endemic species, as would be expected for a site dominated by heath and mature forest.

No non-endemic species were recorded at Tsinimouapanga or Convalescence. Bahani had the greatest non-endemic species richness, but all the other four locations had similar non-endemic richness (Figure 6).

Anjouan

Altitude was found to be a significant predictor of species richness. Habitat and location were also significant in all cases except for location with regard to non-endemic species. The F-ratios and p-values for each level of species richness are summarised in Table 2.

Table 2 – A summary of F-ratios and P-values for the three different levels of species richness for each variable in the GLM for Anjouan. Grey squares indicate non-significant results in the model.

		Total Endemics	Non-Endemics	Total Species
Alt	$F_{1,96}$	0.25	55.88	8.95
	P-value	0.616	<0.0005	0.004
Alt*Alt	$F_{1,96}$	18.55	3.63	20.61
	P-value	<0.0005	0.060	<0.0005
Habitat	$F_{3,96}$	5.94	2.78	3.70
	P-value	0.001	0.045	0.014
Location	$F_{7,96}$	2.80	1.30	2.22
	P-value	0.011	0.258	0.039

Species richness and altitude

There is a significant quadratic relationship between species richness and altitude. Total species richness increases with altitude, peaking between 600 and 800m (Figure 7), then declining after around 1000m. Species richness is greater at lower altitudes than at very high altitudes.

Endemic species richness is negligible at low altitudes (Figure 8). Endemic richness increases with altitude, peaking slightly higher than total species richness, at around 800-1000m. After this level, endemic species richness declines, but remains greater than at very low altitudes.

Non-endemic richness decreases with altitude, and was highest at sea-level (Figure 9). Non-endemic species are found up to 1000m, and even occasionally above 1200m.

Species Richness and Habitat

Species richness on Anjouan follows a similar pattern to Grande Comore (Figure 10). As on Grande Comore, affected forest (a combination of underplanted forest and regenerating forest) has the greatest endemic richness and consequently total species richness. Surprisingly, however, mature forest has the lowest total species richness of the four habitats, even lower than padza.

Similarly, non-endemism follows the pattern found on Grande Comore (Figure 11). The richness of non-endemics increases with increased habitat disturbance. Non-endemics are rarely recorded in mature forest, whereas they are most abundant in padza.

Species Richness and Location

Moya has the greatest species richness and endemic richness, along with Lingoni, Ouzini and Paje. Dindi, which has a large amount of mature forest, has the lowest species richness. None of the differences are significant (Figure 12).

Dindi and Lingoni, which both share a large amount of mature forest, have the lowest richness of non-endemic species. Moya, Ouzini and Paje have the highest total species richness, endemic richness and non-endemic richness.

Comparisons between bird and butterfly species richness

On Grande Comore, Pearson correlations of total birds species richness against total butterfly species richness ($r = 0.018$, $n = 61$, $P = 0.892$), and endemic butterfly species richness against endemic butterfly species richness ($r = 0.578$, $n = 61$, $P = 0.578$) were insignificant.

This was also the case on Anjouan: Pearson correlations were insignificant between butterfly and bird total species richness ($r = 0.162$, $n = 48$, $P = 0.272$) and endemic species richness ($r = 0.267$, $n = 48$ $P = 0.067$). However, this last correlation is only marginally insignificant, so caution should be taken in its interpretation.

Fig. 7 – Plot of fitted values against Altitude for Total Species richness on Anjouan

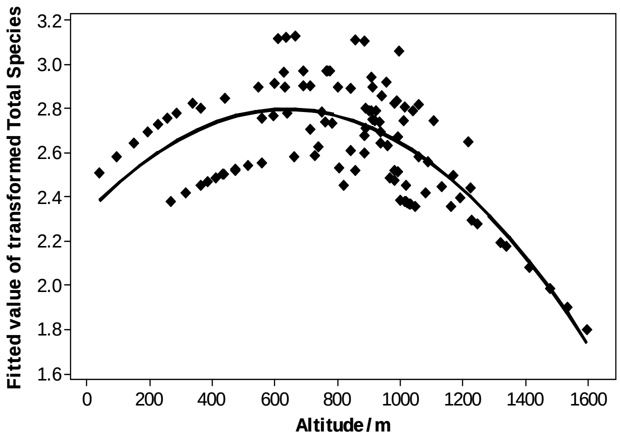


Fig. 8 – Plot of fitted values against Altitude for Endemic Species on Anjouan

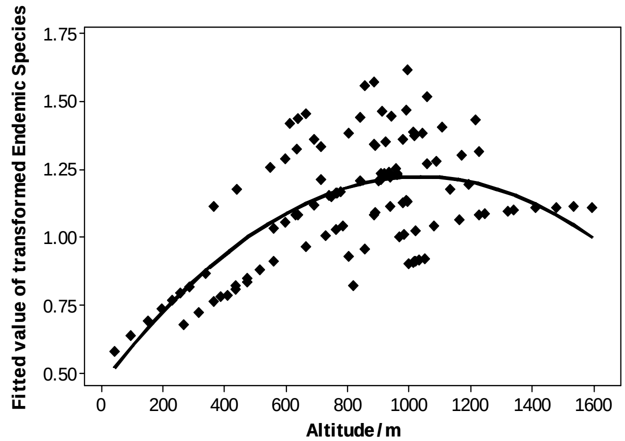


Fig. 9 – Plot of fitted values against Altitude for Non-endemic richness on Anjouan

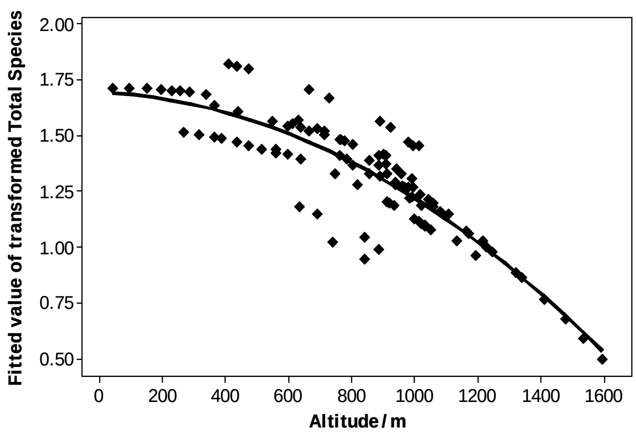
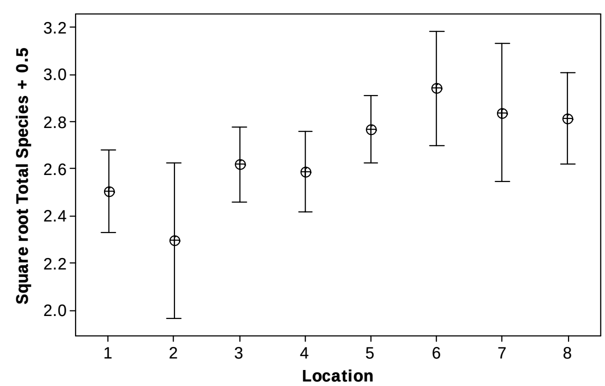


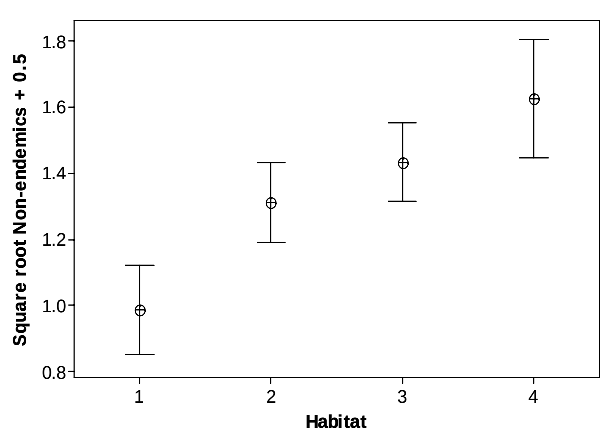
Fig. 12 – Interval Plot for Total Species against Location for Anjouan with 95% CI for mean



Key: 1 - Basimini (n = 17), 2 - Dindi (n = 14), 3 - Hombo (n = 16), 4 – Koni (n = 21), 5 – Lingoni (n = 6), 6 – Moya (n = 15), 7 – Ouzini (n = 5), 8 – Paje (n = 15)

Fig. 10 – Interval Plot for Total Species against Habitat for Anjouan with 95% CI for mean

Fig. 11 – Interval Plot for Non-endemics against Habitat for Anjouan with 95% CI for mean



Key: 1 - Mature (n = 23), 2 - Affected forest (n = 33), 3 - Plantation (n = 43), 4 – Padza (n = 10)

4. Discussion

Grande Comore

Species richness and altitude

The lower boundary of underplanted forest and mature forest is around 800m. We would expect the zone of highest species richness to be at this lower altitudinal band of native forest as this pattern was found by Stevens et al (1993) from data collected in 1985 and 1989. In that study species richness peaked at around 800m, decreasing after around 1700m. However, in the current survey, species richness peaked at around 1300m, 500m higher than that found by Stevens. It appears that the zone of peak species richness (and consequently endemism) has been pushed upwards. Degraded habitats were found occurring up to 1200m, just below the height at which species richness was at its greatest. The zone of highest species richness now occurs much closer to the altitude at which species richness starts to decrease, estimated to be at around 1700m in both this study, and that of Stevens. This would suggest that human pressure on the forest has increased since the 1985 and 1989 surveys, with deforestation and underplanting occurring at higher altitudes.

Species richness and habitat

Underplanted forest has higher species richness than mature forest. It is possible that this is because underplanted forest maintains a closed canopy like mature forest but occurs at lower altitudes. Stevens (1992) observed that species richness decreases linearly with altitude, and so we might expect that species richness would be naturally greater in forest habitats at lower altitudes than similar forest at higher altitudes (see below for a further discussion). Certainly, two endemics, the Cuckoo-roller, *Leptosomus discolor*, and the Grande Comoro Drongo, *Dicrurus fuscipennis*, both known to favour lower altitudes, were recorded in underplanted forest but not in mature forest.

Regenerating forest remains higher in species richness than might be expected, as the habitat is dominated by the invasive *Psidium cattleianum*, and often no native vegetation is present. Regenerating forest often borders underplanted and mature forest, and this may result in edge effects and greater habitat heterogeneity inflating species richness, as well as recruiting from these more species-rich areas. Seasonal inflation may also occur, as at the time of surveying *P. cattleianum* was at the end of its fruiting season. Large flocks of the Greater Vasa, *Coracopsis vasa*, containing over 50 individuals, were recording feeding on *P. cattleianum* fruit.

Mature forest and underplanted forest have remained fairly impervious to colonisation from non-endemics, suggesting their avifaunal composition is relatively complete. Consequently their preservation remains critical for the conservation of endemism on Grande Comore. However, the underplanting of mature forest by bananas allows no opportunity for natural regeneration of the forest. Therefore, although underplanted forest currently provides a temporary sanctuary of endemism, it is likely that the forest will eventually degenerate, at which point it may become colonised by the invasives *P. cattleianum* and *C. hirta*, preventing future growth of natural forest.

Heath, although appearing low in species richness, remains a very important habitat for endemics. In particular, it represents the entire global range of the Karthala White-eye, *Zosterops mouroniensis*. In contrast, pioneer forest, regenerating forest and plantation habitats have a low level of endemism. Pioneer forest may, however, be an important natural habitat for endemic species that prefer open habitats and lower altitudes, such as *L. discolor* and *D. fuscipennis*. Greater knowledge of natural histories is required in order to determine how important open forests are in the life-cycles of endemic species. This may be particularly important as they become increasingly dominated by *P. cattleianum* and *C. hirta*.

The lack of a closed canopy and the prevalence of invasive plants in these three habitats have allowed colonisation by non-endemic species. All non-endemic species are thought to have colonised recently with the aid of man, and are characterised by their ability to adapt to modified environments. Consequently they are confined to open habitats and degraded forest. Only on a single occasion were non-endemics recorded in underplanted forest. This suggests that it is the presence of a closed canopy that inhibits the colonisation of non-endemic species.

Anjouan

Species richness and altitude

Although peaking much lower than on Grande Comore, species richness shows the same humped relationship with altitude. Species richness begins to decline at approximately 1000m (300m lower than where species richness peaks on Grande Comore). On the basis of the Grande Comore data, we might expect species richness to remain stable or increase up to these heights. However, on Anjouan there is little land above 1000m (all land above 1400m occurs on the peak Ntingui) and that land is confined to the steep slopes and peaks, and so we might expect there to be naturally lower species richness due to the species-area curve. Additionally, although the effects of altitude and habitat are not mutually exclusive, surveys at these altitudes were predominantly performed in mature forest, which has the lowest species richness. The altitude of highest species richness occurs, however, where there is a high proportion of species-rich affected forest.

Endemic richness shows a similar correlation with altitude, except that it is extremely meagre at very low altitudes, as would be expected owing to the lack of natural vegetation. High altitudes remain rich in endemic species, owing to domination by mature forest.

Non-endemics show the opposite relationship with altitude, again in line with results found on Grande Comore. However, they were recorded higher than on Grande Comore, almost to the summit of Ntingui at 1600m. This reflects the huge human pressure exerted on the forest in Anjouan, and the degradation of forest even at its highest altitudes. Agriculture was observed only a few tens of meters below the summit of Ntingui, showing that there is not the altitudinal buffer on the forest that exist on Grande Comore. Unaffected forest survives only on particularly steep, inaccessible slopes.

Species richness and habitat

Surprisingly, mature forest was more depauperate than padza. Surveys of mature forest were mainly at high altitudes and thus would be expected to have lower species richness. Safford noted that nowhere did pristine mature forest remain, and that invasive vegetation was always to be found, expressing doubt that the forest is capable of any regeneration at all (Safford 1993). Additionally, with the reduced visibility of mature forest, we would expect a reduction in encounter rates of cryptic, less vocal species, such as the fodies.

The most species-rich habitat, affected forest, is a matrix of underplanted and regenerating forest, often bordering plantations or mature forest. There is therefore an increase in species richness due to increased habitat heterogeneity and edge effects. However, species richness is not greater than in the two non-forest habitats to the same extent that it appears on Grande Comore. The Anjouan landscape is highly degraded, with any remaining forest clinging to steep, isolated slopes. More depauperate than Grande Comore, the Anjouan avifauna may consist of species better adapted to degraded habitats. Consequently many of the species found in forest habitats are also found in open habitats. Additionally, agricultural practices are somewhat different from those on Grande Comore, with larger trees, such as *Mangifera indica* and *Syzygium aromaticum*, being more prevalent in agricultural areas, and thus more suitable for forest species.

As would be expected, there is a clear correlation between non-endemic species and degraded habitats. However, non-endemics are present in mature forest (which is not the case on Grande Comore). Non-endemics would be expected if a forest habitat was degraded and relatively open, and this highlights the fractured and degraded nature of even the remaining mature forest on Anjouan.

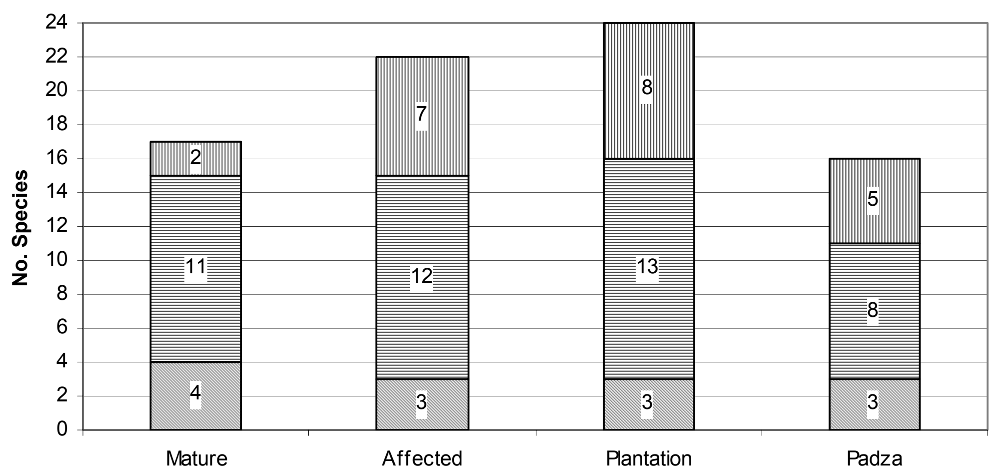


Fig. 13 - Total number of species seen during point counts in each habitat category on Anjouan. Lowest sections represent endemic species, middle sections endemic subspecies, and top sections non-endemic species.

When the total numbers of species are combined (Figure 13), plantation is surprisingly the most species rich and highest in endemic richness. To what extent endemic species utilise plantation is unclear. More knowledge of their life histories is required in order to make appropriate judgements of habitat quality. For example, *Otus capnodes* was recorded in plantation habitat, however it is thought that large forest trees with natural holes are essential for breeding and roosting activities (Safford 1993). It is possible that plantations are used for feeding purposes but it does not account for local movements and reliance on other habitats. As many endemic species on Grande Comore have yet to colonise non-forest habitats, the endemic species on Anjouan may simply have been forced into occupying these habitats. The long-term viability of these populations must therefore be in doubt.

Comparisons between bird and butterfly species richness

For both Grande Comore and Anjouan, butterflies have different patterns of species richness from that of birds. Lawton similarly found no correlation between the two taxa in a meta analysis (Lawton 1998), although Pearson found a significant correlation at two different spatial scales in North America (Pearson and Carroll 1999). The comparison for endemic richness of birds and butterflies on Anjouan was only marginally insignificant at $p = 0.067$, and so further work is needed to see whether there is a true correlation. If such a correlation did become apparent this could be further evidence of the fragile nature of much of Anjouan's endemic forest fauna, which is being pushed together into small forest remnants, no longer able to inhabit preferred niches within a wider forest resource.

The current lack of a significant correlation may be due to the differences in altitudinal patterns of species richness between the two taxa. Species richness of butterflies remains fairly constant between 200-1400m, and many of the endemic species have the mid-points of their ranges between 600-1000m, much lower than birds. Butterflies are more sensitive to temperature than birds. With deforestation pushing the lower limit of the remaining forest upwards, it appears that some bird species have accordingly pushed their ranges upwards. This may not be possible for butterfly species that cannot tolerate the lower temperatures at higher altitudes.

If reserves were to be implemented, then both bird species richness and butterfly species richness would have to be considered. Reserves would most probably have to cover a wide altitudinal range and different locations in order to best preserve the biodiversity of both taxa.

Scops owl surveys

Nocturnal surveys were carried out on the two IUCN critically endangered owls, the Grande Comore Scops Owl, *Otus pauliana*, and the Anjouan Scops Owl, *O. capnodes*. 22 Scops Owl surveys were completed, 14 on Anjouan and 8 on Grande Comore. On Grande Comore the aim was to confirm the presence of the owl at sites thought best for avifaunal richness; on Anjouan surveys were used to determine the minimum altitudes at which owls were present.

1. Methods

Methods closely followed that of Currie *et al*. (2004). Conspecific calls were played for five minutes each through speakers placed pointing north and south. Surveys were carried out before 05:45 and after 18:45. Each call was played on an IRiver HP120 with Sony SRS-A5 speakers set at a constant volume so as to be heard by humans 150 metres away in calm weather. The recordings used were taken from *Guide sonore des Oiseaux des Comores*. Surveys were not carried out in rainy or windy weather.

Owls responding within a 200 metre radius were recorded. Points were located at least 500m apart to minimise the chances of double-counting the same individual. The following data were recorded for each individual heard: distance to individual, time and bearing to the individual when first heard, habitat type, canopy height, GPS coordinate, cloud cover, weather, time and altitude.

2. Anjouan Scops Owl

14 surveys were carried out at eight different locations from 07/08 to 20/08. 26 individuals were recorded, occurring either singly or in pairs (see Table 3), and a further four individuals were recorded in two separate locations as incidental recordings. Sites were located just below or at the lower boundary of secondary forest. Individuals were recorded down to 300m and in highly degraded forest, although previous surveys had suggested that they could not be found below 800m (Safford 1993) or 600m (Moorcroft 1995), and never in exotic lowland vegetation. Abundances were highest at Basimini at 900m, where six individuals were recorded, and Lac Dzialoutsounga at 960m, where nine individuals were recorded. No owls were recorded at Koni, although the moon was full and bright, and so activity there may have been limited.

Where pairs were heard from the same location it is almost certain that these were the result of males and females duetting, as is known from the behaviour of the Seychelles Scops Owl, *O. insularis*, although males respond to playback more strongly (Currie *et al.,* 2004). It is possible that the length of time of playback should be extended as it took up to nine minutes for a response. Currie *et al.* found response success to be lowest in June-August and was 87% in October-March during breeding when males are defending territories. Although time of breeding is unknown, it is likely to be the same as for the Grande Comore Scops Owl, which is thought to breed between September and December (Herremans *et al.* 1991), so this would seem to be the ideal time to do further surveys.

Table 3 – Summary of Anjouan Scops Owl surveys

Point No.	Location	Co-ordinate E	Co-ordinate S	Altitude (m)	Habitat	No. Owls	Distance (m)
1	Paje	44˚23.416'	12˚11.814'	459	Plantation	-	-
2	Paje	44˚23.640'	12˚12.026'	601	Regenerating	1	120
						1	100
3	Hombo	44˚24.662'	12˚11.172'	386	Plantation	1	60
						1	50
4	Hombo	44˚24.841'	12˚11.302'	464	Plantation	2	150
						1	70
5	Basimini	44˚27.528'	12˚11.146'	810	Plantation	-	-
6	Basimini	44˚27.616'	12˚11.081'	904	Regenerating	2	30
						2	100
						1	100
						1	50
7	Moya	44˚27.765'	12˚18.391'	698	Plantation	1	60
8	Moya	44˚28.004'	12˚18.147'	890	Padza	-	-
9	Lingoni	44˚25.231'	12˚15.239'	300	Plantation	1	120
10	Lingoni	44˚25.579'	12˚15.021'	503	Plantation	1	150
11	Ouzini	44˚29.507'	12˚16.478'	443	Plantation	-	-
12	Ouzini	44˚29.507'	12˚16.322'	506	Regenerating	1	60
13	Koni	44˚28.945'	12˚12.966'	879	Regenerating	-	-
14	Dindi	44˚25.928'	12˚13.291'	961	Regenerating	2	150
						2	50
						2	70
						1	150
						2	100
Incidental Sightings							
	Dindi	44˚26.410'	12˚13.712'	868	Plantation	1	75
						1	50
	Lingoni	44˚26.379'	12˚14.956'	738	Mature	2	-

There was one incidental sighting of a roosting pair at 738m in mature forest above Lingoni. Located on the edge of a valley with a running stream, the forest had a low canopy, 8m, but some large trees over 20m. Lots of saplings, ferns and tree ferns were present. A pair consisting of a rufous phase male and a dark phase female were observed roosting around 3-4m off the ground on the bottom branch of a tree fern. As the birds were previously thought to roost within or outside tree cavities (Safford 1993) this may indicate that breeding was not taking place.

