Mauritian Forest Dynamics
Expedition Report 2001

Edinburgh University Ecological Expedition to Brise Fer, Black River Gorges National Park, Mauritius: August 16th – November 1st 2001

Phase Two – Non-managed Area

By

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Background

Mauritian Forests

Mauritius can be considered to be a biodiversity 'hotspot'. Of the 644 native flowering species found in Mauritius 287 (45%) are endemic to Mauritius and 122 (19%) are endemic to the Mascarenes (Safford, 1997). It has been estimated that 80% of the native flora is under threat (Strahm, 1994). The majority of these threatened species are found in the upland rainforests. The remaining fragments of this vegetation are located in areas above ca. 350 m altitude with suitable soil that receive more than ca. 2,500 mm rainfall per year. These fragments of upland forest cover approximately 4% of mainland Mauritius. All the native upland forest in Mauritius is degraded to some extent. Full-canopy native upland forest covers only about 1% of the island (Page and D'Argent, 1997). Even these areas contain invasive alien plants in their understories (Lorence and Sussman, 1986 and 1988).

Historically, direct habitat destruction has been an important cause of forest degradation in Mauritius. This appears to be of little importance today. Currently the impacts of alien species on the native ecosystem are the main concern of conservation managers in Mauritius. Introduced plants such as Chinese guava *Psidium cattleianum* and privet *Ligustrum robustum* var. *walkeri* can out-compete native plants, a process, which reduces or prevents their regeneration. These alien species benefit from a lack of natural enemies and from exotic animals such as the feral pig, the monkey and the red-whiskered bulbul which can act as seed dispersal agents (Cheke, 1987). Alien animals can also directly damage native plants by browsing seedlings and saplings and by seed predation (Owadally, 1981). The interaction of these processes with background mortality factors such as tree senescence, disease, and cyclones seems to be producing a gradual degradation of the upland forests in Mauritius (Dulloo and Strahm, 1983). A loss of closely co-evolved native pollinators and seed dispersers may also be reducing the regeneration capacity of some native plants (Staub, 1988).

The best known conservation efforts in Mauritius have centred around the *in situ* and *ex situ* management of the Mauritius kestrel, pink pigeon and echo parakeet (Jones and Owadally, 1985). However, interest in conservation of native species and ecosystems dates back many years in Mauritius (Dulloo *et al.*, 1996).

CMAs & their development

Vaughan & Wiehe (1937 and 1941) studied the forest structure in an area of what was then comparatively intact forest. It was clear even then that this forest would not maintain its structure if it were not managed. The proposed management consisted of fencing to keep out feral deer and pigs and the weeding of alien plant species. A plot of 20 x 50 m, which had been intensively studied, was earmarked for management. Unfortunately management was not consistent. Nevertheless it appeared that even intermittent management resulted in a greater diversity of native plants surviving than in adjacent non-managed areas. In 1986 the plot at Macchabé was weeded and fenced by MWF and the Forestry Service with Wendy Strahm, Eshan Dulloo and Gabriel D'Argent leading this work.

Following the surveys conducted in 1980 and 1984 (Lorence and Sussman, 1986) the Brise Fer area was chosen as the location of another CMA. This plot, now known as 'The Old Plot' was first weeded and fenced in 1987. Although long term monitoring has not been carried out systematically it has been clear that these plots were showing a good level of native plant regeneration. In addition they have been shown to be favourable habitat for native Mauritian birds (Hill unpublished data) and butterflies (Mauremootoo unpublished data). Several other CMAs have been created since 1987 including the Mare Longue CMA created in 1993 and the new plot in Brise Fer created in 1996.

Mauritian Forest Dynamics: Phase One – Conservation Management Area

Brian Pickles, Joshua Clayton and Kenneth Sutcliffe successfully carried out Phase One of this study in the summer of 2000. This phase of the study consisted of a complete spatial inventory of trees and vines in the contiguous 10m x 10m strata of the Brise Fer Old Plot. For more information please refer to the expedition report from 2000, entitled "A study on the diversity of Phanerophytes in managed and non-managed areas of the upland forests of Mauritius. Phase One – Conservation Management Area."