Female dark morph of Anjouan Scops Owl, *Otus capnodes*

Roosting pair of Anjouan Scops Owl, *Otus capnodes*

The Anjouan Scops Owl was rediscovered by Safford in June 1992 (Safford 1993). He found no evidence of the owl below 800m, hypothesising that it was reliant upon the presence of large trees for breeding. It was usually impossible in this survey to determine precisely the habitat from which birds were calling. However, where birds were recorded below the bounds of true mature or secondary forest, it appeared that they were located only in highly degraded forest or plantations where large native trees were present. Encouragingly, these are the first recordings from exotic habitats which may indicate that the species is adapting to non-forest habitats. However, as these surveys probably didn't coincide with the breeding period it is possible that individuals come down to plantations and degraded forest to forage, but need mature forest in order to breed. Although trees with large cavities that have the potential for breeding purposes are undoubtedly present in the lowlands, it is possible that owls would be excluded by the introduced Common Mynah, *Acridotheres tristis* (Herremans *et al.* 1991). However, as nothing is known of the breeding or feeding habits of the Anjouan Scops Owl any suggestions are purely conjecture.

Safford estimated a population of some 100-200 pairs, based on 10-20km^2 of remaining suitable habitat and nesting densities the same as or lower than that of the Grande Comore Scops Owl, estimated to be 5 ha by Herremans (1991). This nesting density may, however, be an overestimate: Currie *et al.* (2004) estimated a larger territory size for the closely related Seychelles Scops Owl with around 4.5 territories in 1km^2. If similar densities are found for the Anjouan Scops Owl then the estimate should be halved. A Newcastle University expedition in 1995 surveyed mature and regenerating forest above 600m and estimated there were around 50 individuals remaining (Moorcraft *et al.*, 1995). This is likely to be an underestimate, especially as owls have now been shown to occur as low as 300m; the population is probably somewhere between Safford's and Moorcraft's estimates. Reliable estimates of the population densities and territory sizes are needed to fully establish the status of the owl. However, a full baseline population survey using a grid system such as that used by Currie *et al.* is likely to be very difficult owing to the inaccessibility of much of the forest habitat.

It is probable that at least some of the remaining mature forest on Anjouan is naturally protected by its inaccessibility and so there will always remain suitable forest fragments available. What remains uncertain is whether these patches are large enough to support minimum viable populations, and the effect that fragmentation has on the island's metapopulation. Essential research is required on aspects of the breeding behaviour and feeding ecology of the owl, of which nothing is known, and in particular on the level of reliance on the remaining few fragments of mature forest.

4. Grande Comore Scops Owl

Surveys were carried out opportunistically at three locations, with 11 individuals recorded. Owls were recorded down to 830m in regenerating forest A (that dominated by *Psidium cattleianum*) at Tsinimouapanga. Surprisingly, no owls were recorded during two consecutive nights at La Convalescence. Previous surveys have recorded 13 individuals on four separate occasions from August to December, and the Comorian guide said the owls could usually be heard there, so this anomaly remains unexplained.

Table 4 – Summary of Grande Comore Scops Owl surveys

Point No.	Location	Co-ordinate E	Co-ordinate S	Altitude/m	Habitat	No. Owls	Distance
1	Kourani	043˚24.867'	11˚49.844'	1069	Underplanted	-	-
2	Kourani	043˚24.757'	11˚49.600'	1096	Underplanted	1	50
						1	30
						1	75
3	Kourani	043˚24.700'	11˚49.335'	1132	Underplanted	2	80
4	Tsinimoupanga	043˚25.964'	11˚48.596'	830	Regenerating A	3	70
						1	20
						2	80
5	Convalescence	043˚20.153'	11˚45.338'	1905	Mature	-	-
6	Convalescence	043˚20.013'	11˚45.431'	1871	Mature	-	-
7	Convalescence	043˚19.783'	11˚45.423'	1773	Mature	-	-
8	Convalescence	043˚19.796'	11˚45.289'	1757	Mature	-	-

The population estimate of around 1000 pairs by Herremans *et al.* (1991) is likely to be somewhat low as they assumed the eastern flanks of Karthala were unoccupied because they did not record any owls at Tsinimouapanga. In our survey, at a slightly higher altitude than Herreman's survey, the owl was found to be abundant, with six individuals recorded. As yet, encroachment on the forest is still well below the altitudinal stronghold of the owl, so numbers should not be too affected. If the densities suggested by Herremans are correct then we may recommend a slightly increased estimate.

Butterfly Surveys

1. Introduction

Lepidoptera are one of the few taxonomically tractable insect orders occurring at suitable levels of species richness in tropical areas to act as a target taxon for surveys (Lewis *et al.*, 1998; Thomas, 2005). They are therefore rare amongst insects in that they are now often the subject of single-species conservation measures (New, 1997). Although there is debate about their value as indicators (Hambler and Speight, 2004), and research is far from conclusive (Lawton, 1998; Kremen *et al.*, 2003), their sensitivity to light levels and disturbance, and their close association with host plants means that they are widely acknowledged as useful indicator species for habitat disturbance (Kremen, 1992 & 1994; Spitzer *et al.*, 1996; Kremen *et al.*, 2003; Cleary, 2004; Danielsen and Treadway, 2004) and the distribution of other terrestrial insects (New, 1997; Thomas, 2005). They are also thought to be suitable study taxa for understanding the effects of environmental change (Parmesan, 2003).

Surveys of butterfly distribution can therefore be used to outline priority conservation areas for terrestrial insects as a whole when it is not possible to devote the huge amounts of time required to sample many of the other insect orders in the tropics (Lawton, 1998). This is of course in addition to highlighting priorities for butterflies themselves, and in particular the status of, and threats to, individual endangered species. It is important that efforts are concentrated on these species of highest conservation value, generally restricted-range taxa (Spitzer *et al.*, 1996; New, 1997; Thomas *et al.*, 1998).

Here we use research into butterfly distributions on the Comoro Islands to outline conservation priorities for butterflies and other terrestrial insect orders. Like many oceanic islands, the Comoros have a high number of endemic taxa (Howarth and Ramsay, 1991), and over 30% of butterfly species are endemic to the archipelago (GEF, 2000). Lewis *et al.* (1998) established the patterns of the endemic and non-endemic butterflies of Grande Comore (one of the four main islands) through surveys performed in the dry season in 1992 (Lewis *et al.*, 1993) and the wet season in 1994 (Lewis *et al.*, 1994). The authors submitted conservation recommendations based on their results to the UNDP and the IUCN, which highlighted the need for implementing protection of remaining low-level forest (Lewis *et al.*, 1994). Unfortunately reserves have yet to be implemented on Grande Comore, and deforestation has continued in the intervening period, particularly at lower altitudes (M. Said, 2000). Similarly, the other islands of the archipelago support unique endemic taxa but have been subject to even more severe loss of natural habitats (Louette *et al.*, 2004). The aims of this study where therefore to:

(1) assess whether the continued habitat degradation had caused any changes in the established butterfly patterns and increased the threat to endemic species on Grande Comore;

(2) to research the effect of location on endemic richness within the forest on Grande Comore;

(3) to expand the previous research to assess priorities on a second island, Anjouan.

The threatened endemic butterflies on Grande Comore preferentially inhabit forest habitats (Lewis *et al.*, 1998). By resurveying locations surveyed in 1992, we were able to analyse changes in the elevation patterns of endemics with respect to habitat degradation at the lower altitudinal reaches of the forest. By repeating exactly the same transects we could assess whether degradation of habitats has caused concurrent changes in endemic richness on a more localised scale. We also assessed the level of spatial heterogeneity in endemic richness within the forest on Grande Comore by including location in analyses. Finally, we assessed conservation priorities on Anjouan by investigating the patterns in species richness and abundance of its endemic butterflies.

Through combining these results, we make recommendations for the conservation of butterflies on Grande Comore and Anjouan, which are likely to also have implications for the conservation of many other terrestrial insect orders on those two islands, as well as wider implications for the assessment of conservation priorities within other global biodiversity hotspots.

2. Methods

Butterflies of the Comoros

Like most oceanic islands, the Comoros have an impoverished butterfly fauna, but high levels of endemism (Howarth and Ramsay, 1991; Lewis *et al.*, 1998). The butterflies have been well studied and the species list must be largely complete, although taxa continue to be added occasionally, largely from the families Hesperiidae and Lycaenidae (S. Collins, *pers. comm.*). Only two previous studies have looked into the patterns of distribution (Lewis *et al.*, 1993 & 1994), and this study follows those in restricting investigation to the Papilionidae, the Pieridae and the Nymphalidae families.

There are currently thought to be 62 species and subspecies in these families present on the archipelago, of which 23 are classified as full species endemic to the Comoros and 12 as subspecies endemic to the Comoros. Grande Comore houses 44 of these, including 11 endemic species and eight endemic subspecies, and Anjouan 36, including nine endemic species and eight endemic subspecies (Turlin, 1993-1996, S. Collins and B. Turlin, pers. comm.). Four of the species are on the IUCN red-list, three of which occur on Grande Comore (IUCN, 2004).

The restricted ranges of the endemic butterflies makes them of high conservation value (Spitzer *et al.*, 1996; New, 1997; Thomas *et al.*, 1998). In addition, Lewis *et al.* (1998) note that the ‘endemic butterflies are taxonomically diverse and as such, would receive high ‘value’ in conservation rankings taking into account taxonomic distinctness’. In contrast, ‘the non-endemic butterflies are all widespread in continental Africa, Madagascar or both, and are not of high conservation priority’ (Lewis *et al.*, 1998). This study therefore focuses on those species and subspecies endemic to the Comoros. Endemic subspecies are given the same status as full species in analyses. Distinctiveness of subspecies is high in tropical islands, and subspecies should therefore be given the same status as full species to avoid the loss of significant evolutionary units (Danielsen and Treadaway, 2004). In addition, a lower status for subspecies might reflect the bias of taxonomists who may be more likely to classify certain taxa as full species (Lewis *et al.*, 1998).

Habitat categories

Forest habitat categories for Grande Comore were taken from Lewis *et al.* (1998) (Table 1).

Table 1. Forest habitat categories on Grande Comore

Category	Description
Pioneer forest on old lava flows	Canopy 3-8m with scattered taller trees and a variety of shrub species on a substrate of lava.
Regenerating secondary forest	Canopy 3-8m with scattered taller trees in areas which have been subject to selective logging. *Psidium* sp. constitute 80% or more of cover.
Underplanted mature forest	Canopy 8m or higher with understorey composed largely of banana or other crops.
Primary forest	Canopy 8m or higher with understorey composed largely of native plants

Habitat categories for Anjouan were modified, as appropriate for conditions on the ground, from those used by Lewis *et al.* (1993) for Grande Comore (Table 2.)

Table 2. Habitat categories on Anjouan

Category	Description
Padza	Very little vegetation, sparse crops, soil very dry and of poor quality.
Plantation	Crops with the occasional native tree. Canopy consists of banana plants, coconut palms, clove or mango trees.
Degraded forest	Canopy 8m or higher composed of native trees with understorey composed largely of either crops or secondary regrowth, or non-existent
Primary forest	Canopy 8m or higher composed of native trees with understorey composed largely of native plants

Census technique

Preparation work involved creating a pictorial guide to the butterflies of the Comoros using photos scanned from Turlin (1993-96), Louette *et al.* (2004) and d'Abrera (1997 & 2004). The islands currently known to be inhabited by each species and endemic species or subspecific status were confirmed in consultation with Turlin and Collins. One week was set aside at the start of surveying on Grande Comore and two days at the start of Anjouan to allow for species familiarisation. Netting was used for low-flying individuals when identification was unclear, and 8 x 42 binoculars for canopy-flyers.

For sampling, we used transect walks derived from Pollard (1977) and as modified by Lewis *et al.* (1998). Transect walks are recognised as an appropriate method for making comparisons between sites during short surveys, and as such are seen frequently in the literature (eg Thomas, 1985; Spitzer *et al.*, 1993 and 1997; Devy, 1998; Lewis *et al.*, 1998; Cleary, 2004). Population density figures obtained from transect walks correlate well with those obtained from the mark/recapture method whilst reducing effort and avoiding problems caused by handling (Thomas, 1983).

Walks were carried out along tracks or paths in the forest so that sun-loving species were included in the observations (Lewis, 1993; Sparrow, 1994). Results are intended as relative measures to allow comparison of the results of different transects rather than as an absolute measure of the richness or abundance of species within a given area.

All species were distinguishable in flight other than those of the families Hesperiidae and Lycaneidae, and the four different *Eurema* species (Pieridae), identification of which requires capture and often microscopic examination of the genitalia. These taxa were therefore left out of analyses.

Methodology differed from that of Lewis *et al.* (1998) only in the use of Global Positioning System (GPS) units and an effort to maintain transect time as close as possible to 4 minutes. The first observer walked ahead at a steady, even pace calling out the names of all butterflies entering an imaginary box 2.5m to both sides and 5m in front of him, and extending from the ground to the canopy. He also recorded the length of each transect with a stopwatch, stopping the clock whenever a break was needed, for example for species identification. The second observer walked behind noting down the number of each species seen per transect and counting out the number of paces up to 255, equalling about 170m. A location point was taken with a handheld GPS Garmin 76 unit at the start and end of each transect as soon as good signal reception had been achieved. Altitude for the transect was then averaged between these two readings.

Wilson (1993) investigated the effect of different variables upon the efficacy of the transect walk technique on Grande Comore, and his findings were taken into account during these surveys. Transect walk duration was found to be a significant source of sampling error and so every effort was made to maintain transect time as close as possible to 4 minutes. Transect walks were only carried out between 10:00 and 15:30 hours during weather conditions suitable for butterfly activity. Date of survey, temperature and relative humidity were found not to significantly influence the results of the 1992 surveys, so these were not taken into account during recording. Transects interrupted by cloudy conditions, that were over 15 seconds shorter or longer than 4 minutes, or that switched between habitat categories were not included in analyses. Butterflies with less than five sightings in either 1992 or 2005 were left out of the comparison of elevational patterns on Grande Comore, as were the results for individual species on Anjouan.

A total of 307 butterfly transects were recorded over the two islands: 208 on Grande Comore between July 17 & 28 and September 2 & 19, and 99 on Anjouan between August 3 & 29.

Data analysis

Lewis *et al.* (1998) were followed in using the number of endemic or non-endemic taxa recorded on a transect, R, as the measure of species richness. R is sensitive to sample size but as they note, the alternative, an index of diversity, would be difficult to interpret given the small number of species recorded on each transect, and a choice of any particular index would be arbitrary.

The data were subjected to a square root transformation as appropriate for count data (Sokal and Rohlf, 1995; Grafen and Hails, 2002). In all cases this improved homogeneity of variance whilst maintaining the other assumptions required of parametric tests. A small constant of 0.5 was added to all data before transformation owing to the presence of zero values (Sokal and Rohlf, 1995). All analyses used the statistical package Minitab 14.

3. Results

Patterns in the species richness and abundance of endemic butterflies on Grande Comore

Eleven of the endemic Papilionidae, Pieridae (excluding *Eurema* sp.) and Nymphalidae were recorded during transects on Grande Comore (nine endemic species and two endemic subspecies), the same number recorded by Lewis *et al.* in 1992 (Lewis *et al.*, 1993). One other endemic species and five other endemic subspecies in those families are currently thought to inhabit Grande Comore (Turlin, 1993-1996, B. Turlin and S. Collins, pers. comm.). The results for the surveys therefore give a comprehensive impression of the status of the endemic butterflies on Grande Comore.

Elevational shifts

Change in abundance of the different endemics between 1992 and 2005 across the elevational range 500-1000m was assessed to see whether there had been elevational shifts in line with habitat conversion at low altitudes. We predicted a shift upwards in the elevation of peak butterfly abundance if butterfly numbers were decreasing in areas where habitat had been degraded at lower altitudes. This shift would not reach above 1000m, as there has been little habitat conversion in the 800-1000m range.

There were enough sightings of only six species in both 1992 and 2005 to allow comparison. Data from both years were split into 100m elevational bands, and the average abundance per band calculated as the number of sightings of each species divided by the number of transects performed in that band. The data for 1992 were subtracted from the data for 2005 to give abundance change values for the different elevational bands for each species. The figure for each species was then subjected to a Pearson's correlation to assess whether richness at lower elevations had declined relative to higher elevations.

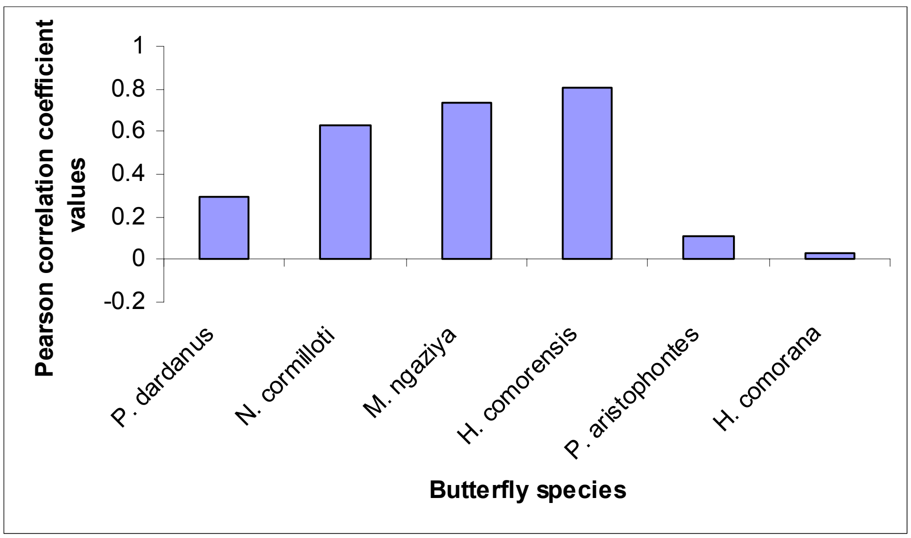
All Pearson correlation coefficients were positive, although none significant (Table 3), indicating a (non-significant) trend for individual species to decline in abundance at low elevations relative to high elevations within the 500-1000m elevational range surveyed. The fact that data for individual species were non-significant is unsurprising given the small sample sizes (five elevational zones). However, even if data for individual species do not reach significance, patterns across species may reveal clearer trends.

The correlation coefficients (r) were therefore subjected to a one-sample T-test to see whether there was a significantly greater decrease in abundance at lower altitudes across all species ($H_0 \leq 0$). This test was significant ($T = 3.20$, d.f. = 5, $p = 0.012$), showing that habitat degradation at the lowest altitudes of the forest had caused an upwards shift in overall endemic abundance (Figure 1).

Table 3. Changes in abundance of endemic species from 1992 to 2005 in different elevational zones on Grande Comore, with their Pearson correlation coefficients (r) and associated significance levels (p values)

Altitude	*Papilio dardanus* Oberthur 1888 ssp. *humbloti*	*Neptis cormilloti* Turlin 1994	*Mylothris ngaziya* Oberthur 1888	*Henotesia comorensis* Oberthur 1916 ssp. *salami*	*Papilio aristophontes* Oberthur 1897	*Henotesia comorana* Oberthur 1916
500-599	0.01	-0.62	-3.06	-2.87	0.14	-0.55
600-699	0.2	-0.17	-1	-0.8	0	0.43
700-799	0.02	0.45	3	0.55	-0.16	0
800-899	0	0.1	-0.13	0.12	0.15	0.21
900-999	0.21	0.03	2.16	0.19	0.11	-0.4
r values	0.30	0.63	0.73	0.81	0.11	0.03
p values	0.63	0.25	0.16	0.10	0.86	0.96

Figure 1. Pearson correlation coefficients for six species on Grande Comore across the 500-1000m range, the positive values showing a trend for endemic richness to have declined in abundance at low elevations relative to high elevations between 1992 and 2005.

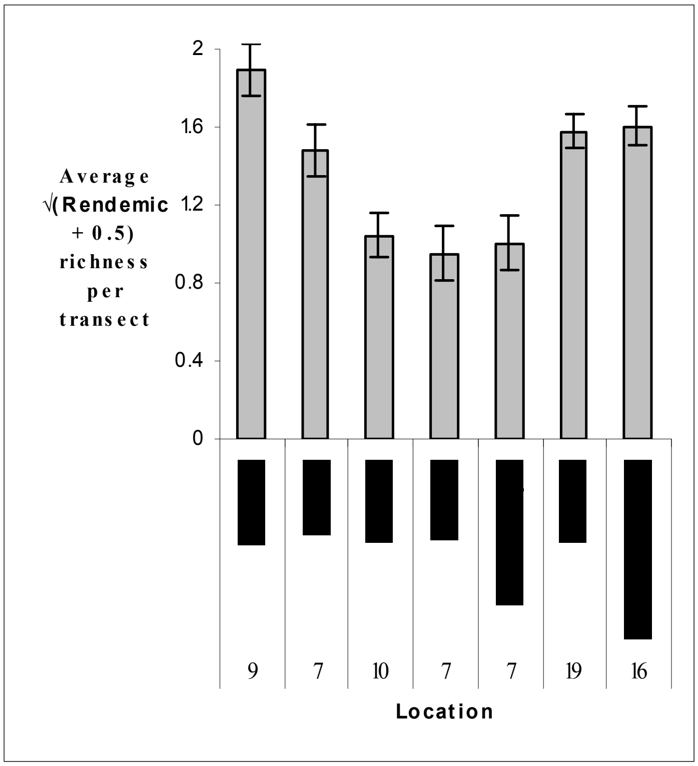


Location patterns

Location was found to be a highly significant predictor of endemic richness in all analyses (at all times, $p < 0.0005$), and also always a more significant predictor than habitat. Transects were restricted to the 800-1000m zone in assessing which locations were highest in endemic richness in order to avoid the confounding affects of altitude. Analysis of covariance using the GLM command confirmed that altitude had no significant effect within this restricted elevational zone ($F_{1,61} = 0.21$, $p = 0.650$). Both location ($F_{6,62} = 6.54$, $p < 0.0005$) and habitat ($F_{2,62} = 3.44$, $p = 0.038$) were significant within this zone.

Adjusting for the effects of habitat, locations to the north and the southeast of remaining forest were highest in endemic richness (Figure 2). Tukey's comparison tests showed that the only significant differences were for Mvouni and Boboni compared against La Grille, Kourani and Tsinimouapanga, and Nioumabdjou compared against La Grille.

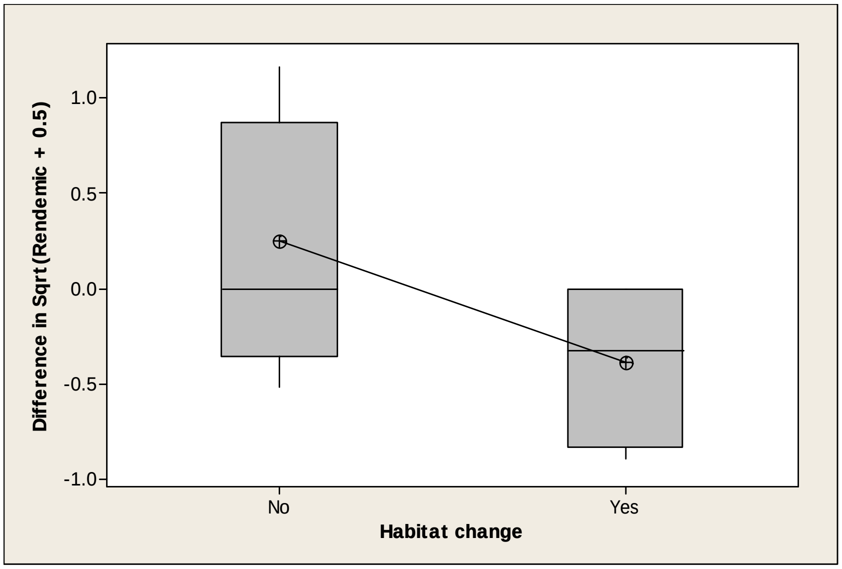
Figure 2. Average $\sqrt{(R_{endemic} + 0.5)}$ per transect in the 800-1000m zone across 7 different locations on Grande Comore, adjusted for the effects of habitat (error bars = standard error, numbers at base of column = number of transects performed).



Habitat degradation and consequent changes in endemic butterfly richness on transect repeats of 1992 surveys on Grande Comore

Ninety of Lewis' 1992 transects were repeated in 2005. It was possible to classify forest habitat from the 1994 surveys for 52 of those 1992 transects. Of those 52 repeats, only five had deteriorated in habitat class (four from underplanted forest to secondary forest, and one from mature forest to underplanted forest). The change from underplanted to secondary forest was therefore the only habitat change with enough comparisons for statistical analysis to be possible. There was an *a priori* reason to believe that endemic richness would have decreased on degraded transects relative to those that had remained underplanted. A two-sampled, one-tailed t-test was therefore used to test this hypothesis. There was a significant decrease in $\sqrt{(R_{endemic} + 0.5)}$ on degraded transects (four transects) relative to those that had remained underplanted (11 transects) ($T = 2.14$, $d.f = 7$, $p = 0.035$) (Figure 3).

Fig 3. Boxplot showing the difference in √($R_{endemic}$ + 0.5) on 1992 underplanted transects that had and had not been degraded to secondary forest between 1994 and 2005.



Patterns in the species richness and abundance of endemic and non-endemic butterflies on Anjouan

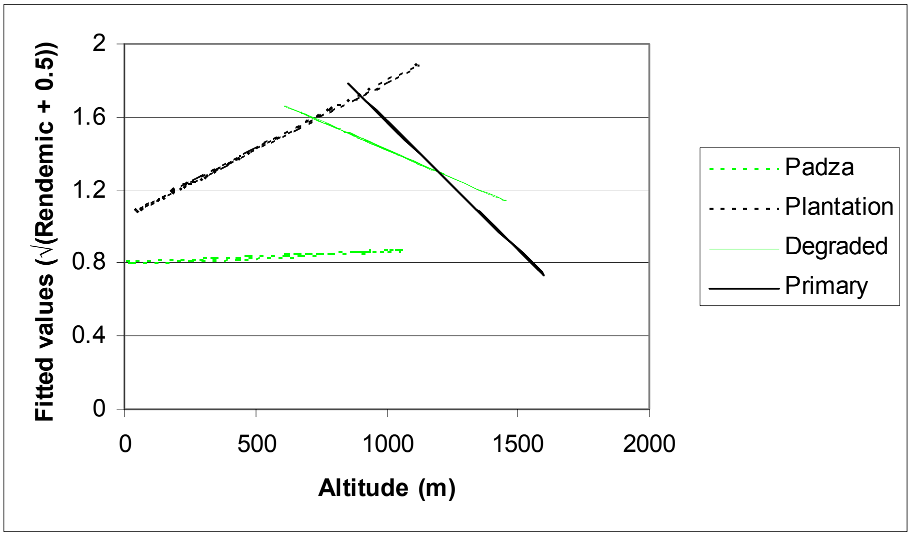
24 of the Papilionidae, Pieridae (excluding *Eurema* sp.) and Nymphalidae were recorded during transects on Anjouan (seven endemic species, three endemic subspecies and 15 non-endemics). Nine other species in those families, including one endemic species and four endemic subspecies, are currently thought to inhabit Anjouan (Turlin, 1993-1996, B. Turlin and S. Collins, pers. comm.). Results are thus representative of both the endemic and non-endemic butterflies of Anjouan.

Elevational patterns

Analysis of covariance using the GLM command showed that the interaction between habitat and altitude was non-significant for non-endemic richness ($F_{3,85}$ = 0.58, p = 0.631). Non-endemic richness peaks at low altitudes, from where richness declines linearly (√($R_{non\text{-}endemic}$ + 0.5) = 1.47920 – 4.87 x 10^{-4} altitude, $F_{1,91}$ = 23.11, p < 0.0005). Analysis of the effect of altitude alone on endemic richness suggested that its pattern contrasted significantly with a humped distribution (√($R_{endemic}$ + 0.5) = 0.7601 + 0.001633 Altitude - 0.000001 Altitude**Altitude, $F_{2,90}$ = 8.40, p < 0.0005). However, when habitat was included in the model, this polynomial distribution was found to be non-significant based on conventional significance levels ($F_{1,84}$ = 2.87, p = 0.094). The result is however marginal, and should therefore be treated with caution.

The interaction between altitude and habitat *was* significant for endemics ($F_{3,85}$ = 9.64, p < 0.0005) and so the effect of altitude varies according to habitat and vice-versa. Endemic richness increases sharply with increasing altitude in plantation across its elevational range and rises gently in padza, but decreases sharply with increasing altitude in degraded and primary forest categories. Endemic species richness is thus highest at the higher altitudes reached by plantations and the lower elevations of primary and degraded forest (in the region of 800-1200m) (Figure 4).

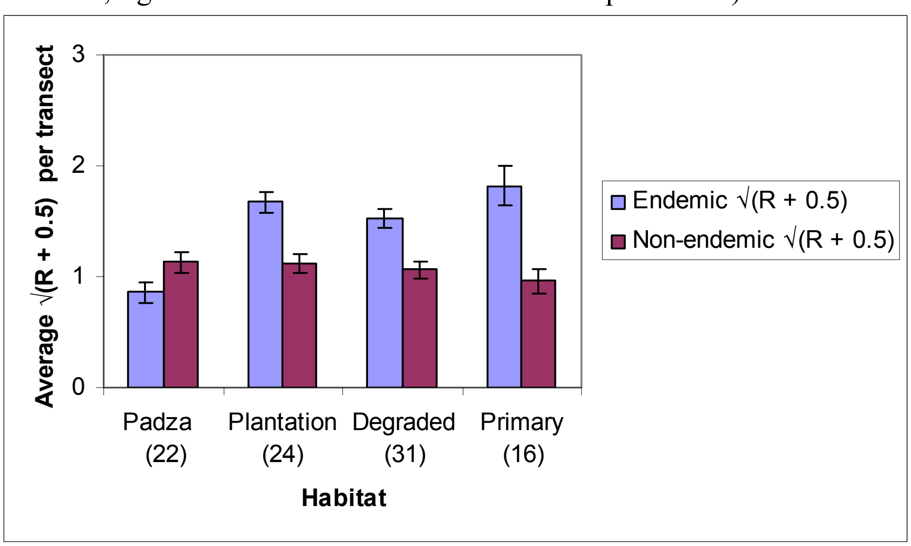
Figure 4. Fitted values against altitude, showing the effect of altitude on endemic species richness in the different habitats on Anjouan.



Habitat patterns

Habitat was found not to have a significant effect on non-endemic species richness when the effect of altitude was taken into account ($\sqrt{(R_{non\text{-}endemic} + 0.5)}$ = altitude + habitat, $F_{3,88} = 0.42$, p = 0.739). Habitat was, however, significant for endemic species richness as the interactions were significant (see earlier GLMs). Padza was found to be significantly lower than the other habitats for endemic richness using Tukey's comparison tests. Plantation, degraded forest and primary forest had similar average endemic species richness and were not significantly different from each other (Figure 5).

Figure 5. Average endemic and non-endemic species √(R + 0.5) per transect in the different habitats on Anjouan, adjusting for the effect of altitude (error bars = standard error, figures in brackets = number of transect performed).



Elevational preferences of individual endemics

Elevational preferences were calculated by dividing the number of individuals seen in an elevational band by the number of transects surveyed in that band. Elevational preferences including all habitats were variable rather than clustered around a particular altitude. Four of the endemic butterflies peaked in abundance below 800m, the lowest point reached by all but small pockets of the forest (Figure 6). The midpoint of the ranges of these four species was also below 800m (Table 4).

Figure 6. Number of endemics peaking in abundance in each 100m elevational zone across all habitat types on Anjouan.

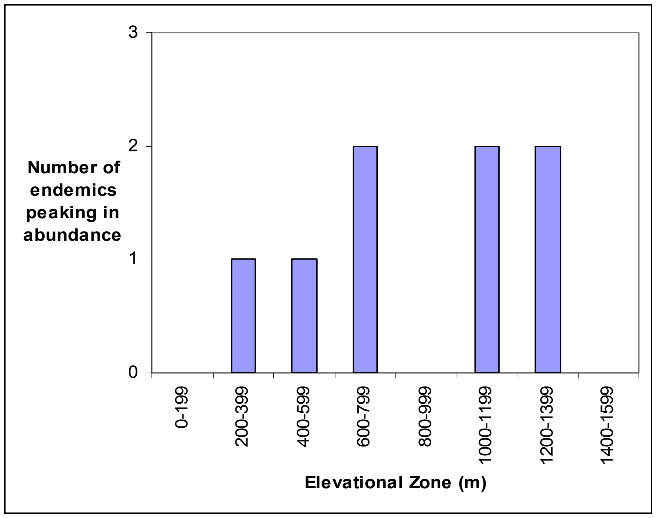


Table 4. Range sizes and range midpoints for Anjouan endemics

Species	Lowest altitude (m)	Highest altitude (m)	Range size (m)	Midpoint (m)
Mylothris humbloti Oberthur 1888	830	1220	390	1025
Amauris ochlea Boisduval 1847 ssp. *Moya*	650	1300	650	975
Acraea masaris Oberthur 1893 ssp. *Masaris*	230	1200	970	715
Henotesia comorensis Oberthur 1926 ssp. *Comorensis*	230	1200	970	715
Henotesia subrufa Turlin 1994	910	1460	550	1185
Neptis comoranum Oberthur 1890 ssp. *Comorarum*	350	1040	690	695
Pseudacraea lucretia Oberthur 1890 ssp. *Comorana*	350	880	530	615
Charaxes nicati Canu 1991	910	1240	330	1075

Elevational preferences within forest habitat were also variable. Three of the six species of which there were more than five records in the forest peaked in abundance in the lowest forest elevational band, 800-999m (Table 5), but two of those were species whose elevational range midpoint was below the start of the forest (Table 4). Two other species peaked in abundance within the forest in the 1000-1199m band, and one even higher in the 1200-1399m band (Table 5).

Table 5. Elevational preferences of individual endemics in forest habitats on Anjouan.

Species	Elevational band			
	800-999	1000-1199	1200-1399	1400-1599
Mylothris humbloti	0.59	**0.92**	0.75	0
Amauris ochlea moya	**0.88**	0.31	0.75	0
Acraea masaris masaris	**0.53**	0.31	0.13	0
Henotesia comorensis comorensis	**0.71**	0.23	0.13	0
Henotesia subrufa	0.18	**0.69**	0.63	0.17
Charaxes nicati	0.12	0.15	**0.25**	0
Number of transects	17	13	8	6

Habitat preferences of individual endemics

Habitat preferences for individual endemics were calculated by dividing the number of individuals of each species seen in a habitat by the number of transects performed in that habitat. Two endemic species peaked in abundance in plantations, four in degraded forest and two in primary forest (Table 6).

Table 6. Habitat preferences of individual endemics on Anjouan.

Species	Habitat category			
	Padza	Plantation	Degraded	Primary
Mylothris humbloti	0	0.04	**0.84**	0.13
Amauris ochlea moya	0.09	0.25	**0.68**	0.38
Acraea masaris masaris	0	**1.21**	0.58	0.13
Henotesia comorensis comorensis	0.23	**1.92**	0.52	0.13
Henotesia subrufa	0	0.08	0.16	**0.81**
Neptis comoranum comorarum	0	0.04	**0.16**	0
Pseudacraea lucretia comorana	0	0.04	**0.19**	0
Charaxes nicati	0	0	0	**0.38**
Number of transects	22	24	31	16

4. Discussion

Effects of forest degradation on the abundance and richness of restricted-range butterflies

Results for Grande Comore confirm the hypothesis that increased anthropogenic forest disturbance decreases the richness and abundance of restricted-range butterfly species in that area, thus decreasing its conservation importance (Spitzer *et al.*, 1993 & 1997; Hamer *et al.*, 1997; Lewis *et al.*, 1998). Just under 10% of repeated transects had degraded in habitat quality between 1994 and 2005 on Grande Comore. Across all endemic species (those with restricted ranges), this forest degradation at lower altitudes has caused reduced abundance at lower altitudes compared to that at higher altitudes (Figure 1). Individual transects where habitat had degraded from underplanted to secondary forest had a significantly lower endemic richness than transects where habitat had remained underplanted (Figure 3).

On Anjouan, however, there was similar endemic richness across forest and plantation habitats, seemingly contradicting the above hypothesis (Figure 5). These were not native tree plantations, suggested by Lawton *et al.* (1998) to be potentially important for conservation, but consisted mainly of exotic crops with the occasional native tree. Closer inspection of results revealed that some of the restricted-range endemic species had seemingly adapted to plantation habitat as their abundance peaked in plantations and below the level of remaining forest habitat (Table 6 and Figure 6). Other endemic species preferentially inhabit underplanted forest, while two more were largely confined to what little remained of primary forest. Given this result, it seems sensible to assess the abundance of Grande Comore endemics in plantations, to see whether some of those species are also no longer reliant on the forest habitat and thus no longer of conservation priority.

Location effects on insect richness and abundance in tropical forest

Tropical forests are known to have high spatial heterogeneity in insect richness and abundance (Lewis and Basset, 2006). The extremely high significance of location on endemic richness confirms this theory for the endemic butterflies of Grande Comore. It was perhaps surprising to find that location was a much more significant predictor of endemic richness than habitat. Habitat categories are sometimes indistinct, and it is also possible for small 'islands' of one habitat to be surveyed within a larger matrix of a different habitat. Both of these possibilities would contribute to errors in habitat recording leading to reduced significance of separate habitats. In addition, different habitat samples were frequently far closer geographically than different location samples, meaning a comparatively lower significance for habitat due to high butterfly mobility. Nevertheless, the much higher significance of location over habitat suggests that blocking should be used in all investigations into the distribution patterns of butterflies and other insects in tropical forests if errors in interpretation are to be avoided.

There are many possible reasons for the significant effect of location. Butterflies are known to be sensitive to local climatic conditions (New, 1997; Thomas *et al.*, 1998; Parmesan, 2003; Danielsen, 2004), and the Karthala massif produces different microclimates around Grande Comore (Battistini and Verin, 1984), so it is quite possible that this is the cause. Other potential reasons include differences in topography (Lewis and Basset, 2006) or the distribution of host plants (Kremen, 1992;

Danielsen and Treadway, 2004). Determining the causes of the high significance of location on Grande Comore would therefore have to involve investigation of all these potential factors.

Locations to the north and southeast of Grande Comore were highest in endemic richness within the 800-1000m elevational band (Figure 2). These findings contrast with those of Lewis (1993), who found that the highest location for endemic richness was in the southwest at Nioumbadjou, although he did not use results from La Grille. However, his aim was to find the areas with highest richness of endemic butterflies within the forest, regardless of altitude or habitat type. With pressure highest at lower altitudes and forest rapidly receding, it seemed sensible to find the richest locations at an altitude where forest protection might be socially feasible. Inclusion of habitat within the analysis ensures that differences in location results are not an artefact of different amounts of sampling in endemic-rich or endemic-poor habitats between locations. Thus recommendations can be made for protection of a particular habitat in a particular location. Further work is needed to confirm the findings as, for example, Nioumbadjou was not significantly lower in endemic richness than the three locations with the highest results.

Elevational patterns of butterfly richness and abundance

Lewis *et al.* (1998) found that overall species richness decreased with altitude on Grande Comore, though this trend hid contrasting patterns for endemics and non-endemics. Non-endemics decreased linearly with highest richness at low altitudes, whilst endemic richness showed a significant humped distribution with highest species richness at mid altitudes. The results for Anjouan showed a similar linear decrease for non-endemic richness. An analysis assessing the effect of altitude alone on endemic richness also confirmed a humped distribution.

However, the analyses used by Lewis *et al.* and the Anjouan endemics analysis were flawed in that they failed to include habitat as a second predictor variable. For example, if an artefact of recording rather than the distribution of different habitats led to a lot of sampling in endemic-rich habitats at mid elevation as compared to higher elevations, then skewed sampling would have contributed to the significance of the humped distribution. When habitat was included in the Anjouan analysis, altitude*altitude was marginally non-significant ($p = 0.094$), so caution should be taken in stating that Anjouan endemics do not follow a humped elevational distribution. Further work would be needed to confirm this finding.

The Anjouan results show that the interaction between habitat and altitude is significant for endemic richness, so the effect of altitude depends on habitat. Endemic richness increases with increasing altitude in padza and plantation while decreasing in degraded and primary forest (Figure 4), a result which could be partly due to the non-random distribution of habitats across the elevational range. For instance, if plantations continued above 1100m, it is possible that this habitat would show a humped distribution for endemic richness.

The elevational preferences of individual endemics in forest habitats proved similar across the two islands with 44% and 50% of species with more than five sightings peaking in the lowest elevational band of the forest in Grande Comore (Lewis *et al.*, 1993) and Anjouan respectively (Table 5). Three of the six species on Anjouan peaked in abundance higher than the highest-peaking species of Grande Comore at 901-1000, which is likely to reflect the much higher limit to forest on Anjouan. In support of this conclusion, half of the Anjouan endemics have substantially higher recorded minimum altitudes than the largest minimum altitude recorded for an endemic on Grande Comore (500m) (Table 4).

Implications for conservation

Previous studies have shown that total butterfly species richness is not an accurate indicator of butterfly conservation priorities (eg. Kremen *et al.*, 2003). The results from Anjouan go further, suggesting that the richness of restricted-range species is also not a reliable indicator of the importance of a particular habitat or area. It seems that more attention must therefore be paid to the distributions of individual species restricted to threatened habitats, confirming the assertion of Spitzer *et al.* (1997) that species identification is cardinal in identifying conservation priorities.

The results obtained for Grande Comore confirm the threats posed to the endemic butterflies by degradation of forest habitats and a spread of invasive species prevalent in secondary forest. Deforestation at the lowest altitudes is of particular concern as it is pushing endemic species further up the slopes, threatening those that preferentially inhabit lower forest levels, and reducing the range of the others which are dependent on the forest. The endemics are generally at risk due to narrow geographic ranges rather than lower local densities (Thomas *et al.*, 1998), and this trend is only exacerbating this problem.

On Anjouan, continued deforestation does not threaten those endemics preferentially inhabiting plantations unless the land is subsequently overexploited and turned into padza, which supports few endemic species. Deforestation does pose a threat to those species that seem to be reliant on forest habitats, again particularly at the lower altitudes of the forest, where endemic species richness is greatest (Table 5).

In the absence of distribution surveys of other terrestrial insect groups on the Comoros, it should be assumed that they face the same threats as butterflies, and that threatened species in these taxa have ecological requirements similar to the threatened butterfly species. If we hope to preserve all threatened insect species, we should therefore base conservation priorities upon the requirements of the threatened butterfly species.

As Thomas *et al.* (1998) note, species should be protected, as far as possible, where they are common and thus have viable long-term populations. On Grande Comore this means the lowest reaches of underplanted and mature forest at La Grille and towards the south east of the island. Some species seem to be highly localised or occur in lower abundance than others. Surveys would need to be done in the wet season to confirm the rarity or confined range of these species and other ones that were unobserved.

On Anjouan, the priority is those species that seem unable to adapt to inhabit plantations and remain reliant on forest habitat, and particularly those that appear confined to the primary forest habitat (*Henotesia subrufa* and *Charaxes nicati*).