The team did not encounter any major problems during the first phase of the study. There were some initial difficulties in developing a mapping technique that was quick and accurate, and there were obvious problems with plant identification at the start. However these obstacles were soon overcome and the work progressed efficiently. Overall the mapping did take much longer than anticipated because of taxonomically problematic species and thus had to be separated into two phases. Phase Two was carried out more quickly than expected due to familiarity with the flora gained in Phase One. This allowed the new team to gather extra data from each study area, resulting in additional information on sapling numbers and the contribution of dead trees to forest structure.

Aims

Phase One of this study gathered detailed data from the Brise Fer Old Plot (CMA) that could then be applied in the following ways:

i) Establishing a baseline from which to examine changes in forest structure over time.

ii) Collection of information on the spatial distribution of trees in an area containing the best-conserved native forest remaining in Mauritius. Providing a model on which to base forest reconstruction programs for the future.

iii) Establishing the similarities and differences between Mauritian forests and other forests studied elsewhere.

Phase Two enhances the results of Phase One and makes the following additional applications possible:

iv) Data will provide relevant information for studies of the faunal composition of managed and non-managed areas e.g. where released endangered birds are nesting, etc.

v) Data will give us some idea of how similar the managed and non-managed areas were before management. Because of the slow rate of growth of native trees it is likely that adult composition is still similar to the situation at the time when management began. These data will allow us to establish how valid the non-managed areas are as controls.

Locations

Phase Two of this project consisted of a complete spatial inventory of trees and vines (phanerophytes) in the contiguous 10m x 10m strata of the Brise Fer Non-managed plot (sampling area 0.82 ha).

Phase One was completed in the summer of 2000 in which a similar inventory of phanerophytes was carried out in the Brise Fer Old Plot (sampling area 0.72 ha), an area weeded of exotic species since 1987.

It is hoped that the techniques used for this study will also be applied to several other study areas of interest within the next few years, including:

1. The Brise Fer area first weeded in 1996 (sampling area 0.67 ha)
2. The Mare Longue plot (sampling area 1.1 ha)
3. The Mare Longue non-managed area (sampling area 0.80 ha)

Methods

<u>Spatial distribution/Size categories of species</u>

The 0.82 ha study area was divided up into a 10m x 10m stratum of grid squares (82 quadrats), which were then permanently marked with waterproofed steel posts and individually numbered (figure 1). All native phanerophytes of greater than 1.3 m in height were identified as far as possible to species level and measurements of diameter at breast height were taken. Those that could not be identified to species level immediately were tagged for later identification. The location of each native phanerophyte within each quadrat was individually recorded. All exotic species except for guava (*Psidium cattleianum*) and privet (*Ligustrum robustrum* var. *walkerii*) were also recorded as above.

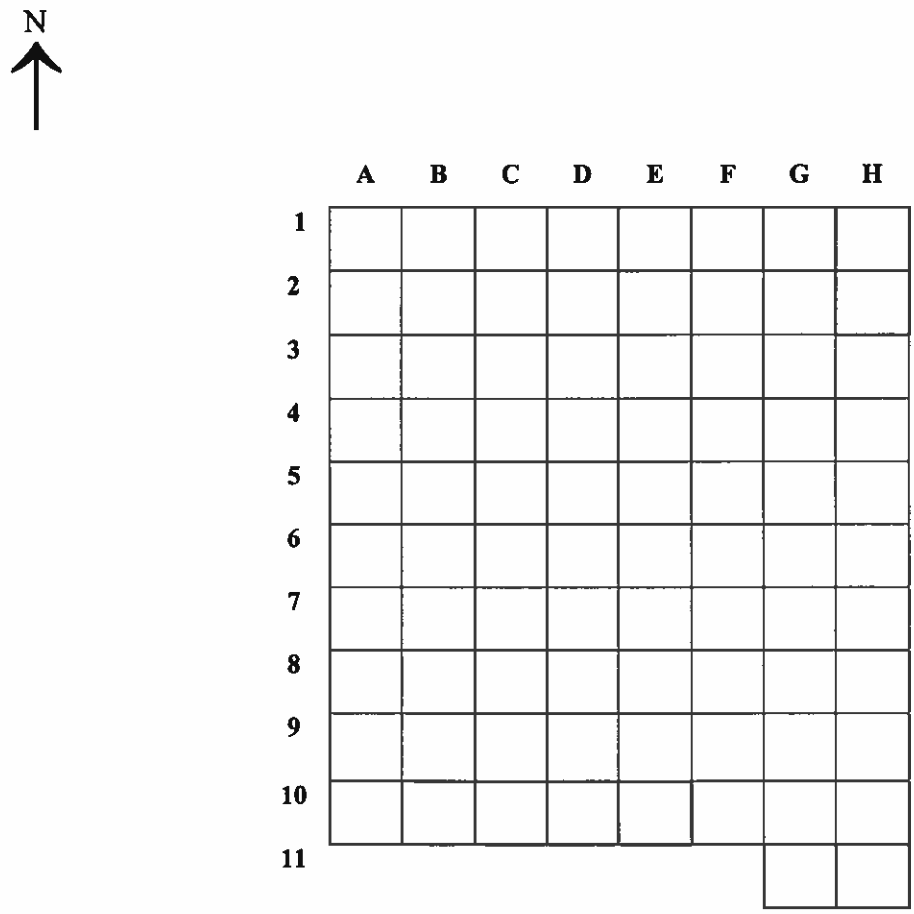

Fig 1. 10m x 10m permanent grid within Brise Fer Unweeded Plot.

Guava and Privet
For each quadrat the total number of guava and privet stems greater than 1.3 m in height were recorded and privet stems >2.5cm dbh were mapped. In ten randomly selected quadrats all guava stems >1.3m in height were also mapped.

Dead trees
The total number of dead native trees and their dbh values were recorded for each quadrat in both the Old Plot and the Unweeded Plot.

Saplings
The total number of individuals and each individual's height were recorded for all phanerophytes within a 4m^2 area in the NW corner of every quadrat. This inventory consisted of all individuals ≥20cm and ≤130cm in height, native and exotic. Saplings were recorded in both study areas.

Data handling
Once collected the information was compiled into a series of spreadsheets and GIS files to allow easy access to the data. These are currently held by the Mauritian Wildlife Foundation.

Results

Presented below are a series of tables illustrating some of the information gathered over the course of this project. The data gathered on saplings is currently being compiled in Mauritius and so is unavailable at this time.

Table 1 provides a comparison of several characteristics of interest between the Old Plot and the Unweeded Plot.

Table 1. Summary statistics for Brise Fer Plots.

Statistics	Old Plot	Unweeded Plot
Date of survey	July/Aug/Sep 2000	Aug/Sep 2001
Area surveyed (m^2)	7200	8200
Total no. trees per ha	9090	22138
Natives per ha	9025	5634
Exotics per ha	65	16504
Total number of species	96	79
Number of native species	88	73
Number of exotic species	8	6
Number of species unique to plot	27	10
Unique natives	20	5
Unique exotics	7	5
Basal area of natives per ha (m^2)	63.6943	63.6484

Table 2 shows the relative importance of the major native tree species to the composition of the two study areas. Importance values were calculated for all native tree species including a category for dead native trees. This uses frequency, density and basal areas to produce a statistic for each species or group whose total values add up to 300. The highest individual value is ranked as most important to the species assembly.

Table 2. Importance values for selected tree species in Brise Fer plots (Importance Rank in parenthesis).

Species	**Old Plot**	**Unweeded Plot**	**Mean**
Diospyros tessellaria	26.0 (2)	44.4 (1)	35.2 (1)
Erythrospermum monticolum var. *pyrifolium*	27.1 (1)	35.9 (2)	31.5 (2)
Syzygium glomeratum	18.7 (4)	19.3 (4)	19.0 (3)
Cassine orientalis	23.0 (3)	9.0 (10)	16.0 (4)
DEAD	4.5 (19)	23.4 (3)	14.0 (5)
Securinega durissima	14.3 (6)	12.0 (7)	13.1 (6)
Eugenia/Monimiastrum spp.	10.7 (9)	13.3 (6)	12.0 (7)
Protium obtusifolium	16.5 (5)	7.1 (12)	11.8 (8)
Tabernaemontana mauritiana	10.7 (10)	11.1 (8)	10.9 (9)
Labourdonnaisia glauca	6.6 (15)	14.6 (5)	10.6 (10)
Canarium paniculatum	11.1 (8)	7.6 (11)	9.3 (11)
Chassalia/Gaertnera spp.	11.4 (7)	2.9 (26)	7.2 (13)
Warnekia trinervis	3.4 (24)	10.5 (9)	7.0 (14)

Point of interest: *Sideroxylon grandiflorum*, the Dodo tree

Prior to this survey conclusive evidence for the natural regeneration of *S. grandiflorum* within recent times (*i.e.* the last few hundred years) has been lacking. During the mapping phase of this year's project two individuals of this species were recorded with dbh values of 10.0 cm and 6.0 cm. It seems most likely that these two trees germinated recently, within the last 150 years. This would have been prior to the introduction (c. 1940) and spread of invasive exotic plant species, but after the introduction of destructive animal species (ongoing since c. 1500's).