Participatory Rural Appraisal (PRA)

1. Background

With deforestation the main threat to the Comoros' habitats and biodiversity, conservation is only ever going to be successful if solutions are developed in partnership with local people. We hoped to develop a picture of the local people's attitudes to the forest and the solutions that they themselves suggested, ideas that could then be used as the basis for developing attempts to reduce deforestation. The first step to finding such solutions is to understand the problems, and we developed our aims for the PRA work with these ideas in mind. We consulted various documents and produced an initial plan which we presented to our partners in the Comoros, and then worked with them to develop the detailed aims and structure of the work.

The 'Strategie Nationale pour la Conservation de la Biodiversité Biologique en RFI des Comores' (2000), developed for the CBD, provided much useful information, in particular the framework for detailed investigation into the problems leading to deforestation. The other most important information source was a US NGO CARE Comores report (Hunter et al., 1992\), which suggested ways to investigate environmental awareness levels, and also helped to outline appropriate methods to be used. Their work had looked into the ways people in five villages of Anjouan used the forest as a resource. The mode of investigation used by CARE was a questionnaire, and it was noted that this method did not allow the researchers to elicit full answers from informants. It was found that many people seemed nervous – they had had little experience of participating in surveys and were afraid that they would be held accountable for their responses. We therefore took on the recommendations that for future investigations a more informal and participatory method be used.

The scoping trip in April 2005 strengthened our ideas of what we would investigate, and in addition the Director General of the Environment, Mohammed Baccar Dossar, suggested that we explore how people might react to new environmental protection legislation that the current government was developing (Doumbe-Bille 2001).

Aims

- To assess in detail the problems leading to deforestation in order to provide information that can assist in developing and implementing ways to reduce the level of human impact on native forest.
- To assess the scale of community impact on the forest.
- To assess the level of environmental knowledge to assist the awareness work.
- To assess the potential reaction to the government's plans of dividing land into three zones: reserves, private land and community land, and to see what solutions the communities themselves proposed to combat deforestation.

The goal of the work was not to get quantitative data on, for example, the level of impact on the forest. Instead, we hoped to create a picture of the problems in the Comoros from the community perspective – recent plans to involve World Bank funding in reserve creation fell through due to a lack of community consultation, and this work can be seen as a preliminary step to full community engagement in conservation efforts.

2. Methodology

Four villages were surveyed: Djoumoichongo and nKourani-Sima on Grande Comore, and Mjumvia and Lingoni on Anjouan. These villages were selected because they are all situated near the forest, but vary in their impact on the forest. We spent an average of two weeks at each village, and all interviews, meetings and presentations in villages were conducted in the local language. At least 50 community members were consulted in each village. All members of the Oxford team worked alongside a Comorian translator translating from Comorian to French.

Introductions

Before starting research in any of the villages, our Comorian counterparts designated a reliable villager to be our point of contact and organise meetings with informants. As a first step, the whole team introduced themselves to the communities at pre-arranged but informal, open gatherings to explain our project and the kind of information we wished to obtain. These gatherings proved extremely valuable in assuaging villagers' fears, reassuring them that we always had their interests in mind, and taking names for future meetings. We also made clear that while the work we were doing was intended to help the community in the long-run, we could not guarantee any concrete results, and found this openness very important in gaining trust and support. When we had some spare moments we also made time to engage with villagers on an informal basis; playing with children, sharing a meal, helping with household and agricultural tasks and playing football – efforts such as these were greatly appreciated.

Interview technique

In seeking our information we decided not to conduct rigid questionnaires with set answers, as we feared that we would lose detail that was important to our aims. Instead we created a 'conceptual framework' (see below), a list of topics that we wished to address through semi-structured interviews in whatever way was appropriate given the situation. In this way interviews were more relaxed and facilitated open discussion between researchers and informants. Every interview began with introductions, a brief explanation of the aim of our work, and an invitation for informants to ask questions. A team of investigators always comprised at least two members of Conservation Comores, with one person asking questions and directing conversation while another took notes. Interviews rarely exceeded one hour, unless informants were particularly interested to stay and talk to us for longer. Wherever possible, gender norms were followed with women researchers interviewing local women. Sometimes a male translator had to be used, but in most cases we felt that this did not seem to affect the nature of responses from women.

Interviews in villages

For interviews in villages, groups were organised to be either homogenous with respect to age, sex, social status and occupation to gain particular viewpoints and to avoid 'uppers' in the social hierarchy dominating discussion, or deliberately heterogeneous in order to invite discussion and debate between different community members. We also interviewed key informants individually on specialist matters, for example religious leaders and local government officials. We always attempted to hold meetings in locations appropriate to the age, sex, social status and occupation of the interviewees to put them at ease. Women who did not work in the fields tended to be free at all times of day except evenings, whilst group meetings with men were possible in the afternoons and were arranged around key prayer times of 12, 3 and 6pm.

Transect walks

Transect walks were used to obtain information in a more informal setting. Researchers walked to the village fields, talking to people along the way and then going from field to field chatting to those who were willing. People seemed to be much happier to give their time whilst working, and it was often possible to obtain more detailed information as the interviewees were generally much more relaxed and discussions lasted for longer. It also allowed us to find people working in specific agricultural zones in which we were interested, or for which knowledge was lacking. Thus the combination of organised village interviews and informal talks in the fields allowed us to collect a wide range of views and information.

Mapping exercises

Maps were used as an important method of communication and in eliciting information. Village and agricultural zoning maps were created, usually on paper, guided by reliable informants. These could then be refined and used in discussions with others, providing an easy way of asking about land ownership and the differences between agricultural zones in terms of cultivation methods, crops etc. Most people seemed to be able to use maps as a tool, though inevitably there was some confusion and disagreement. A few examples of the maps created are presented in the results pages.

Validation meetings

Before leaving a village, we consolidated our data and presented preliminary results at open community meetings using spider diagrams, transect diagrams or maps, and historical timelines. The purpose of the results presentations were to validate the information we had found and to explain what would be done with our results. They served as an important way of reassuring the communities of our intentions.

Payment

We paid our village ‘point of contact’ a small sum for their assistance. We did not pay informants for their time; we stressed at our introductory gatherings that participation was voluntary.

3. Conceptual Framework

Section 1: Peoples’ perceptions of the forest and its protection

- What and where do the villagers consider the “forest” to be?
- What is the value of the forest and what would be the point of protecting it?
- What do people understand by the term “conservation”?

Section 2: What is the impact of villagers’ activities on the forest?

- How do the people of the village use the forest?
- Why do people cut down trees?
- Who and how many take part in it? (age, gender, social position)
- What is the resource availability? (Present, historical and seasonal)

- What is the history of forest encroachment and protection?

Section 3: What are the problems related to deforestation?

- What are the major problems facing the community?
- How important are environmental problems compared to others?
- What do they see as being the causes of these problems?
- What problems are caused by deforestation?

Section 4: Who do people see as decision-makers on forest use?

- How are resources owned?
- Who makes decisions regarding resource use?
- Who enforces these decisions? Who controls resources? (past and present)
- Are there conflicts between decision-making systems?
- Who is responsible for taking decisions relating to the protection of the forest?

Section 5: What do people propose as solutions?

- How would people react and respond to the government's idea of dividing the land into three groups; reserves, private land and community land?
- What are opinions on conservation measures that have already been undertaken?
- What solutions do they propose to reduce deforestation and alleviate their problems?
- What infrastructure would be needed to effect these changes?

4. Results

We have not laid out the full results of our work as these would spread for many pages, instead we have attempted to summarise what we thought most relevant. Full results are available upon request.

Section 1: Peoples' perceptions of the forest and its protection

Where/what is the forest?

Djoumoichongo: people designated three zones: "the village", site of human habitations; "fields" located between the border of the village and the old sawmill half an hour away at Nioumbadjou; and "forest", anywhere after Nioumbadjou. The label of "the forest" referred more to a geographical boundary that to vegetation type, reflecting where forest had been in previous years.

NKourani-Sima: forest was defined as being "where the big trees start" which meant species of the natural forest; or where only bananas and taro grow well but not manioc or other crops grown in fields downhill of the village.

Mjumvia: definitions were based on either vegetation type or official designation. Forest is where trees grow naturally as opposed to having been planted by people. There are also three officially demarcated zones; the "zones de bas" or lower zones of fields closest to the village; "réserves dominiales" which is forest owned by the state but given to the village for its use; and "zones forestières" or primary forest.

Lingoni: forest is defined by the presence of a high density of endemic tree species but, as for Djoumoichongo, the label also applies to underplanted forest. The limit of Lingoni's forest is the river Shoungoui to the east.

What is the value of the forest and how important is its protection?

Values of the forest cited in general were: agricultural uses (clearance for fields, maintaining soil fertility, shade, crop protection, pollinator and propagator habitat); wood (endemic species for timber, others for firewood); forest products (medicinal plants, plants for traditional ceremonies, fruits, game, fodder); ecosystem functions (assuring rainfalls and flowing rivers, preventing erosion and aridity, oxygen and biodiversity habitat). Religious leaders in all villages emphasised that the Qu'ran highlights the importance of environmental protection in maintaining health.

Djoumoichongo: the most frequently cited values were of those relating to agriculture and of ensuring rainfall. Overall environmental awareness was low as very few people could name further ecosystem functions of the forest, and those who could did not have in-depth knowledge of the forest ecosystem: for instance, confusing the functions of endemic species of forest trees with fruit trees or red guava. Motivation to protect the forest was low and people often used the high level of rainfall in Djoumoichongo as proof that the forest was not under threat.

NKourani-Sima: the value most frequently cited was for timber, as this is the main source of revenue for most families in the village. Agriculture was also often cited. Awareness of other forest functions was low with the exception of its role in maintaining rainfall. There were conflicting attitudes towards forest protection in the village; on the one hand, measures were seen by some as highly necessary as long as it did not affect their income, but these ideas conflicted with the widespread notion that the forest is an infinite resource.

Mjumvia: agricultural values of the forest were very frequently cited. Other values mentioned were: habitat for many animals and birds, soil preservation and river and rainfall maintenance. Overall, people had a reasonable collective knowledge of the functions of the forest, as most people we spoke to, with the exception of older people, could name at least one ecosystem function. People generally were also conscientious about protecting the forest, and there seemed to be a significant body of people who were committed to promoting its protection. However, among older people the view was widespread that conservation entailed prohibition of any use of the forest, and that protection of people should come before protection of the environment.

Lingoni: most people could name at least one ecosystem function of the forest, although the values most often cited were for agriculture or firewood. People generally were in favour of forest protection, even if this involved exclusion reserves.

Figure 1. Map of the Agricultural zones of Nkourani-Sima

Section 2: What is the impact of villagers' activities on the forest?

Djoumoichongo: exerts minimal pressure on the native forest – while most men in the village are cultivators, few new fields are created that encroach on the forest as agricultural land cleared during the colonial period still satisfies the needs of the village, though increasingly today fewer young people are working the land as they seek faster revenue-generating activities. There are only around ten practising woodcutters in the village since the desirable trees are now located too far away (at least two to three hours' walk) for the activity to be particularly profitable. Firewood comes mainly from guava (*Psidium sp.*), and so does not affect endemic tree species. Other forest products such as medicinal plants and fodder are harvested only occasionally.

NKourani-Sima: exerts a high pressure on the primary forest in its vicinity as the majority of active men in the village cut trees for income – agricultural yields are periodic so wood is needed to sell in the difficult seasons. Three to four trees can be cut a month by a group of three people with a handsaw. It is rare that people will cut down the trees of the forest solely to make fields because only bananas and taro will grow there, and these crops can be planted opportunistically after timber has been cut. Around 80 women in the village prepare firewood and charcoal as their main source of income; red guava is the preferred source of faggots. This invasive species colonises tracts of forest already cleared by woodcutters so making charcoal from this wood does not impact negatively on the native forest.

Older informants explained to us the history of production and consumption in the village and told us people need more money now because tastes have changed and older lifestyles are no longer sufficient to meet people's needs. Traditionally, sources of revenue came from the creation of traditional artefacts but the demand for these declined with modernisation. Agriculture used to be more important, but once rice and other products started to be imported in the 1970s people stopped growing these crops themselves and needed more immediate sources of revenue to buy it. Vanilla became a big earner but in the 1980s prices fell. In the late '80s, a government project encouraged them to grow maize, but when this ended in 1990 the number of farmers dropped. This, in addition to the fact that the first tarmacked road to the capital was built in 1992, meant that the number of woodcutters increased dramatically. People also need more money these days to pay for health and education.

Figure 2. Historical chart of Nkourani-Sima

Mjumvia: exerts significant pressure on the remaining tracts of primary forest in its vicinity through underplanting or regular clearing for new fields. The villagers are dependent on agriculture owing to a lack of alternative resource-generating activities. The fields already available to them have been steadily falling in fertility due to over-exploitation and badly adapted agricultural practices, such as continued planting of clove trees in the hope that they will regain their value on the global market. Yields are also lost as a result of pests and natural disasters, problems exacerbated by deforestation. An ill-adapted land-ownership system means people are not allowed to use fields that are abandoned by emigrants.

Lingoni: exerts high pressure on the forest through clandestine logging. Population pressure and a lack of workable land have increased the need for this activity as the sale of crops no longer satisfies people's needs and all cultivatable land has already been cleared. Distilling ylang ylang essence is the only other major source of revenue, with about 25 functioning distilleries in the village. However, the distilleries are energetically inefficient and require large quantities of firewood, and the wood, although generally not from the primary forest, is becoming scarce, and negative effects such as erosion are being observed.

Figure 3. Transect of the agricultural zones of Mjumvia

Section 3: What are the problems related to deforestation?

Djoumoichongo: The only clear problem attributed to deforestation was a lack of trees for timber. People tended to cite socioeconomic problems, such as a lack of opportunities, jobs and revenue, over and above forest-related or 'environmental' problems. One exception were agricultural problems such as the coconut virus, falling yields, and soil exhaustion, but in these cases reasons for the problems did not include forest degradation. People also mentioned increasing drought as a problem: 1992 was so dry that people had to go to rivers and lakes to get water, since then water tanks have been built but these were not able to supply enough water during the summer of 2005. People did not attribute drought to deforestation.

NKourani-Sima: The lack of revenue-generating activities is a huge problem to the community, meaning that many have to work as woodcutters to earn money. The wet season has halved to around three months over the past decade, and the once permanent river near the village no longer flows. While some people attributed these changes to deforestation, many older people said they did not know why it had happened and attributed it to God's work. In the early '90s, trees used to be closer to the village, but now the woodcutters have to go to higher altitudes to get the best trees. People did mention that if this trend continues it will cause serious problems for the next generation. However, despite this observation, the view was also widespread that there would always be forest to use, because the trees regenerate as fast as, if not faster than people are cutting them down. People informed us that there were always areas where big trees could still be found, and so they were not too concerned for the future.

Mjumvia: People cite forest-related problems and the effects of deforestation as the principal problems for the community, in particular declining yields due to soil over-exploitation and mass planting of clove trees which take the nutrients from the soil. There is also little cultivatable land that is not already in use, owing to the lack of alternative jobs, population growth and a poor land-legislation system that means that abandoned fields are often left unused. Other problems relating to agriculture are a coconut parasite, an increase in crop pests, increased cyclone damage to the crops and theft of yields owing to general poverty and lack of food. Many noted that the dry season was longer and that the river was running slower now than in the past. This was widely attributed to deforestation, and the community now collectively prohibits the cutting of trees near the river.

Lingoni: Lack of jobs and opportunities, especially due to the falling price of cash crops, and the theft of subsistence crops because of general poverty, were cited as problems more often than environmental issues. The villagers observed that in the past ten years the river has ceased to run permanently, and while a project in the 1990s planted non-native trees near the river to alleviate the problems, people have since cut them down for wood. However, the river did not seem to be one of the more pressing concerns of the decision-makers in the village, and motivation to protect the forest did not seem to be strong. Many people complained that their yields were declining over time, regardless of the fact that they left their fields for a fallow period after three to four years of use, and that there was a general lack of land. Suitable trees for making planks are also becoming rarer and in the past ten years firewood has become less abundant, so much so that the price for one firing of the distillery has doubled in the last five years.

Section 4: Who do people see as decision-makers as regards forest use?

The Comores are characterised by a fusion of traditional, Islamic and governmental law, and these do not always coincide. We found that many practises regarding decision making and regulations were the same in all of the villages; it is noted where they differ.

Obtaining and owning a field

Each village has an area of forest around it that was allocated to it by the colonial powers. The boundaries of these areas are often marked by geographical limits, such as rivers or ridges. People respect these limits and do not work land that is not of their village unless they marry someone of that village or are invited. Fields in or near the village are all already owned and are generally passed on through inheritance (split equally between male and female children) or occasionally sold to other village members. The produce of a field belongs to those who work it, but old or infirm people can lend their field to another to work and will receive a proportion of the harvest as payment.

Technically the land in the forest belongs to the state, but according to Islamic law, land becomes the property of the first person to work it. Thus it is possible to go into the forest and claim a piece of land by working on it, and this happens often in all the villages we surveyed. When selling a plot in the forest, one sells the crops themselves. Thus, if a field is left un-worked in the village, it still has an owner, whereas this is not true for an abandoned plot in the forest.

Authorization for woodcutting

Since the 1980s regulations have been in place to reduce deforestation and ensure that tree-felling is done in a controlled manner. The law states that cutting down trees alongside roads or rivers is prohibited. If people wish to fell a tree, they have to seek permission from the rural guard at the town council. If people are caught felling a tree without permission they are supposedly reported to the Department of the Environment and then prosecuted. In practice, people do not obey these regulations as it is a hassle to seek permission and there is also a fee. The authorities lack the resources to patrol and enforce the legislation, and so deforestation continues with little interruption.

NKourani-Sima: In the last ten years the village committee decided to prohibit outsiders from cutting trees near to the village. They proposed the idea to the mayor, and a pilot committee was set up to enforce it.

Lingoni: In the past two years the local gendarmerie has made it illegal to cut trees and attempted to enforce its ruling, but it still happens regularly, if clandestinely.

Mjumvia: The community collectively decided not to cut trees near the river, and a community forestry guard was appointed whose responsibility it is to inform anyone found cutting trees in this area of the dangers of what they are doing. They do not have the means to punish people who break the rule, but try and teach them why they should not do it.

Community decision-making

Traditionally, the Comores is characterised by a hierarchical, patriarchal decision-making system (Ahamada Mmadi, 1999). The males of Comorian society are organised into nine different classes of social status, which are acceded to by performing different social ceremonies or customs, the most important being an expensive wedding called the 'Grand Mariage'. Those who have not yet undertaken the Grand Mariage are the minors, those who have are the notable class. The notables have the main decision making power, and convene in an assembly to suggest community projects that are then voted on by the other members. Community decisions taken by this group are then taken by the village chief to the mayor and the town council to be enforced. The villages we surveyed varied in the degree to which this structure was followed.

Djoumoichongo: Decision making follows the traditional pattern quite closely. Women were often reluctant to speak to us, reflecting the fact that they are traditionally not part of the formal decision-making process, and being a notable is still a strong requirement for making decisions.

NKourani-Sima: This village exhibited the closest adherence to the traditional mode of decision-making. It was connected to the capital by a road in only 1992, and so modernisation and movement away from the traditional system have been slow. Men are still seen as decision-makers in the village, and while in theory a woman can propose an idea to the village committee, no one can remember it having happened. Women we spoke to about decision-making told us that they did not know about it as it was not their affair.

Mjumvia: Since 1993, the decisions of the community have been strongly influenced by a group of male intellectuals aged 18-30, who work alongside the notables. It was this group that decided to prohibit the cutting of trees near the river. They stressed that money was no longer the most important requirement of decision making status, as being respectful and having motivation and initiative were also important. Women can gain a lot of respect within the women's group, and do participate informally in discussions, although they cannot become notables.

Lingoni: Lingoni follows a more traditional mode of decision making. People we spoke to said that only the notables can propose community projects.

Section 5: What do people propose as solutions?

Djoumoichongo: Alternative resource-generating activities were proposed as solutions to the socio-economic problems of the community. One idea was the manufacture of fruit juices, as sugar cane and citrus fruits grow well in the area, but there is currently no way of preserving or storing the fruit. Another idea was the tourism potential of the Nioumbadjou site. Tree planting was suggested by some woodcutters so that they might sustain the species they exploit. They felt that they had the expertise to plant the trees, but that financial means would be the biggest barrier as they would require a small salary for those people who do replanting instead of working, tools, and possibly saplings or the means to make a nursery. They felt that this money could not be raised at the community level because people in the community do not see the problem as being theirs. We were also told that many cultivators plant leguminous species in their fields to increase its fertility, but that widespread implementation would require input from the ministry of agriculture. Various people we spoke to expressed concern about the government's proposed plans; they worried that their needs would not be taken into account and that the delineation of community land might potentially create limits that do not correspond with the way land is used in practice.

NKourani-Sima: The community wants alternative resource-generating activities, although specific ideas were lacking. The supply of wood was felt to be greater than the demand. Many people we spoke to could see the value of planting trees to regenerate the forest for the sake of the environment and also to make the lives of the woodcutters easier, but they were not sure if the planting of endemic trees was possible. Few people were in favour of a reserve, as they felt that it would inhibit them from earning a living. In addition, it is unlikely that the community itself would be in favour of setting aside an area because they are so reliant on the trees as a resource.

Mjumvia: Solutions most often mentioned were the improvement of agricultural techniques, an improvement in the land tenure system and alternative resource-generating activities. People who had left their plot fallow for five years or more reported positive results, and some older members of the village said that they had not previously heard of the technique but would start using it. Many people suggested using natural fertilisers, but that implementation could not be universal owing to different types of soil and altitude. People said that they would like to use a fallow system, but that low yields and theft mean that they cannot afford to. Some people suggested that planting of clove trees should be stopped as they take the nutrients from the soil, but that they continued to plant them in the hope that the prices would increase again. Ecotourism was suggested as an alternative source of income.

Another suggestion to reduce the level of deforestation and to combat deforestation-related problems was tree planting. In the 1990s there was a project near the village which organised tree nurseries and people to plant the trees, but since the funding ran out people have not been willing to plant the trees voluntarily. Another barrier people spoke of was a lack of education on the need or the methods involved in the planting. While people who understood the benefit of protecting the forest supported the governments' plans in theory, they said that demographic pressure and a lack of government capacity for enforcement would be major barriers.

Lingoni: The main solution people proposed was alternative resource-generating activities. They suggested that the ylang ylang distilleries could be converted to use hydroelectricity coming from the dam in the village founded in 2003. This idea would both create jobs at the plant, decrease pressure for fuel-wood and increase people's salaries. Many people we spoke to were aware of the technique of leaving plots as fallow, but often complained that their fields were not large enough to permit its use. Natural fertilisers were also used by some people, but again this could not be universal due to the lack of cattle. A few people suggested tree planting as a solution to fuelwood scarcity, drought, erosion and aridity. However, many people who could see the advantage of tree planting told us that others would not understand the benefits, or that they would not be interested in working for long-term benefits when their immediate needs are so pressing. Younger people tended to say that they were aware of the detrimental effects of deforestation, and that this awareness was missing in the older generation but that they were loath to try and educate people as they had to cut trees themselves for a living, and that they were not listened to in the village. Feelings were mixed on the subject of reserves as some saw the forest as an infinite resource so could not see the benefits, others stressed that a financial reward would need to be offered, and if they had no alternatives to working in the forest and there was inadequate enforcement, the system would be ignored.

5. Discussion

The causes of deforestation

It is difficult to untangle the ultimate causes of deforestation from the complex interplay of many different factors. As a proximate cause, deforestation continues on the Comoros because a large percentage of the people rely directly on forest exploitation for their livelihoods, either through collecting timber to make money or creating new fields to boost yields. The Comoros thus seem to conform, at least to some extent, to the 'Tragedy of the Commons', where it is in the interests of the individual to continue felling trees and clearing land, but against the interests of the community. The lack of alternative resource-generating activities, either in the form of state or private jobs, or from local production, was identified by most informants as the reason for the reliance on forest exploitation, and this in essence comes down to the very poor economic condition of the Comoros. A rapidly increasing population, due in large part to a lack of birth control in rural areas, is one of the main reasons why this reliance leads to overexploitation, as more fields are needed to feed more people and traditional methods of subsistence agriculture are now unsustainable. However, other factors undoubtedly come into play.

On Anjouan, fertility is decreasing away from the forest due to inappropriate agricultural techniques: few trees have been left to help shelter the land and the crops or to aid nutrient and water supply, and manure and fallow rotations are rarely used. These techniques do not interact positively with natural conditions conducive to erosion such as strong winds, heavy rain and steep slopes. People in Mjumvia noted that an inappropriate land tenure system is causing problems as many fertile fields abandoned by their emigrating owners are left unused, although it is not clear how widespread this problem is. Currently unfavourable economic conditions such as the declining value of export crops like cloves mean that people are relying even more on subsistence agriculture. The end result of these factors is additional pressure to create new fertile fields in the forest, even though poor agricultural practices mean that this fertility is rapidly lost.

On Grande Comore, a lack of environmental awareness means that people do not understand the long-term impact of continual timber extraction and forest destruction, although it is already becoming evident. Increased awareness will only have an effect if this leads to the necessary consensus to act, which seems lacking at least to some extent at the moment, even on Anjouan. In line with this, the lack of government enforcement of existing forestry legislation was identified by many informants on both islands as a hindrance to efforts to reduce deforestation.

Scale of community impact on the forest

Despite the legislation aimed at reducing deforestation, the complete lack of enforcement means that deforestation continues in all the villages we worked in. The level and method of that impact on the primary forest differs considerably between the different villages. On Grande Comore, Djoumoichongo is perhaps an anomaly as mass clearance in colonial times means that it is now situated far below the primary forest and only heavily affects secondary growth. In contrast, nKourani-Sima has the highest current impact on the primary forest of the four villages. Casual observation of similarly heavy deforestation around the nearby Tsinimouapanga suggests that this is due to the proximity of large primary forest trees which can yield attractive prices from buyers in the local area or in Moroni. While there is limited timber-gathering from Djoumoichongo, the time needed to find the right trees makes it a largely unprofitable activity.

The two villages on Anjouan both exert a high pressure on the native forest, though a history of overexploitation means that its lower boundary is far away from the villages and so current levels of deforestation are not as great as in nKourani-Sima. A greater chance of punishment, the lack of suitable trees and poorer economic conditions also contribute to a much lower level of timber extraction. Creating new fields drives much of the deforestation as fertility continues to decrease in areas further away from the forest.

Levels of environmental awareness and attitudes to conservation

There are clear differences between the responses we obtained from the villages on the two islands. On Grande Comore, people could rarely cite values of the forest other than the forest products they used directly. Conservation principles were largely absent, with the exception of religions leaders who talked about Quranic verses relating to the environment. On Anjouan, most people were familiar with the ecosystem functions of the forest and could see the importance of its protection, although awareness was much greater in the younger generation.

These different levels of understanding reflect the history of environmental education and forest degradation on the two islands. The population on Grande Comore has received little formal environmental education while awareness campaigns have been undertaken on Anjouan throughout the past decade, thus for example, the people of nKourani-Sima were unaware of how damaging their activities would be in the long run to both the forest and the inhabitants of the village. In addition, deforestation on Grande Comore has not reached as critical a level as on Anjouan, where its effects are immediately obvious even to the uneducated.

It is interesting to note the impact of the awareness programs on Anjouan. Lingoni, located close to a Livingstone Bat's roost-site has been subject to much greater awareness work on the value of the bat and the forest than Mjumvia. The consequence seemed to be more positive attitudes to conservation and forest protection. However, there was an impression that the inhabitants seemed more likely to say what they thought we wanted to hear, rather than what they actually felt. Hence the degree to which environmental protection is viewed as a priority by inhabitants of the village is uncertain.

Reaction to the government's ideas and other solutions suggested for reducing deforestation

At the time of surveying, the government had little power to enforce legislation and therefore played a relatively small role in the lives of the local communities. This was reflected in a general feeling across all villages, even amongst those who thought it might be a good idea, that the government would be unable to implement plans to divide forest land into reserves, and community and privately owned areas. Many were also worried that current boundaries and the needs of the people would be ignored if the government pushed its plans through.

The general consensus was that community-led decisions would be more likely to be followed than those imposed from above. Some community action was already evident; in Mjumvia the community decision to prevent tree cutting near to the river seemed to be particularly effective. However, there was wide variation in motivation to restrict forest use between the villages and between the inhabitants of each village. There was also large variation between the villages with respect to which sections of the community have decision-making power. All of which means that any attempts to reduce deforestation have to be tailored to the specific circumstances of each community.

Solutions suggested reflect the impact the village has on the forest, the most pressing concerns of the community, and the history of past solutions already attempted in the area. The idea of alternative resource-generating activities that would reduce reliance on the forest came up most frequently, although there were few clear ideas of what these might be. Similarly, afforestation was a popular idea but there was little idea of how this would work. In many cases the pressing needs of poverty meant that long-term environmental and human benefits were not seen as strong enough incentives to motivate action.

Environmental Awareness Work

1. Background

In the early 1990s Care Comores, an international conservation and development NGO, established that the general public on the Comoros was not well informed about environmental issues. Environmental threats were either not understood or seen as secondary to problems such as poor health and literacy rates. People did not see themselves as having the power or the responsibility to change their condition or environment. Peace Corps volunteers were drafted in to increase awareness of the importance of the Comoros' threatened ecosystems and biodiversity, working as environmental educators in local schools, and establishing large-scale public education through the use of radio programmes (Hunter et al., 1992).

They also helped to set up some of the first 'Ulanga' groups. 'Ulanga' is the Comorian for environment, and the Ulanga groups on the islands are community groups set up to protect their local environment. The first group was created in Mutsumudu on Anjouan in 1990 and the idea spread to Grande Comore the following year. Groups consisting of a few dozen willing and enthusiastic individuals now exist in most villages. They are often created by young people in the community and focus on voluntary participation in activities such as increasing awareness of environmental problems, organising rubbish collection and planting native trees (Ahmed, undated).

At the same time as the creation of these first Ulanga groups, expeditions from the University of Bristol started the process of setting up a local NGO, Action Comores, with the aim of saving the endemic Livingstone's Flying Fox (LFF) and its forest habitat on Anjouan and Mohéli. The lack of LFFs and the more intact ecosystems means that there has been far less NGO influence and environmental awareness work on Grande Comore, a fact which is reflected in our findings on the current levels of environmental awareness (see PRA results).

In addition to training villagers living near LFF roosts to survey and monitor the bats, Action Comores launched an environmental education programme (EEP) to highlight the importance of the LFF and its forest habitat in the lives of the Comorian people. The programme targeted villagers living close to bat roosts through posters, stickers, a locally shot video, theatrical presentations and touring workshops. Local educators were also trained to develop further EEPs (Trewhella *et al*., 2005). ACA continued the work of the project after this initial thrust, but there has been no major education or awareness-raising efforts since the mid 1990s.

A recent evaluation of the work (Trewhella *et al*., 2005) noted that direct methods were more effective than those involving interpretation by educators, such as the development of lesson plans. The film was found to be a great success, owing largely to its novelty, being made in the local language, and its widespread accessibility through free video copying and repeated showings on local television. Stickers and posters were also found to be useful in prompting curiosity and discussion. Interviews in 2001 in villages where awareness campaigns had been undertaken showed that the EEP had achieved its aim in significantly raising awareness of the importance of the LFF and the interdependence of the bat, the forest and the people.

Despite these efforts the 'National Strategy and Plan of Action for the Conservation of Biodiversity on the Comoros' (UNDP et al., 2000) states that there is still a lack of awareness in the general population regarding activities and behaviours detrimental to the environment, and that people are not aware of current environmental legislation. The plan suggests that environmental education is still required to make people more aware of the long-term consequences of their impact upon the environment and of the environmental laws already in operation, and to help coordinate the Ulanga associations in working to achieve conservation aims.

In planning our awareness drive we took account of the history of awareness efforts on the two islands, working in consultation with all our partners in the Comoros and Will Trewhella, who had been responsible for setting up Action Comores and its subsequent EEP. We also took account of the recommendations of the UNDP report, working with UNDP and government officials to incorporate their suggestions into the work.

2. 'Ulanga' days

Introduction

The Ulanga groups suffer from a lack of detailed knowledge of the issues surrounding the environmental problems at hand, and are prone to collapse or at least dormancy when young founder individuals leave the community. Many also lack any form of investment. Nevertheless they represent a vibrant and widespread potential groundswell of environmental action.

We hoped to build on this potential for the benefit of future conservation efforts. A male and female member of Ulanga groups from villages near to remaining forest were invited to take part in a workshop. Two workshops were held, one in Mutsumudu and the other in Moroni. Around 40 people attended each day.

Aims

- To increase knowledge of environmental issues in the Ulanga groups so that they are better able to spread awareness and act to protect their ecosystems.
- To create a widespread network of people willing to work for the environment in the future.
- To discuss the results of the PRA and see whether the experience of a few villages coincided with that of a wider sample.
- To discuss possible solutions to the problems identified and to explore the viability of some of those suggested during the course of the fieldwork.

Programme

09:00 Introduction to the project and the day
09:20 The biodiversity of the Comoros and its importance (lecture)
09:40 Forest ecosystems (lecture)
10:00 Questions on these two lectures
10:30 Group discussions on forest values and the problems caused by deforestation
12:15 Lunch
13:00 Group discussions on the causes of deforestation and possible solutions
15:15 The role of the Ulanga groups in environmental work (lecture)
15:40 The Ulanga groups' role in *Conservation Comores*
16:00 Round-up

Methodology

We specified in our invitations that we would like enthusiastic and prominent members of each group to attend, who could also speak French. The project paid for their travel expenses, and also provided refreshments throughout the day. We handed out a notebook and pen at the start of the day so that they could all take notes.

The three lectures were delivered by our Comorian partners in a combination of French and Comorian using Microsoft powerpoint. We split into groups of five or six for the discussion sections, run in French, each small group being led by one of the project team. One member of each group then presented their ideas to all the participants before everyone moved onto the next discussion.

At the end of the day contact details of all the participants were collected to facilitate distribution of the project's awareness posters and films. We wrote resumés of the day's work and all the information presented which were distributed to the participants by our Comorian partners a few weeks after the event.

Results

Little was added to the lists of values of the forest or problems caused by deforestation that had been compiled during the PRA fieldwork. This is not to say that the problems experienced by each community are the same, they aren't. It illustrates only that the villages surveyed on each island covered most of the uses and values of the forest, and most of the problems experienced by forest communities in terms of environmental degradation.

The causes of deforestation were ranked in importance (Table 1). Most frequently cited as important causes of deforestation were demographic pressure, a lack of employment and a lack of knowledge regarding the importance of the forest and its finite nature as a resource. This information had not been collected during the fieldwork and is important for targeting future work as it shows what the Comorian villagers believe to be the biggest problems leading to deforestation.

Table 1. Ranking of the causes of deforestation by the different groups on Anjouan (1 = most important factor)

Cause of deforestation	**Group**				
	A	B	C	D	E
Population expansion		2	3	1	1
Lack of employment	1	1	1	2	2
Lack of environmental awareness		3	2	3	3
Abandoned fields away from the forest		5		4	
Poor agricultural techniques	2		5		
Inappropriate legislation and a lack of its enforcement		4	4		
Importing of chainsaws					4
Crop theft			6		

The participants were asked to discuss the viability of solutions suggested during the PRA fieldwork and add any others that might be applicable. Topics for discussion included who would be responsible for implementation (Table 2) and how soon solutions could be implemented. Short-term solutions which it was thought could be implemented by the Ulanga groups in partnership with NGOs included environmental awareness and education programmes, creation of income-generating microprojects, reforestation of padzas, and the creation of an environmental network of motivated individuals to facilitate communication of initiatives and information. Musical and theatrical events were highlighted as important ways of raising environmental awareness. Solutions that were thought to be the responsibility of the state included improving laws regarding the forest and land tenure, the instigation of environmental education in schools, use of family planning and elevating the status of conservation within the political process.

Table 2. Potential solutions and the institutions responsible for their implementation, from the participants in Grande Comore

Potential solution	Institutions responsible (L = Local, S = State, I = International)
Awareness work	L
Environmental education	L, S
Biodiversity reserves	L, S, I
Tree nurseries	L, S
Elaboration and application of forestry law	S
Guarding of forest	L, S
Creation of employment	L, S
Reforestation of padzas	L
Plantations outside the forest	L
Institution capacity building	S, I
Reducing the price of petrol	S
Importing wood and construction material	S
Political will in favour of conservation	S
Coordination of local initiatives	L
Family planning	L, S, I

Evaluation

In general the days were a success, with all of the aims achieved at least to some extent. The PRA results were shown to be broadly accurate, and additional information useful to the project was collated, particularly as regards possible solutions. We hope that the participants used the information and the resumés to spread the conservation message across their villages, undoubtedly their own environmental knowledge was improved. We will be using the networks created to disseminate the posters and films and hope that they will form a long-term basis for environmental projects.

The methods employed worked well. Using powerpoint presentations enlivened the lectures, which were kept short to ensure that attention was held throughout. The small discussion groups successfully maximised the participation of all, although could have benefited from better direction and mixing individuals through the day. It was important that equal numbers of men and women attended so that there were as a full range of perspectives in evidence and a realistic chance of the information being spread to the whole community. Some groups were dominated by men so firm direction was needed to ensure that the women were able to express their views. Unfortunately we were unable to distribute the handouts at the time of the workshop; in the future it would be preferable if participants are able to take all relevant material away with them.

3. Awareness films

After the success of the previous film, Action Comores Anjouan suggested that a new one produced with better equipment would be particularly beneficial. We are producing two half-hour films to raise the awareness of the environmental problems and the need to act now to protect what remains of the forest. There will be one each for Grande Comore and Anjouan, narrated in Shingazidja and Shindzuwani respectively, and subtitled in French. This has allowed us to tailor the content of the films to the significantly different environmental and economic circumstances of the two islands, and will ensure that the films can be understood by all the target audience.

We have produced over 16 hours of footage, and are in the process of editing the final films. The films, although differing in content, will follow a similar structure. Both introduce the islands and the significance of the relationship between the islanders and the forest. They go on to discuss the uses the islanders make of the forest, and the impact of these upon the forests, before discussing the problems caused by deforestation; presenting ecosystem benefits of the forest using a combination of footage and clear diagrams. Finally they move onto discuss potential solutions. We have included interviews with political and religious figures, as well as those who use the forest for their livelihoods, to emphasise the collective responsibility for finding and implementing solutions. The scripts were recorded by our Comorian partners, sentence by sentence with a French translation, so that we can edit them into the film back in the UK.

We hope that the films will make everyone understand that the situation is urgent, facilitate discussion of solutions, and empower local people with the knowledge that they can work to combat the deforestation and its effects. The films will be shown on the local and national TV channels, and copies distributed as widely as possible. We are also investigating the possibilities of public screenings in the villages.

4. Awareness Posters

We are printing awareness posters in the UK, which will be distributed by our partners and the Ulanga network during the longer project. They show the basic importance of the forest in a diagram annotated in French and Comorian (Figure 1). We hope that they will also serve to raise awareness about the ongoing project and the NGOs. Trewhella et al. (2005) found that although posters were a useful way of transmitting information, they were often treasured by individuals and kept away from public viewing for fear of being damaged. We are therefore laminating the posters so that they can be displayed outside without being damaged by the weather.

Figure 1. Awareness poster produced for Anjouan.

5. Press conferences

Press conferences were organised on both islands to spread the conservation message and explain what the project was hoping to achieve. On Anjouan, a ceremony organised by Action Comores to celebrate winning two of the international BP Conservation Programme awards was attended by over a hundred people, including the mayors of all the villages, and subsequently covered by all the media. On Grande Comore, Yahaya organised a presentation of the project to the government and the press, and half-hour reports went out on the national TV and radio. Details were also well covered in the national newspapers.

Conservation Recommendations

1. Further research

The recommendations that follow are based on only three months work in the field; further research is needed before a concrete analysis of the situation in the Comoros from both a biodiversity and a human perspective can be made, and before effective conservation measures can be implemented. We suggest that future research should include:

- Continued habitat surveys and population assessments of endemic species from as many taxa as possible. These should be converted into GIS maps of habitats and biodiversity richness to facilitate conservation decision-making and comparison with future research.
- Detailed research into individual endangered species such as the Scops Owls so that appropriate conservation plans can be devised.
- More detailed socioeconomic research is needed to investigate the attitudes of all stakeholders to conservation, and to identify the levels of deforestation and environmental awareness. A public engagement strategy can then be devised, using the materials of this preliminary project as a starting point.
- Maps of land use and ownership will be needed if participatory management plans for the remaining forest are to be drawn up.
- Implementation of conservation measures will require research into, amongst others, possible alternative revenue-generating activities, agricultural and agroforestry options and improvements, and the specific institutional arrangements required for participatory management to be successful.

2. Protecting the biodiversity

The results of the butterfly and bird surveys clearly show the dangers that continuing deforestation is posing to many of the endemic species; several are largely dependent on forest where a native canopy remains. Some sort of reserve system must be implemented soon if enough native forest is to be protected to maintain biodiversity and the ecosystem functions that it provides. One likely aim would be to protect as full a complement of the Comorian fauna and flora as possible within exclusion reserve boundaries. We base recommendations on three months of bird and butterfly surveys and a study of the literature of earlier surveys of these two taxa – further focal taxa research is needed before concrete biodiversity recommendations can be made.

On Grande Comore, an exclusion reserve would best be located on the south-eastern flanks of Karthala, where a large amount of relatively intact native forest remains and endemic species richness is at its highest for birds and butterflies. Ideally the lower boundary of such a reserve would extend to around 750m to include the zones of highest richness for endemic butterflies, whilst the upper bounds would stretch into the heath zone at around 1900m in order to include the endemic Karthala white-eye.

On Anjouan, there is such a small amount of native forest left that any remaining patches should be protected, preferably with regenerating corridors in between. The research underlines the importance of protecting native forest at lower altitudes. Unfortunately there was not time to work on Mohéli, the third island of the Union, during this short project. Discussions during the September 2006 visit suggested that a terrestrial reserve would best be linked with the existing Mohéli marine park.

3. Reducing deforestation

Of course, producing biodiversity recommendations is not sufficient when the most important factors influencing conservation action are likely to be political, economic and cultural.. Regardless of moral and ethical considerations, conservation on the Comoros will not succeed in the face of abject poverty if it does not focus on the needs of the human population. We hope that with our participatory work in the villages we have made a move in this direction.

The first step towards targeting efforts to reduce deforestation is to acquire as complete an understanding as is possible of the causes of deforestation. Those outlined in this report may be somewhat simplistic, focussing as they do on the local situation and ignoring the broader political and economic conditions emphasised in, for instance, a political ecological approach. There has, for example, been much criticism of the ‘Tragedy of the Commons’ theory, whereby degradation occurs as the interests of individuals override those of the community. At the same time, it seems apparent that this plays at least something of a role in the Comoros. Further discussions with all stakeholders and international advisors should help to get a more complete picture of the situation. Our ideas on the next steps in the process are outlined in the further research section above and the objectives of the ongoing project below.

Despite the brevity of our research, we hope that the following recommendations will be of some use, whilst acknowledging that they will need adapting as understanding improves. We decided that it would be more appropriate simply to outline our thoughts rather than go into detailed discussion and referencing.

1) **Building cooperation**
Firstly, research and common sense dictates that the Tragedy of the Commons can only be overcome through stakeholder consensus. The Comoros will progress only if there is agreement between individuals, between communities, between institutes and between islands. Conflict resolution and building cooperation will have to form a large part of future efforts, and this will take time.

2) **Diverse solutions not blueprints**
Different solutions will be required for different situations at all levels. Again, this necessitates long-term investment rather than an attempt at rapid implementation of blueprint ideas.

3) **Environmental awareness work**
There is a crucial need for environmental awareness work on Grande Comore to inform people about the negative effects of forest degradation. Few people on Grande Comore were aware of the severity of the situation on Anjouan, which would provide

a valuable example for comparison. On Anjouan, younger people seemed to have a reasonable level of environmental awareness, presumably as they were more susceptible to the messages emanating from school and the media. However, younger people are not often the principal decision-makers, so awareness efforts may need to be targeted at older generations. Ideally, one would also encourage greater participation of neglected sectors of society, though this may prove especially difficult.

4) **Poverty reduction**
Ultimately, solutions are likely to be successful only if poverty is alleviated and reliance on overexploitation is reduced. The generation of alternative income-generating activities was the most frequently cited solution by the villagers. Possibilities suggested during the project included juice production, hydro-electricity, and improving mariculture and livestock yields. Given the poor economic condition of the Comoros and the 'resource curse' inherent in its dependence on cash crops for foreign cash, it has to be doubtful how viable and sustainable such efforts would be. It may well be that parallel efforts will have to focus on the burgeoning field of direct payment for conservation and ecosystem services. Such a system would have to work for the long-term and be linked directly to reducing dependence on the forest. Much research and discussion is needed.

5) **Population problems**
There is also the tricky problem of population growth, again frequently cited by the local people as a significant cause of ongoing deforestation. Both neo-Malthusian (population growth leads inexorably to greater degradation) and Boserupian (population growth leads to greater innovation and efficiency) theories on the effect of population growth have been dismissed by some at the local level, while others are keen to highlight examples of where they apply. Just as it has been challenged as naïve to assume a Malthusian or Boserupian perspective, it also seems naïve to ignore them completely for all situations. Perhaps the Comoros as a small island state lends itself to Malthusian ideas, they certainly appear to apply at least to some extent. Although population growth has become almost a taboo subject in development circles, it appears that any serious long-term effort to tackle deforestation must engage with this contentious issue.

6) **Agricultural improvement**
Poor agricultural techniques and inefficiency lead to a greater demand for the creation of new fertile fields in the forest. Before the political instability of the 1990s, several international organisations worked with farmers to improve cultivation methods through techniques such as contour planting to stabilize soils, inter-cropping, and planting nitrogen-fixing trees to improve soil productivity. Well researched efforts such as these would be very beneficial.

7) **Improving forestry and land legislation**
The existing forestry and land legislation and lack of enforcement also contribute to the continued creation of new fields in the forest. The fact that the forestry legislation is ill-adapted to the situation on the Comores has long been recognised, and it is in the process of being updated by the government. However, its future enforcement is crucial if it is to be effective.

The current overlap in land legislation of traditional, Islamic and colonial laws does not foster the long-term investment of farmers in their plot of land, nor the development of activities to support agricultural sustainability. In addition, deserted plots of land are not taken over by others, owing to the lack of transparent ownership rights. We therefore stress the need to address the land tenure system.

8) **Afforestation**

Afforestation has been put forward as a solution to a variety of problems: low soil fertility, degraded land and padzas, erosion, unsustainable exploitation of firewood and timber and water shortages. For the past 50 years, padzas have been reforested on Anjouan but in recent times slow progress has been made as problems with access make supervision and management hard, and dependence on food-for-work labour has created additional problems. In order to develop exploitation of wood for timber the FAO attempted the planting of forest species (eg Weinmania and Khaya comoriensis) in agroforestry systems but discontinued this because the trees competed too much with crops. However, there is still much potential in restructuring groups of woodcutters and carvers so they have more incentive to protect their resources, and in managing timber for commercial wood production. The capability of communities to produce locally all the wood they need for fuel wood could be assured by introducing village woodlots. Reforestation along water sources should use medicinal or fruit trees to discourage their being cut down once the project ends. Projects such as these would require forestry expertise, financial backing, immediate and direct incentive for participants, strong organisation, and the provision of necessary materials, advice and education.

9) **Protected areas**

Central to future conservation efforts will be a system of protected areas. Every effort should be made to include all stakeholders in the design, implementation and benefits of an appropriate system.

Follow-up scoping trip and the future for Conservation Comores

Hugh Doulton undertook a follow-up scoping trip between 31st August and 9th September 2006 to discuss the future of the project and specifically to prepare an application for the UK Government's Darwin Initiative. The trip was the result of months of work following the initial expedition that aimed to expand the project into something that could make a difference. It was agreed with the main funders (University of Oxford, BP and RGS) that money left over from the original expedition could be used for this purpose.

During the week's visit meetings were held with: members of the UNDP environmental bureau, the World Bank representative and her team, the head of the civil service for the National Government, members of the National Ministries for the Environment and Education, members of the Grande Comore, Anjouan and Mohéli Environment Ministries, members of the National Direction for the Environment, members of the CNDRS, members of FADC, and members of the NGOs: AIDE, Action Comores Anjouan and Action Comores Mohéli.

The result was partnerships agreed with all of these organisations in making a Darwin Award application entitled: 'A Forest Conservation Management Plan for the Comoro Islands'. The stated aim was to '*To enable conservation of endemic forest biodiversity in the Union of the Comoros by developing a conservation plan for forest in partnership with all stakeholders, and by identifying the funds and building the capacity and social acceptance necessary for its implementation.*'

The five specific objectives were:

1) Building legitimacy (social acceptance) for conservation plans and agencies locally, through a public consultation and engagement programme;

2) Building Comorian technical capacity in project management, GIS modelling, habitat and biodiversity surveys, community engagement, and participatory learning and action;

3) GIS modelling of forest habitat types, associated land-uses and ownership, and endemic biodiversity (bird and butterflies);

4) Working with local communities to establish deforestation rates, land-uses and ownership, and using these results to help them develop management plans for areas under their control;

5) Integrating these results into a forest management plan for each island to include designation of protected areas, land-use zoning and avenues to generate alternative livelihoods, all validated by local communities.

The plan involved Hugh Doulton project managing on the ground with the support of three academics from the University of Oxford who would deliver training on biodiversity surveys and GIS, and work to develop the management plans. Bristol Zoo Gardens was another key partner in this, with Neil Maddison, their head of conservation programmes, leading on the participatory process.

The application went through to the second stage with strong recommendations but unfortunately we heard in March that the project had not been selected for financing at the final stage. The funding situation at DEFRA may have played a large part in this – only 14 rather than the usual 40 projects were financed. The feedback was also that the application seemed ambitious and risked not being completed within three years.

Taking this into consideration, Hugh Doulton has been developing alternative plans with Bristol Zoo Gardens and our Comorian partners. The current plan is for Neil Maddison and Hugh Doulton to visit the Comoros in October 2007 to hold meetings with all partners. Work will then commence on Mohéli, with Neil delivering training in the participatory process. Hugh will stay on to project manage for an initial term of one year, supported by Bristol Zoo Gardens, the three academics from the University of Oxford, and possibly further academics from the University of East Anglia. Funds are available from Bristol Zoo Gardens, and these will be supplemented where necessary by further grant applications (we are currently preparing some GEF small grant applications as these have just been opened up for the Comoros). The project will be rolled over to the other islands in subsequent years if all goes well.

Conservation Comores thus lives on and, we hope, will come to make a positive difference to the Comorian people and biodiversity.

Outputs

Expeditions/ Projects
Scoping trip: 8th April to 14th April 2005
Main project: 30th June to 14th September 2005
Scoping trip for follow-up project: 31st August to 9th September 2006
Future project: October 2007 onwards

Reports (all available from Hugh Doulton and the RGS)
Scoping trip report: April 2005
Preliminary report: October 2005
Final report (including follow-up trip report): June 2007

Publications (all in progress)
2 chapters in a Bird Atlas for the Comoros to be published by the Royal Museum for Central Africa (Charlie Marsh and Hugh Doulton)
1 paper on Papilio Aristophontes (Dr Owen Lewis and Hugh Doulton)
1 paper on butterfly survey comparisons (Hugh Doulton and Dr Owen Lewis)
1 paper on Scops Owl Surveys (Charlie Marsh)
Photos of Otus Capnodes for the Birdlife International publication on critically endangered bird species (Charlie Marsh)

Partnerships
International: World Bank, UNDP, Conservation International, Bristol Zoo Gardens, Durrell Wildlife Conservation Trust, the Royal Museum for Central Africa in Belgium
Comorian: National Environment Ministry and Civil Service; Grande Comore, Anjouan and Mohéli Environment Ministries, FADC, CNDRS, Action Comores Anjouan, Action Comores Mohéli, AIDE

Future Grant Applications (many more to come…)
Darwin Initiative 2006 (failed)
Mauritius Round of Funders for the Comoros (in review)
GEF small grants (in review)

Dissertations (largely incorporated within this report)
Hugh Doulton – 'Conservation priorities within a global biodiversity hotspot: a case study of the butterflies of two tropical Indian Ocean Islands'
Charlie Marsh – 'Bird conservation priorities in the Comoro Islands'

Lectures
Royal Geographical Society, January 2006 (for the iNOMAD award)
University of Oxford, November 2005
Various schools – October 2005 to January 2006

Other
Two awareness films and awareness posters; two training days; equipment donated to Comorian NGOs; pictorial guide to the Comorian butterflies

Medical and Safety Report

With the significant exception of the car crash in which one of our key collaborators was killed, the expedition was free from all but minor medical and safety incidents.

1. Car Crash 29/07/2005

Four weeks after arriving on Grande Comore, a taxi carrying expedition member Charles Marsh and collaborators Hamidou Ali and Mouhoutari Ahamada crashed into a tree early in the morning. The crash resulted in the death of Hamidou, whilst Charlie required stitching to a cut on his right ear. Both he and Mouhoutari were physically and mentally shaken-up. An accident report was written by Charlie, the medical officer and the expedition leader two days after the crash. It concluded that:

- Though the pre-expedition planning was not flawless, it is highly unlikely the crash and its consequences could have been prevented. The likelihood of car crashes in the Comoros is probably lower than in many third world countries as a result of reasonably high standards of roads and driving, and the lack of alcohol.
- The exact cause of the crash remains uncertain; we speculated that the most likely causes were either driver error or tyre failure as no other cars were involved. Further investigation was not possible as the tyres were removed from the car before examination was possible and the police in the Comoros do not traditionally pursue investigations in such circumstances.
- The risk assessment and contingency plan drawn up prior to the expedition were adequate and were followed, but should have been gone through with the whole team once more upon arrival in the Comoros.

We recommended that:

- A member of the Oxford team in each group should have a mobile phone at all times (in the risk assessment it was decided that every group should have a mobile phone, but in this incident it meant that Charlie was left at the scene without a mobile after Mouhoutari had taken Hamidou to the hospital).
- The tyres of taxis should be checked prior to making significant journeys, and drivers should be told to drive carefully if and when necessary.

2. Medical & Safety Related Logistics

Vaccinations We obtained all medical advice through the University of Oxford Occupationial Health Service. They recommended vaccination against Diptheria, Polio, Tetanus, Tuberculosis, Hepatitis A and B, Rabies, Typhoid and Yellow Fever.

Insurance Taken out at a very good rate through the University of Oxford with Royal & Sun Alliance. We made a couple of claims which were dealt with promptly and carried a £25 excess charge. Be aware, however, that equipment named as the expedition's rather than an individual's carries an excess charge of £250.

Embassy There is no British embassy in the Comoros, we sent our details and itinerary to the British Embassy in Antananarivo, Madagascar. However, the FCO now recommends the High Commission in Mauritius: bhc@intnet.mu as the nearest consulate (check www.fco.gov.uk for updated details).

Malaria Malaria is prevalent in the Comores; anti-malarials are essential. Our expedition used Doxycycline or Larium (Mefloquine). The usual precautions of covering up at night, using repellent and mosquito nets were also taken.

Medical Training Both the Medical Officer and Expedition Leader attended Far From Help Part I training (run by Wilderness Medical Training: www.wildernessmedicaltraining.co.uk), and the MO also attended Far From Help Part II. In addition, all expedition members received first aid training. This would be recommended.

Medical Kit We used Nomad Travel for all our medical supplies, www.nomadtravel.co.uk, who we highly recommend. Those who have completed Wilderness Medical Training courses get a discount.

> Creams and Ointments: Aqueous cream, Clotrimazole Cream, Betadine Antiseptic Paint, Hydrocortizone Cream (1%), Bactroban Cream, Benadryl Antihistamine Cream.
>
> Antibiotics: Flucloxacillin, Ciprofloxacin, Chloramphenicol, Metronidazole, Erithromycin.
>
> Pain Killers etc: Ibuprofen, Paracetemol, Tramadol, Co-Codamol, Adrenaline (for injection).
>
> Other Medication: Cetirizine, Lidocaine (for injection), Salbutomol Inhalers, Buccastem, Fluorescein Sodium Strips, Ranitidine tablets, Rehydration Sachets, Loperamide Hydrochloride.
>
> Hardware, Dressings etc: Stethoscope, Aneroid Sphygmanometer, Pre-injection swabs, disposable scalpels, Otoscope, 'Tuff-Cut' Scissors, Micropore, Safety Pins, Plasters, Steristrips, Foil Blankets, Gloves, Cotton Buds, Compressed Triangular Bandages, Cotton Crepe Bandages, Dressings (nos. 15 and 14 style), Plain White Gauze Swabs, Vaseline Gauze, Melolin Dressings, Mepore dressings, Alcohol Gel, Needles (Blue, Green, Orange), Forceps, Needle Holder, Scissors, Toothend Forceps, Digital Thermometer, 2 and 5ml syringes, Cannulation Needles, Suture Thread and Needle.

Medical Facilities Charlie had stitches inserted at El Marrouf hospital in Moroni. It seemed that the services are of reasonable, but not remotely Western standard. You need to have cash in hand ready to pay for fees and equipment. Evacuation to Mayotte is required for major injuries so make sure this is included in insurance. We did not use the hospital on Anjouan. There are numerous private clinics of variable standard (we did not use any), check with Comorian partners for recommendations.

Water Tap water was found to be safe on Grande Comore and was drunk without incident (although the supply is occasionally cut off for hours at a time, so keeping several litres spare is useful). On Anjouan we used iodine to purify water. Bottled water is available.

Boat travel The boat journey from Grande Comore to Anjouan was rougher than expected, expeditions would be advised to have a supply of anti-emetics (e.g. buccastem) and use them pre-emptively.

Injuries Many of the paths in the forest in Grande Comore and especially on Anjouan are extremely steep, and potentially dangerous when wet. They are also frequently hard to follow. It is thus best to avoid walking them alone, and each groups should have a compass, map and GPS system, or a guide who definitely knows the paths.

Logistical Report

Dates

July 1	Hugh Doulton and Anneke Newman arrive Grande Comore
July 8	Rest of UK team arrive Grande Comore, based in Moroni
August 2	UK team move to Anjouan, based in Mutsumudu
August 14	Move to Moya
August 25	Return to Mutsumudu
August 30	Return to Grande Comore, based in Moroni
September 14	UK team leave Grande Comore for Tanzania
September 20	UK team arrive back in London

Fund-raising

The bulk of our funding came through grants (see acknowledgements), researched mainly through the RGS and past expedition reports. We advise making a list of possible grant sources and their deadlines early and producing an attractive brochure to send in with all applications and handing out to anyone else. We also raised about £800 from organising a party and raffle. Restaurants and other companies around Oxford were surprisingly happy to donate decent prizes once we had explained the charitable nature of the project. Organise things like this early on so that you can show fundraising bodies the fruits of your efforts when you send in applications. We also benefited from hijacking an event, rather than having to push people to come and support our own.

Visas

It is crucial that you have the necessary permits for conducting research, though these are easily obtained when working with Comorian partners. We obtained free working visas for the Comores through the CNDRS. We also had to present ourselves to immigration on arrival in Anjouan. Make a copy of visas and passports and keep them with you at all times – we had mild problems once on Grande Comore when some members of the party were stopped at a police roadblock without their papers.

Finances

We held a club account with Lloyds which ran very smoothly. Getting large sums of money to the Comoros was not particularly easy. Check with your choice of bank whether they will handle transfers to the Comoros and the cost before you open your account. Barclays would not handle transfers for us, we did not try Lloyds. Transfers arranged through the University of Oxford cost £50 each time, once the fees of the sending and receiving banks had been taken into account. You will obviously need someone willing to receive your money in the Comoros!

The exchange rate at the time of the expedition was: 1 pound sterling = 1.369 euros = 728.58 Comorian Francs (KMF).

It is easy to swap Euro travellers cheques in Moroni, we were warned it would be difficult in Mutusmudu and did not try. There was a fee for each transaction of 3150 KMF, approximately 6.3 euros. Be aware that the Comoros are not cheap compared to other nearby countries such as Madagascar and Tanzania as the Comorian Franc is tied to the Euro. Fees for counterparts are therefore not as cheap as you might expect.

Accommodation

We hired houses in all three places that we stayed (Moroni, Mutsumudu and Moya), organised for us by our Comorian partners. The rates were very cheap at around 57000 KMF for spacious houses with beds, and the Moroni and Mutsumudu houses came complete with stoves, cold running water and electricity. We recommend asking for somewhere quiet, though that's quite a challenge with the early morning call to prayer. We took tents and sleeping bags with us for camping and these weren't readily available on the Comoros. Think of taking spare sleeping bags for Comorian partners.

Communication

Landlines and mobile phones are widespread. We bought Comorian simcards for 25,000 KMF, mobiles are also available for about 40,000 KMF. If taking mobiles over with you make sure they are unlocked. Mobiles worked well over much of Anjouan, even in the forest. Signal is much more interrupted in Grande Comore, where mobiles rarely worked in the forest.

Internet access is only available in the two capitals. Contact with and cheap access in Moroni is easy, but much harder in Mutsumudu, where it is frequently cut off for days at a time.

Travel and Transport

We flew with BA to Tanzania, who kindly gave us discount flights once we had sent them information about the project, and on with Air Tanzania to the Comoros, with whom we were able to get cheap student tickets on production of an international student card. Book BA flights as early as possible to get the cheaper tickets. Tickets through Air Tanzania were difficult to obtain from the UK as their phone lines rarely worked – our partners organised these from the Comoros and we paid for them in the airport. In addition, we found out a few days before departure that Air Tanzania had changed their flight days to the Comoros and so we had to spend a night in Dar es Salaam at our expense, apparently this happens frequently. BA kindly gave us 50kg extra of baggage allowance on the way out to the Comoros, and with a little imagination we were able to take some up this back with us to England without paying extra. Baggage allowances for Air Tanzania were nominally 35kg, but more could have been taken without any problems.

For travelling to Anjouan, we used the boat company 'Twamaan'. The price was very cheap at 10,000 KMF one way, but it took 8 hours and made us very sick! Boats only run every few days. The faster and more comfortable 'Dauphin' was in for repairs at the time we travelled. We opted to take the plane with Air Comores on the way back to Grande Comore, priced at 30 450KMF per person one way. Flights run most days and only take an hour, though delays can occur. If baggage allowances are a problem you can always send kit by boat.

We used taxis to travel around on both Grande Comore and Anjouan. Car hire is apparently possible, but we felt that taxis would be safer. There are masses of shared taxis milling around in Moroni and Mutsamudu happy to take you short distances for small prices. If you want to go further you either have to pay much more to hire a taxi on your own, or wait for the right one to turn up and fill up to the seams. Cheaper minibuses travel to most places, again these tend to wait to fill up before departing. Ask locals the places and times of departure. In Anjouan, we hired a minibus and the Action Comores driver for the whole of our stay which proved to be the best and cheapest option, particularly when we needed various groups heading off promptly from dusk to dawn. It was still fairly costly at 12 500 KMF per day, plus petrol which was around 15000 KMF per day depending on distance travelled. We continued with this policy on return to Grande Comore, where the best hire-price we could get was 25000 KMF per day plus petrol. If travelling back to the capitals from anywhere more than half an hour away it's best to have an arrangement for pick-up or you could find yourself waiting around for a long time.

Road quality was often poor. The roads in Grande Comore, though tarmacced, were often too narrow to let two vehicles pass easily. On Anjouan, the roads further away from Mutsumudu sometimes descended into stony tracks, but were of much higher quality otherwise. Accidents are common but not frequent. Ask drivers to slow down if necessary.

Food

There are markets and shops in Moroni and Mutsumudu that provide you with all the food you need at cheap prices. Bartering wasn't necessary in the markets. Cheap restaurants also abound in Moroni, see the Lonely Planet Guide. In addition we recommend the little restaurant down a side-street just before ComorOptic for a 30p lunchtime curry. If you're white and smile sweetly they'll even give you a free extra bowl of sauce. There are fewer restaurants in Mutsumudu, we recommend 'Le Jardin' for good, cheap food. Foodstuffs were much harder to come by in Moya but there were plenty of people willing to cook meals for us cheaply. There are also some relatively expensive restaurants down by the beach.

Equipment

Do not assume that anything is available in the Comoros – it took us weeks to find an outdoors thermometer. Transport all scientific equipment and leave some behind for partner organisations. Batteries and camera films are available in the Comoros but of poor quality – we took rechargeable batteries. Plugs are French model so take adaptors. On the other hand, most things like clothes and toiletries are freely available, though sometimes of dubious quality.

Cultural awareness

The Comorians are strictly though tolerantly Moslem. The women always wear large, colourful wraps that they use to cover their heads and shoulders, and the men go to the mosque around three times a day and for half a day on Fridays. It is advisable for women to wear long skirts and tops that cover shoulders. Although not obligatory, it was much appreciated when Anneke and Katie wore the Comorian wraps, which could be used to cover the head during the religious prayers that introduce most public meetings - it proved a simple way of showing respect for the culture. On public beaches girls tend to cover up even when swimming; on hotel beaches this is not necessary. Both sexes should be particularly respectful when talking to members of the opposite sex, older men on Grande Comore were sometimes surprised at being interviewed by girls! Alcohol is available on the Comoros but should never be drunk in public.

Appendix 1: Status of the endemic bird species of Grande Comore and Anjouan

Taxonomic and endemic status follows that set out by Louette *et al*. (2004).

Red Data Book Species

Otus pauliani (Karthala Scops Owl)
Endemic to the slopes of Karthala, Grande Comore. Considered 'Critically Endangered' in IUCN red data book.
Grande Comore: See page 38 for details

Otus capnodes (Anjouan Scops Owl)
Endemic to Anjouan, rediscovered in 1992. Considered 'Critically Endangered' in IUCN red data book.
Anjouan: See page 35 for details.

Humblotia flavirostris (Humblot's Flycatcher)
Endemic to the slopes of Karthala, Grande Comore. Considered 'Endangered' in IUCN red data book.
Grande Comore: Rarely recorded (18 during points) but population still seems healthy. Confined to mature and underplanted forest with the lowest recorded at 930m at Tsinimouapanga, and reaching 1710m below Convalescence. Seems most abundant in the forests above Tsinimouapanga, Mvouni and below Convalescence.

Dicrurus fuscipennis (Grande Comore Drongo)
Endemic to the slopes of Karthala, Grande Comore. Considered 'Endangered' in IUCN red data book.
Grande Comore: Only three pairs recorded during the whole expedition. One pair was seen in underplanted forest above Kourani at 1120m, another in coconut plantations at Mvouni at 400m, and a third feeding in underplanted forest above Tsinimouapanga at 1050m. Although perhaps a cause for concern it appears the population is always low and possibly fluctuates (Louette, *pers. comm.*), so a much more detailed survey is needed to determine its status.

Zosterops mouroniensis (Karthala White-eye)
Endemic to the tree heath zone at the summit of Karthala, Grande Comore. Considered 'Vulnerable' in IUCN red data book.
Grande Comore: The species still remains abundant here since the eruption in April 2005, with some 86 individuals recorded in the seven points carried out in the heath. Seemed most abundant at the lower edges of the heath zone. A further three individuals were recorded at the upper extent of the mature forest at 1870m.

Columba polleni (Comoro Olive Pigeon)
Endemic species found on all four islands. Considered 'near threatened' in IUCN red data book.
Grande Comore: Recorded infrequently in the points (19 individuals), generally confined to underplanted, regenerating A and mature forest but also recorded in pioneer forest. Nearly always encountered singly or in pairs. Most abundant in the wetter forest on the south-east slopes of Karthala above Tsinimouapanga. Also recorded at La Grille. Found up to 1760m at Convalescence and even recorded down to 440m in plantations at Djouamouachongo.
Anjouan: Recorded infrequently but not uncommon (13 in points) at most locations, generally singly or in pairs. Most frequent in mature and affected forest, but also recorded in plantations, and even one record from padza. Peaks in abundance at around 800-1000m. Not recorded below 690m, but recorded to nearly the summit of Ntingui at 1540m.

Endemic Species (not present in the red data books)

Alectroenas sganzini sganzini (Comoro Blue Pigeon)
Endemic to all four islands and Aldabra, here treated as a full endemic species.
Grande Comore: By far the most frequently recorded pigeon on Grande Comore with 180 individuals recorded during points. Found in all the forested habitats, most frequently in mature, underplanted and regenerating B. Not recorded at all in plantations or in the heath zone. Abundance increases with altitude, peaking at 1400-1600m and decreasing afterwards. Recorded up to 1890m, just below the heath, and down to 500m at Djouamouachongo.
Anjouan: By far the most abundant pigeon, although not as common as on Grande Comore. 92 were recorded in point counts in all habitats, although most frequently in affected forest and plantations. Recorded down to 430m in padza at Koni, but most abundant between 600 and 800m.

Hypsipetes parvirostris parvirostris (Comoro Bulbul)
Endemic to Grande Comore and Moheli, with a separate subspecies on each island.
Grande Comore: Replaces the Madagascar Bulbul in mature and underplanted forest and above 800m, where it is very common, occurring in small groups. Most abundant at the lower edge of the range. Recorded down to 710m at Boboni. Also infrequently encountered in the heath above the mature forest, up to 2010m. Occasionally occurs sympatrically with the Madagascar Bulbul, once during points, 790m at Mvouni in underplanted forest. Very common at La Grille.

Nectarnia humbloti humbloti (Humblot's Sunbird)
Endemic to Grande Comore and Moheli, with a separate subspecies on each island.
Grande Comore: A very common species, recorded in nearly every point, with some 356 individuals. Found from sea-level up to the highest extent of mature forest (1890m), and in every habitat including around human habitation. Absent only from heath.

Nectarinia notata moebii (Green Sunbird)
Endemic to Grande Comore and Moheli, with a separate subspecies on each island.
Grande Comore: Not as abundant as Humblot's Sunbird but still a common bird (69 individuals recorded) in all habitats other than heath, and at all altitudes.

Nesillas brevicaudata (Grande Comore Brush-Warbler)
Endemic to Karthala and La Grille on Grande Comore.
Grande Comore: Frequently recorded (51 during points) in all habitats except plantation, but most abundant in mature and underplanted forest. There is no clear altitudinal preference, although appears most common at mid-elevations. Occurs down to 500m at Djouamouachongo, and up to the very highest extent of mature forest at 1890m.

Turdus bewsheri (Comoro Thrush)
Endemic to Grande Comore, Anjouan and Moheli. Represented on Grande Comore by the subspecies *T. b. comorensis*, and on Anjouan by *T. b. bewsheri*.
Grande Comore: The population remains healthy with 48 individuals recorded during points. Absent only from plantations and showing no clear altitudinal preference. Lowest record of 650m, and highest at 1970m in the tree heath. Occurs in good numbers at La Grille.
Anjouan: Common in all habitats (46 recorded during points), although not recorded around human habitation. Most abundant in affected forest, and between 800 and 1000m. Recorded down to 510m at Hombo and up to the summit of Ntingui.

Endemic Subspecies (not present in the red data books)

Accipiter francesiae (Frances' Sparrowhawk)
Represented on Grande Comore by the endemic subspecies *A. f. griveaudi,* and on Anjouan by the endemic subspecies *A. f. pusillus*
Grande Comore: Seven individuals seen in total, including two during point counts at Bahani in plantations at 730m, and in underplanted forest at 1120m above Tsinimouapanga. A further three individuals were seen at Bahani, where the species appears common; a juvenile perched in a low tree in pioneer scrub, 800m, an adult male perched above a burning plantation, 820m, and a second adult in pioneer forest, 830m. Only one other individual was seen in forested habitat, though this may have been due to reduced visibility.
Anjouan: Recorded much more frequently than on Grande Comore, although previously thought to be rare on Anjouan. Males were being particularly vocal, with only one of the records a female. Recorded on nine occasions during points generally in plantations and affected forest but also in mature forest at Col de Patsy, Paje, Hombo, Lingoni and Moya. Recorded down to 200m at Paje and up to 1000m at Col de Patsy.

Apus barbatus mayottensis (Madagascar Black Swift)
Endemic subspecies found on all four islands.
Grande Comore: Recorded on only two occasions; a group of 23 at 700m at Bahani, and two individuals at the summit of Karthala.
Anjouan: Recorded on three occasions during points. A single individual was seen above mature forest at Col de Patsy (1050m), a group of three in plantations at Paje (340m), and a pair feeding above padza at Koni (730m).

Butorides striatus rhizoporae (Green-backed Heron)
Endemic subspecies found on all four islands.
Grande Comore: A single individual was seen hunting around the boats in the harbour in Moroni and another on the rocks at Gallawa.

Coracina cinerea cucullata (Ashy Cuckoo-shrike)
An endemic subspecies to Grande Comore. A second subspecies is endemic to Moheli.
Grande Comore: A frequent member of mixed-species flocks, typically occurring singly or in pairs. Usually found in forest between below 1200m, but occurs up to Convalescence at 1760m. Recorded down to 780m at Djouamouachongo. Also occurs in more open habitats, occasionally entering plantations and pioneer scrub. All individuals seen were of the grey phase, apart from one green phase male seen with a grey phase male at Bahani.

Coracopsis nigra sibilans (Lesser Vasa Parrot)
An endemic subspecies confined to Grande Comore and Anjouan.
Grande Comore: Recorded predominantly in mature and underplanted forest, but was also found in regenerating forest, pioneer forest and plantations. Less abundant, although more secretive, than the Greater Vasa, although healthy numbers were still recorded (37 in points). It shows a similar range to the Greater Vasa, recorded up to 1540m at Convalescence, and down to 600m at Mvouni. Not recorded at La Grille.
Anjouan: Very scarce, with only eight individuals recorded on five occasions. Seems most abundant at Col de Patsy, where three observations were made: a single individual at 1020m, three individuals feeding low in a plantation at 860m and an individual in affected forest at 780m. There were two other records, one in the forest around Lac Dzialandzee at 970m, and another in affected forest at Moya, 640m.

Coracopsis vasa comorensis (Greater Vasa Parrot)
An endemic subspecies found on all four islands.

Grande Comore: Common in all forested habitats, with 139 individuals recorded during the points. Typically found singly or in small parties, but very large flocks were occasionally encountered feeding on fruiting *Psidium*; 25+ at Boboni (890m) and 70+ at Kourani (890m). Individuals were recorded up to 1760m at Convalescence, and down to 550m at Djouamouachongo. Most abundant around 800m, then decreasing with altitude.
Anjouan: A common species in mature and affected forest and plantations (54 in points). Recorded down to 440m at Moya but most abundant between 600 and 800m. Only recorded up to 1340m but probably occurs above this. Found at all sites but particularly abundant above Paje.

Corythornis vintsioides johannae (Madagascar Kingfisher)
An endemic subspecies found on all islands.
Anjouan: Two individuals recorded. One was regularly seen above a pool beside the road from Moya to Lingoni, and a second individual on the cliffs above the beach at Moya.

Cypsiurus parvus griveaudi (African Palm Swift)
An endemic subspecies found on all four islands.
Grande Comore: Common in the lowlands and especially around human habitation. Only recorded on three occasions during points, at Kourani in pioneer and regenerating A habitats, the highest being at 910m.
Anjouan: Very common around human habitation, in plantations and padza. Occasionally seen in very open affected forest. Highest record of 1020m at Koni.

Dicrurus forficatus potior (Crested Drongo)
A subspecies endemic to Anjouan. Absent from the other three islands.
Anjouan: Not uncommon in plantations and affected forest (42 recorded in points) at lower altitudes, but also recorded in mature forest and padza. Most abundant in plantations. Highest record at 1090m.

Foudia madagascarensis (Madagascar Fody) and ***F. emintentissima*** (Comoros Fody)
Both species are found on all four islands. *F. emintentissima* is an endemic subspecies. Each island has its own subspecies, *F. e. consobrina* on Grande Comore and *F. e. anjouansis* on Anjouan. The two species were not distinguished during points.
Grande Comore: The two species were recorded frequently. The Madagascar Fody is largely confined to lowlands and plantations, and is replaced in the forest by the Comoros Fody. The Comoros Fody was also recorded at 1970m in the heath.
Anjouan: Common in all habitats and at all altitudes (120 individuals recorded during points). Usually encountered singly or in pairs, but occasionally in larger flocks. A flock of 12 was observed in padza at Koni (990m) feeding in a pea plantation, and a flock of 23 was seen in plantations at Hombo (440m).

Leptosomus discolor (Cuckoo-roller)
On Grande Comore it is represented by the endemic subspecies *L. d. gracilis*, on Anjouan by the endemic subspecies *L. d. intermedius.* Populations on Moheli and Mayotte are from the nominate race.
Grande Comore: Common at low densities in all open forest habitats and in plantations at the lower edge of the forest between 540m and 1160m. Does not occur in mature forest or in underplanted forest where a closed canopy remains. Was also recorded in plantations where large native trees remained.
Anjouan: Not uncommon, with 29 individuals recorded during points in mature and affected forest and plantations with no clear habitat preference. Absent from padza. Most abundant at Paje and Col de Patsy, where eight individuals were heard calling in one valley. Recorded down to 430m at Koni, and up to 1320m on Ntingui but most abundant at 600-800m.

Nectarinia souimanga comorensis (Anjouan Sunbird)
An endemic subspecies confined to Anjouan.

Anjouan: Extremely common (337 individuals in points) and recorded in every point count. Found in all habitats and all altitudes including human habitation.

Nesillas typica (Madagascar Brush-Warbler)
Represented on Anjouan by the endemic subspecies *N. t. longicaudata*. Also occurs on Moheli as a separate subspecies.
Anjouan: Very common and recorded in most points (140 individuals) usually singly or in pairs. Occurs from sea-level up to the summit of Ntingui and in all habitats. No clear altitude or habitat preferences.

Saxicola torquata voeltzkowi (Stonechat)
A subspecies endemic to Karthala, Grande Comore
Grande Comore: A healthy population remains in the heath zone on the summit of Karthala since the April eruption. No vegetation remained near the summit, but a male was seen at 2310m. Also common in dry scrub and plantations on the north-west slope at Bahani down to 770m.

Streptopelia picturata comorensis (Madagascar Turtle Dove)
Grande Comore: Widespread in all habitats from exotic lowland vegetation up to the heath zone (34 recorded during points). Recorded up to 1940m on Karthala. Generally observed singly or in pairs but a flock of 15 was seen feeding in regenerating A forest at 930m.
Anjouan: Less common than on Grande Comore, with only 13 recorded during points. Found in all habitats except mature forest, and common around human habitation. Recorded up to 1090m at Koni.

Terpsiphone mutata (Madagascar Paradise Flycatcher)
Found on all four islands, each of which has its own endemic subspecies. On Grande Comore it is represented by *T. m. comoroensis*, on Anjouan by *T. m. vulpine*.
Grande Comore: A common species on the lower slopes in all forest habitats and at all locations. Often a member of mixed-species flocks. Occasionally recorded in plantations but absent from heath. Occurs down to 500m at Djouamouachongo but only up to 1400m. Abundance peaks around 1000-1200 metres in underplanted forest.
Anjouan: Common in affected forest but also found in mature forest, plantations and occasionally padza at all locations. Recorded from 560mm to 1230m at Koni, but most abundant between 800 and 1000m.

Zoonavena grandeidieri (Madagascar Spine-tailed Swift)
Represented by a subspecies endemic to Grande Comore.
Grande Comore: Usually found singly or in pairs in open forest or clearings, especially in underplanted forest. 23 were recorded during point counts. Present at Convalescence (1760m) and down to 710m at Boboni.

Zosterops maderaspatana (Kirk's White-eye)
Common on all four islands, each of which has its own endemic subspecies. On Grande Comore it is represented by *Z. m. kirki*, on Anjouan by *Z. m. anjouanensis*.
Grande Comore: The most abundant species on Grande Comore, found in all habitats and at all altitudes. Some 623 individuals were recorded during points, and the species often forms large flocks which are joined by other species. The largest flock recorded was 107 in plantations at Mvouni (540m). Replaced in heath by the Karthala White-eye.
Anjouan: Very common in all habitats and altitudes (341 in points). Usually found in small groups, often as parts as mixed-species flocks. The largest flock recorded was 36 in plantations at Paje.

Appendix 2: Status of the Endemic Butterfly Species in the Papilionidae, Pieridae and Nymphalidae Families

The following list contains only those species and subspecies of the Papilionidae, Pieridae and Nymphalidae families that are endemic to the archipelago, and are thought to be present on Grande Comore and Anjouan. Assessments are taken from sightings during a total of 307 butterfly transects: 208 on Grande Comore between July 17 & 28 and September 2 & 19, and 99 on Anjouan between August 3 & 29. Additional important incidental sightings or information from other sources are noted as such. Further useful descriptions and recordings can be found in Turlin (1993 - 1996); Lewis *et al.* (1993 & 1994) and Louette *et al*. (2004). The Lepidoptera section of the Louette book contains a complete species list, so one is not provided here. We have, however, compiled a unique photographic identification chart for all the butterflies of the Comoros, which we would be happy to distribute on request.

Red List Species

Official IUCN status is taken from the Red List (IUCN 2006), for which assessments were performed in 1996. The IUCN listings may reflect earlier recording biases (of the four species listed, three are found only on Grande Comore and one only on Mayotte). Given the rapid destruction of what little remains of forest on Anjouan, it may be that a proper assessment is needed of the Anjouan species that appear largely reliant on underplanted or mature native forest. Further surveys are required in the wet season, when all butterflies will be more abundant, before we can make any reliable recommendations.

Papilio aristophontes (GC) Currently listed as 'endangered'. 40 individuals were recorded during transects, with a lowest record of 510m in regenerating forest at Djoumouachongo, and a highest of 1850m in mature forest above Convalescence (an incidental). Both males and females were recorded either feeding or flying at mid-height in all habitats in between these two extreme altitudes and at all locations, including La Grille.

Graphium levassori (GC) Currently listed as 'endangered'. Not recorded during the expedition, which is unsurprising as previous records have only come from the period November to April. It appears that this rarely recorded swallowtail has both a very short flight period and a very localised distribution (S.Collins, *pers. comm*.).

Amauris comorana (GC) Currently listed as 'endangered'. Only 12 recordings. All but one sighting was made between 770 and 1070m of individuals or pairs flying high up in underplanted canopy on the east slopes of Karthala at Kourani and Tsinimouapanga. A further individual was seen in regenerating forest at 500m at Djoumouachaongo.

Endemic Species

Species known only from the Comoros but not listed in the IUCN Red List.

Mylothris humbloti (A) Found flying in and around underplanted forest between 880 and 1220m. Abundant at Koni (25 sightings), with a further three individuals seen at Pajé and one at Hombo. It therefore appears that this species is reliant on native forest, and far from widespread within it, and could thus be under threat.

Mylothris ngaziya (GC) Extremely abundant, with 442 recorded during transects. Common in all forest habitats at all locations and at all altitudes from 450 to 1150m. Most numerous between 700 and 1000m in underplanted forest on the east flank of Karthala.

Acraea masaris, represented by the subspecies *A. m. jodina* (GC) and *A. m. masaris* (A).
Only six recordings of *jodina* on GC, all flying at low heights along tracks in underplanted and mature forest between 900 and 1050m at La Grille. Recorded more frequently by Lewis *et al.* in 1993, however changes in taxonomy mean that they could have confused it with the more abundant *Acraea comor*. More research would need to be done, but this seemingly localised and rare occurrence suggests it could be a species under threat. This is particularly the case if it is restricted to La Grille, where very little native forest remains.
In contrast, *A. m. masaris* is abundant on Anjouan (53 sightings), found in all habitats apart from padza, and at a wide range of altitudes (230 to 1200m).

Acraea comor (GC) 18 sightings, again all flying by tracks in underplanted and mature forest between 900 and 1050m at La Grille. Possibly two further sightings at 800m in underplanted forest at Tsinimouapanga. As for *Acraea masaris*, if it is confirmed that the species is confined to La Grille it should be considered under threat.

Henotesia comorensis, represented by the subspecies *H. c. salami* (GC) and *H. c. comorensis* (A).
Both subspecies very abundant (193 sightings on GC, 73 on A). Found in the shade in all habitats including plantations, often in small groups. Lowest recording of 250m and highest of 1200m.

Henotesia comorana (GC) Commonly found (89 recordings) in all habitats and locations and at all altitudes, though prefers shade. Lowest recording of 500m and highest of 1390m.

Henotesia subrufa (A) The Anjouan equivalent of *H. comorana*. Moderately abundant (20 recordings). Found in plantation and forest habitats but with a marked preference for mature forest (13 sightings). Lowest recording of 740m and highest of 1460m. Could be vulnerable if it is reliant on native primary forest

Neptis cormilloti (GC) 24 sightings distributed across all locations and habitats between 500 and 1020m. This is less than were encountered by Lewis *et al*. in the 1992 dry season, although they found yet more in their 1994 wet season surveys, so it is unlikely that it is a species under threat.

Neptis comoranum Represented by the subspecies *N. c. comorarum* (A). Only seven recordings, all in plantations or underplanted forest, but spread from 250 to 1040m. Similarly Lewis *et al.* found this to be very abundant in the 1994 wet season and it is unlikely to be threatened.

Salamis humbloti (A) Not recorded. Lewis *et al.* (1994) found that it was 'locally common on the fringes of forest' in the wet season.

Charaxes nicati (A) Three sightings of pairs flying relatively high in the canopy on the slopes of Ntingui (910 to 1240m). Not recorded by Lewis *et al.* in 1994, but fruit traps should be used before abundance can be determined. Steve Collins reports frequent trappings of both Anjouanese charaxids at higher altitudes.

Charaxes paradoxa (GC) Not recorded. Fruit trapping needed.

Charaxes viossati (A) One sighting in underplanted forest at Pajé (870m).

Endemic Subspecies

Madagascan or African species occurring on the Comoros as unique subspecies. Non-forest specialists are not noted here as the expedition concentrated research on the forest habitat, specialists of which are the most likely to be under threat.

Papilio dardanus humbloti (GC) Fairly common, with 25 recordings spread around the forest from 500 to 1050m. Most common in pioneer forest at Kourani and regenerating forest low down at Djoumouachongo.

Amauris ochlea moya (A) Fairly frequently recorded in affected forest and plantation habitats between 600 and 1200m. However, there could have been some confusion in identification with *Pseudacraea lucretia comorana*.

Pseudacraea lucretia karthalae (GC) Only one sighting in regenerating forest at Djoumachongo (510m). Only two were seen by Lewis *et al*. in 1994, and it therefore seems likely that this species is under threat.

Pseudacraea lucretia comorana (A) Six recordings in affected forest at around 900m. As noted before, a possibility of confusion with the similar *Amauris ochlea moya*, as the abundance of recording was reversed for these two species for Lewis *et al*. in 1994.

Charaxes castor comoranus (GC) Not recorded, trapping required.

Appendix 3: Accounts

Received	***£***
BP Conservation Programme	4185
AA Paton Fund (Oxford University)	3250
RGS expedition grant	2100
Gilchrist Educational Trust	2000
Trapnell Fund (Oxford University)	2000
Personal contributions	1750
Fundraising	1263
iNomad	1000
African Bird Club	800
Mike Soper Bursaries	800
Duke of Edinburgh Trust	750
African Butterfly Research Institute	500
Timothy Bailey Trust	500
Nicholas Knatchbull Memorial Fund (Dragon School)	350
Somerville College Travel Grant	350
St Anne's College Travel Grants	300
Oxford University Society	300
Lady Margaret's Hall Travel Grant	265
Merton College Travel Grant	225
Royal Entomological Society	200
St Anne's College Junior Common Room	200
Merton College Junior Common Room	150
Total money received	***23238***
Plus discounts:	
British Airways	1000
Wilderness Medical Training	82
Butterfly Traps	150
Total Raised	***24470***

Pre-Expedition Expenditure	**£**
Scoping trip	981
Flights and transfers	3831.03
Medical	588.53
Insurance	225
Training	826.06
Visas	222.10
Communication and admin	216.70
Books and CDs	217.21
Filming equipment	1623.25
GPS units	495.50
Binoculars	314.85
Computer equipment	178.39
Mobiles	205.39
Butterfly nets	187.12
Printer	227
T-shirts	163.91
Miscellaneous equipment (< £100/ expenditure line)	726.03
Total	***11229.07***

In-Field Expenditure	**£**
Travel between islands	277.06
Driver hire, petrol and public transport	2053.28
Food	1686.26
Accommodation and bills	1037.75
Counterpart wages	2015.68
Guides and porters	195.89
Communication and admin	285.55
Ulanga education days	906.46
Press conferences	309.58
Bank charges and currency losses	433.5
Others	128.41
Total	***9329.42***

Post-expedition Expenditure	**£**
Post-expedition scoping trip	1150
Equipment for Action Comores	200
Film developing	101.79
Oxford University Exploration Club Bulletin	100
Binocular replacement and insurance excess charge	124
Computer equipment replacement	177
Traveller cheques re-conversion losses	190
Report and poster printing; film production (estimated)	380
Others	236.71
Total	***2677.30***
Grand Total	***23215.79***

Appendix 4: Acknowledgements

A big thank you to all our sponsors:

The BP Conservation Programme	The AA Paton Fund
The Gumby Corporation (through the Royal Geographical Society with IBG)	
The Trapnell Fund	The Gilchrist Educational Trust
iNOMAD	British Airways
The African Bird Club	The Mike Soper Fund
The Duke of Edinburgh Trust No. 2	The African Butterfly Research Institute
The Timothy Bailey Trust	The Nicholas Knatchbull Memorial Fund
The Oxford University Society	The Heron-Allen Committee
Merton College	Somerville College
St Anne's College	The Royal Entomological Society
St Anne's College JCR	Merton College JCR
Somerville College JCR	

We are indebted to a large number of people without whose advice and support the project would never even have got off the ground.

In particular, Dr Owen Lewis of the University of Oxford, Dr Michel Louette of the Royal Museum for Central Africa in Belgium and Dr Will Trewhella of Action Comores International believed in and supported us from an early stage.
Also from the University of Oxford: Dr Andrew Gosler, Niall O'Dea, Mary Menton, Clive Hambler, Dr Tariq Qureshi, and Sarah Outen; Dr Nick Brown and Dr Paul Jepson for help in developing the ongoing project.
For further advice on bird research: Roger Safford and Claire Spottiswoode of Birdlife International, Keith Betton and John Caddick of the African Bird Club.
For further advice on butterfly research: Steve Collins and Peter Narinda of the African Butterfly Research Institute, Bernard Turlin, Dr David Lees of the Natural History Museum, Dr Alison Cameron of University of California, Berkeley.
For further advice on the PRA: Kathryn Hunter, Natalie Moulaert, Kate Rodriguez-Clark, Marilyn Noguera.
For sharing their knowledge of the Comoros and advice in general: Dr Bryan Carroll and Neil Maddison of Bristol Zoo, Dr Frank Hawkins of Conservation International, Will Masefield, John Fa and Joanna Durbin of the Durrell Wildlife Trust, Brent Sewall, Rob Conway.
Everyone at the BP Conservation Programme, particularly Marianne Carter.
Everyone at iNOMAD – Jamie Buchanan-Dunlop, Olly Steeds, Steve Belgrave Paul Deegan, Aslan Livingstone.
Anne-Marie Doulton for help with editing.

In the Comoros: For their advice and support: Mohamed Bacar Dossar (National Director of the Environment), the Anjouan Environment Minister, Said Hassani Mohamed (Secretary of Ulanga, Grande Comore), Hachim Mohamed Abdallah, Azaly Said Ahmed of the Grande Comore Tourism Ministry, Ouledi Ahmed (President of Ulanga, Grande Comore), Mohamed Youssef Oumouri.
All our translators: Kennedy Mohamed, Sohfati Boinaheri, Amina Youssouf, Elarif Moustoifa, Mohamed Soidik, Saindou Kassim, Mohamed Attoumane.
And of course all the villagers of Mvouni, Djoumoichongo, nKourani-Sima, Mjumvia and Lingoni who worked with us on the PRA!

Appendix 5: References

Books and papers

Adler, G.H. and Dudley, R. (1994) Butterfly biogeography and endemism on tropical Pacific islands. *Biological Journal of the Linnean Society*. **52**(2): 151-162.

Ahamada Mmadi (1999) *Fautes et Sanctions dans la Société Comorienne Traditionelle: L'exemple de NKourani-Sima*. Mémoire d'Etudes de l'ENES.

Bachman, S., Baker, W. J., Brummitt, N., Dransfiels, J., Moat, J. (2004) Elevational gradients, area and tropical island diversity: an example from the palms of New Guinea *Ecography* **27:** 299-310

Battistini, R. and Vérin, P. (1984) *Géographie des Comores.* Editions Fernand Nathan, Paris.

Beccaloni, G.W. & Gaston, K.J. (1994) Predicting the species richness of Neotropical forest butterflies: Ithomiinae (Lepidoptera: Nymph as indicators). *Biological Conservation* **71:** 77–86.

Benson, C.W. (1960) The birds of the Comoro Islands: results of the British Ornithologists' Union Centenary Expedition 1958. *Ibis* **103b:** 5-106.

Bibby, C.J *et al.*. (2000). *Bird Census Techniques 2nd Ed*., Academic Press, London.

Bijnens, L., Stevens, J., Janssens, L., Louette, M. (1987) Community structure of Grande Comoro land birds with special reference to the ecology of congeneric species *Revue Zool. Afr.* **101:** 221-232

Carroll, S.S., Pearson, D. L. (1998) Spatial modelling of butterfly species richness using tiger beetles (Cicindelidae) as a bioindicator taxon *Ecological Applications* **8(2):** 531-543.

Chambers, R. (2002) *Participatory Workshops; a sourcebook of 21 sets of ideas and activities.* Earthscan: London.

Cleary, D. (2004) Assessing the use of butterflies as indicators of logging in Borneo at three taxonomic levels. *Journal of Economic Entomology* **97**(2): 429-435.

Collins N.M., Thomas J.A., (eds.) (1991) *The Conservation of Insects and Their Habitats*. Academic Press, London pp. 71-101.

Colwell, R. K., Lees, D. C. (2000) The mid-domain effect: geometric constraints on the geography of species richness *Trends in ecology and evolution* **15(2):** 70-76.

D'Abrera, B. (1997) *Butterflies of the Afrotropical Region. Part I, Papilionidae, Pieridae, Acraeidae, Danaidae, Satyridae*. Hill House, London.

D'Abrera, B. (2004) *Butterflies of the Afrotropical Region. Part II, Nymphalidae, Libytheidae*. Hill House, London.

Danielsen, F. & Treadaway, C.G. (2004) Priority conservation areas for butterflies (Lepidoptera: Rhopalocera) in the Philippine islands. *Animal Conservation* **7**(1): 79-92.

Devy, M., Ganesh, T. and Davidar, P. (1998) Patterns of butterfly distribution in the Andaman islands: Implications for conservation. *Acta-Oecologica* **19** (6) 527-534.

Doumbe-Bille, S. (2001) *Revision de l'Avant Projet de loi forestière – rapport final par le Projet 'Conservation de la Biodiversité et Developpement Durable aux Comores*. Unpublished report

Dyer, L.A. & Letourneau, D.K. (1999) Trophic cascades in a complex, terrestrial community. *Proceedings of the National Academy of Sciences of the United States of America* **96** 5072-5076.

Fleischmann. K. (1997) Invasion of alien woody plants on the islands of Mahe and Silhouette, Seychelles *Journal of Vegetation Science* **8(1):** 5-12

Global Environment Facility (2000) *Comoros: Capacity-needs assessment for the implementation of the National Biodiversity Strategy*. http://www.gefonline.org/projectDetails.cfm?projID=201. xzdfxg b

Gotelli, N.J., Colwell, R.K. (2001) Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. *Ecology Letters* **4** 379-391.

Grafen, A. and Hails, R. (2002) *Modern Statistics for the Life Sciences*. Oxford University Press.

Hambler, C. and Speight, M.R. (2004) Extinction rates and butterflies. *Science* **305** 1563.

Hamer, K.C., Hill, J.K., Lace, L.A., Langan, A.M. (1997) Ecological and biogeographical effects of forest disturbance on tropical butterflies of Sumba, Indonesia. *Journal of Biogeography* **24** (1) 67-75.

Harper, M.C., Lewis, O.T., Wilson, R.J. (1994) *The Oxford University Comoro Islands Butterfly Survey 1994.* Unpublished report.

Harrison Church, R.J. (2005) The Comoros: Physical and Social Geography. In: Africa South of the Sahara, Regional Surveys of the World, 34th edition, Europa Publications, London.

Henderson, P. A (2003) *Practical Methods in Ecology.* Blackwell Publishing, Oxford.

Herremans, M. (2001) *Bird Calls of the Comores (Guide sonore des oiseaux nicheurs des Comores)* Royal Museum for Central Africa, Belgium.

Howarth, F.G. and Ramsay, G.W., (1991) The Conservation of Island Insects and their Habitats. In: Collins N.M., Thomas J.A. (eds.) *The Conservation of Insects and Their Habitat.* Academic Press, London pp. 71-101.

Hunter, K., Said, M. and Walters, E. (1992) *Etude sur les utilisations de la foret naturelle à Anjouan, Republique Fédérale Islamique des Comores.* CARE-Comores report.

Hunter, K. and Said, M. (1992) *Plan d'aménagement de la forêt d'Anjouan*. Projet CARE-Comores.

International Monetary Fund (2004) Comoros: Statistical Appendage.

International Union for the Conservation of Nature (2004) *2004 IUCN Red List of Threatened Species*. www.iucnredlist.org.

Kapila, S. and F. Lyon, F. (1994) *Expedition Field Techniques: People Orientated Research*. RGS-IBG Expedition Advisory Centre.

Kremen, C. (1992) Assessing the indicator properties of species assemblages for natural areas monitoring. *Ecological Applications* **2** 203-217.

Kremen, C. (1994) Biological inventory using target taxa: a case study of the butterflies of Madagascar. *Ecological Applications* **4** 407–422.

Kremen, C., Lees, D.C., Fay, J.P. (2003) Butterflies and conservation planning in Madagascar: from pattern to practice. In: Boggs, C.L., Watt, W.B., Ehrlich, P.R (eds.) *Butterflies: ecology and evolution taking flight.* The University of Chicago Press, Chicago & London pp. 517-540.

Lawton, J.H., Bignell, D.E., Bolton, B., Bloemers, G.F., Eggleton, P., Thomas, C.D. & Abery, J.C.G. (1995) Biodiversity inventories, indicator taxa and effects of habitat modification in tropical forest. *Nature* **391** 72–76.

Lewis, O.T. (1993) *Patterns in the species richness and abundance of endemic and non-endemic butterflies on a tropical oceanic island, and their implications for conservation*. Unpublished undergraduate thesis.

Lewis, O.T., Wilson, R.J. and Harper, M.C. (1993) *The Oxford University Comoro Islands 1992 butterfly survey, final report*. Unpublished report.

Lewis, O.T., Wilson, R.J. and Harper, M.C. (1994) *Comoro Islands butterfly survey 1994, final report.* Unpublished report.

Lewis, O.T., Wilson, R.J. and Harper, M.C. (1998) Endemic butterflies on Grande Comore: habitat preferences and conservation priorities. *Biological Conservation* **85** 113-121.

Lewis, O.T. & Basset, Y. (2006) Insect Conservation in Tropical Forests. In: Lewis, O.T. New, T.R. & Stewart, A.J.A. (eds) *Insect Conservation Biology.* CABI Publishing, Wallingford. In press.

Louette, M. (1988) *Les Oiseaux des Comores.* Royal Museum for Central Africa, Belgium.

Louette, M. (2000) Bird Communities on the Comoro Islands. *Bonn. Zool. Monogr.* **46:** 325-336.

Louette, M., Herremans, M., Bijnens, L., Janssens, L. (1988) Taxonomy and evolution in the brush warblers *Nesillas* on the Comoro Islands *Tauraco* **1:** 110-129.

Louette, M., Meirte, D., Jocque, R. (2004) *La faune terrestre de l'archipel des Comores.* Royal Museum for Central Africa, Tervuren, Belgium.

Louette, M., Reygel, A. (1989) Oiseaux des Comores et leur protection. *Doc. Zool. Mus. R. Afr. Centr.* **22:** 1-32.

Louette, M., Stevens, J. (1992) Conserving the endemic birds on the Comoro Islands, I: general considerations on survival prospects. *Bird Conservation International* **2:** 61-80.

Louette, M., Stevens, J., Bijnens, L., Janssens, L. (1988) *A survey of the endemic avifauna of the Comoro Islands.* ICBP - Cambridge. *Study Report* **25**: 1-43.

Louette, M., Meirte, D., Jocqué R. (eds.) (2004) *The terrestrial fauna of the Comoros Archipelago, Studies in Afrotropical Zoology No 293*. Royal Museum for Central Africa, Belgium.

Messerschmidt, D.A. (1995). *Rapid Appraisal for Community Forestry: the RA process and rapid diagnostic tools*. IIED, London.

Mittermeier, R.A., Myers, N., Thomsen, J.B., da Fonseca, G.A.B. & Olivieri, S. (1998) Biodiversity hotspots and major tropical wilderness areas: approaches to setting conservation priorities. *Conservation Biology* **12** 516–520.

Mohammed Said (2000) *2nd National Report to the Convention on Biological Diversity.* http://www.biodiv.org/world/map.asp?lg=0&ctr=km.

Mohammed Said (2004) *3rd National Report to the Convention on Biological Diversity.* http://www.biodiv.org/world/map.asp?lg=0&ctr=km.

Moorcroft, D *et al.*. (1995) *Final report of the Newcastle University Anjouan Expedition*. Unpublished report.

Morris, R.J., Lewis, O.T., & Godfray, H.C.J. (2004) Experimental evidence for apparent competition in a tropical forest food web. *Nature* **428** 310-313.

Moulaert, N. (1989) *Etude et conservation de la foret de Moheli massif menace par la pression anthropique*. Unpublished report.

Mukherjee, N. (1993) *Participatory Rural Appraisal: Methodology and Applications*. Concept Publications company.

Myers, N., Mittermeier, R., Mittermeier, C., da Fonseca, G., Kent, J. (2000) Biodiversity hotspots for conservation priorities. *Nature* **403** 853-858.

Myers, N. (1988) Mass extinction – profound problem, splendid opportunity. *Oryx*, Vol **22** No 4.

New, T.R., 1997. *Butterfly Conservation*, 2nd edition. Oxford University Press, Melbourne.

Ouledi Ahmed (undated) *Les associations Ulanga. Document préparé pour la table ronde auditgouvernance locale–ONG*. Unpublished report.

Parmesan, C. (2003) Butterflies as Bioindicators for Climate Change Effects. In: Boggs, C.L., Watt, W.B. and Ehrlich, P.R. (eds.) *Butterflies: ecology and evolution taking flight.* The University of Chicago Press, Chicago & London, pp. 541-559.

Pearson, D. L. (1994) Selecting indicator taxa for the quantitative assessment of biodiversity *Phil. Trans.: Biol. Sc.* **345(1311)** 75-79.

Pearson, D.L., Carroll, S.S. (1999) The influence of spatial scale on cross-taxon congruence patterns and prediction accuracy of species richness. *Journal of Biogeography* **26**: 1079–1090.

Prance, G. T. (1994) A comparison of the efficacy of higher taxa and species numbers in the assessment of biodiversity in the neotropics. *Phil. Trans.: Biol. Sci.* **345(1311):** 89-99.

Pollard, E. (1977) A method for assessing changes in the abundance of butterflies. *Biological Conservation* **12** 115-124.

Rahbek, C. (1997) The relationship among area, elevation, and regional species richness in neotropical birds. *The American Naturalist* **149(5)** 875-902.

Safford, R.J. (1993) Rediscovery, taxonomy and conservation of the Anjouan Scops Owl, *Otus capnodes. Bird Conservation International* **3:**57-74.

Sanchez-Cordero, V. (2001) Elevation gradients of diversity for rodents and bats in Oaxaca, Mexico. *Global Ecology & Biogeography* **10:** 63–76.

Sanders, N. J. (2002) Elevational gradients in ant species richness: area, geometry, and Rappaport's rule. *Ecography* **25:** 25–32.

Sinclair, I., LanGrande, O. (2003) *Birds of the Indian Ocean Islands.* 2nd Ed. Struik Publishers, Cape Town.

Sokal, R.R. and Rohlf, F.J. (1995) *Biometry: the principles and practice of statistics in biological research.* W.H. Freeman, New York.

Sparrow, H.R., Sisk, T.D., Ehrlich, P.R., Murphy, D.D. (1994) Techniques and guidelines for monitoring neotropical butterflies. *Conservation Biology* **8** 800-809

Spitzer, K., Novotny, V., Tonner, M., Leps, J. (1993) Habitat preferences, distribution and seasonality of the butterflies (Lepidoptera, Papilionoidea) in a montane tropical rain-forest, Vietnam*. Journal of Biogeography* **20** 109-121.

Spitzer, K., Jaros, J., Havelka, J., Leps, J. (1997) Effects of small-scale disturbance on butterfly communities of an indochinese montane rainforest. *Biological Conservation* **80** 9-15.

Stevens, G. C. (1992) The elevational Gradient in altitudinal range: an extension of Rapoport's latitudinal rule to altitude. *The American Naturalist* **140(6):** 893-911.

Stevens, J., Louette, M., Bijnens, L., Herremans, M. (1993) Bird Diversity On Ngazidja, Comoro Islands. *Proc. VIII Pan-Afr. Orn. Congr.* 179-186.

Stevens, J., Louette, M., Bijnens, L., Herremans, M. (1995) Conserving the endemic birds on the Comoro Islands, III: bird diversity and habitat selection on Ngazidja. *Bird Conservation International* **5:** 463-480.

Tallents, L. A., Lovett, J. C., Hall, J. B., Hamilton, A. C. (2005) Phylogenetic diversity of forest trees in the Usambara mountains of Tanzania: correlations with altitude. *Botanical Journal of the Linnean Society* **149:** 217–228.

Thogmartin, W. E., Knutson, M. G., Sauer, J.R. (2006) Predicting Regional Abundance of Rare Grassland Birds with a Hierarchical Spatial Count Model. *The Condor* **108 (1):** 25-46.

Thomas, C.D., Mallorie, H.C. (1985) Rarity, species richness and conservation: butterflies of the Atlas mountains in Morocco. *Biological Conservation* **33** 95-117.

Thomas, C.D., Jordano, D., Lewis, O.T., Hill, J.K., Sutcliffe, O.L., Thomas, J.A. (1998) Butterfly distributional patterns, processes and conservation. In: Mace, G.M., Balmford, A., and Ginsberg, J.R. (eds.) *Conservation in a changing World*. Conservation Biology Series 1**,** Cambridge University Press, pp. 107-138.

Thomas, J.A. (2005) Monitoring change in the abundance and distribution of insects using butterflies and other indicator groups. *Philosophical Transactions of the Royal Society of London Series B, Biological-Sciences* **360**(1454) 339-357.

Thomas, J.A. (1983) A quick method for estimating butterfly numbers during surveys. *Biological Conservation* **16** 195-211.

Trewhella, W.J. et al. (2005) Environmental Education as a Component of Multidisciplinary Conservation Programs: Lessons from Conservation Initiatives for Critically Endangered Fruit Bats in the Western Indian Ocean. *Conservation Biology* **19**(1) 1-11.

Turlin, B., 1993-1996. Faune 1épidopterologique de l'Archipel des Comores (Ocean Indien)-Rhopaloceres, Sphingidae, Attacidae. *Lambillionea* XCIII, 345-361; XCIV, 81-94; XCIV, 189-200; XCIV, 372-388; XCIV, 591-601; XCV, 197-210; XCV, 443-452; XCVI, 159-173; XCVI, 329-339; XCVI, 447-454.

UNDP, IUCN, CNDRS *et al*. (2000) *The national strategy and plan of action for protecting biodiversity in the Comoros*. http://www.biodiv.org/doc/world/km/km-nbsap-01-fr.pdf.

UNDP (2005) *Human Development Report 2005 International cooperation at a crossroads: Aid, trade and security in an unequal world.* Available at: http://hdr.undp.org/reports/global/2005/

Wilson, R. (1993) The use of the transect walk method in monitoring differences between the butterfly fauna of sites on Grande Comore Unpublished undergraduate thesis.

World Health Organisation (2003) *The World Health Report 2003*. Available at http://www.who.int/whr/2003/media_centre/en/index.html.

Websites

Birdlife International Endemic Bird Areas of the World
http://birdlife.net/action/science/endemic_bird_areas/

Convention on Biodiversity website for the Comores
http://www.biodiv.org/world/map.asp?lg=0&ctr=km

IUCN red list website http://www.redlist.org

Louette, M, (2004) Comoros section of the African birdclub website http://www.africanbirdclub.org/countries/comoros

UN news on the Comoros http://www.irinnews.org/Africa-Country.aspx?Country=CO

Appendix 6: Contact Details

For any queries regarding this report or ongoing forest management work in the Comoros please contact:

Hugh Doulton
Park Gate House
Weston Road
Bletchingdon
Oxon OX5 3DH
UK
Tel: +44 (0)1869 350987
Email: hughdoulton@hotmail.com

Bristol Zoo Gardens will be fronting up the ongoing project. They can be contacted via their head of Conservation Programmes:

Neil Maddison
Bristol Zoo Gardens
Clifton
Bristol BS8 3HA
UK
Tel: +44 (0)117 974 7300
Fax: +44 (0)117 973 6814
Website: www.bristolzoo.org
Email: nmaddison@bristolzoo.org.uk

Direct contact with the Comoros can sometimes be tricky due to power cuts etc, particularly on Anjouan and Mohéli. Web and email addresses for our partner organizations are:

Action Comores: action_comores@yahoo.fr, action_comores@ifrance.com
http://ibis.nott.ac.uk/Action-Comores/

CNDRS: cndrs@snpt.km, yahayaim@yahoo.fr
http://www.komedit.org/cndrs_web/accueil_cndrs.HTM

AIDE: ahamadas@yahoo.com
http://www.aide.africa-web.org/