Discussion

The thorough nature of this study has made comparisons possible between both the two study plots and areas of tropical forest found elsewhere (and this aspect of the project will be dealt with in a forthcoming journal article). Many of the rare native species would not have been found had a less comprehensive surveying technique been used.

Preliminary findings are as follows:

Spatial mapping

Comparison between the two study plots suggests some interesting similarities and differences. Whilst the total basal area of native trees is almost exactly the same in each location, the distribution of trees among size categories varies.

The two most important tree species in each plot were found to be the same, with *Diospyros tessellaria* (black ebony) and *Erythrospermum monticolum* var. *pyrifolium* (bois manioc) ranked first or second. Other species were much more varied in their representation. Some species such as *Warnekia trinervis* were much more common in the Unweeded Plot, whereas the *Chassalia/Gaertnera* sp. was much more common in the Old Plot.

Dead trees

The importance of dead trees varies considerably between the two plots. The marked increase in the number of dead trees found in the Unweeded Plot suggests a possible negative effect of exotic species on native survival. This is what might be expected given the general state of forest degradation in Mauritius, but it has not been recorded in this way before. At this stage the specific cause and effect is still unknown.

Future work

Following the success of Phase Two of this project a paper examining the findings of the two field seasons is currently in preparation. It is expected that this paper will be submitted for publication in early 2002. Once the paper has been accepted copies will be sent to all sponsors and contacts.

Acknowledgements

The authors would like to thank Professors Lorence and Sussmann for their encouragement and support without which the project would not have taken place.

We would also like to thank the staff and volunteers of the Mauritius Wildlife Foundation variously for their interest, friendship and patience over two field seasons, which combined to make this expedition a success.

Mr Gabriel D'Argent provided invaluable help with identification when it proved necessary. Dr. John Mauremootoo (Mauritius Wildlife Foundation) was the overall supervisor for the project and his excitement and enthusiasm for the work was much appreciated.

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Species list for Brise Fer Mapping

Species	Code	Family	Old Plot no. >1.3m	Unweeded Plot no. >1.3.m	Notes
Allophylus borbonicus	ALLBOR	Sapindaceae	63	1	
Antidesma madagascariense	ANTMAD	Euphorbiaceae	85	79	
Antirhea borbonica	ANTBOR	Rubiaceae	41	11	
Aphloia theiformis	APHTHE	Flacourtiaceae	273	42	
Apodytes dimidiata	APODIM	Icacinaceae	22	4	
Averrhoa carambola	AVECAR	Oxalidaceae	3	0	
Badula multiflora	BADMUL	Myrsinaceae	9	6	
Bauhemia sp.	BAUSPP	Urticaceae	1	0	
Bertiera zaluzania	BERZAL	Rubiaceae	5	4	
Calophyllum tacamahaca	CALTAC	Guttiferae	3	18	
Canarium paniculatum	CANPAN	Burseraceae	31	21	
Casearia coriacea	CASCOR	Flacourtiaceae	5	4	
Casearia mauritiana	CASMAU	Flacourtiaceae	3	0	
Cassine orientalis	CASORI	Celastraceae	583	143	
Chassalia grandifolia	CHAGRA	Rubiaceae	5	0	
Chassalia/Gaetnera sp.	CHGASP	Rubiaceae	354	69	
Chionanthus broomeana	CHIBRO	Oleaceae	1	0	
Citrus vangasay	CITVAN	Rutaceae	2	0	Not native
Clematis mauritiana	CLEMAU	Ranunculaceae	5	0	Liana
Cnestis glabra	CNEGLA	Connaraceae	206	100	Liana
Coffea macrocarpa	COFMAC	Rubiaceae	6	12	
Colea colei	COLCOL	Bignoniaceae	7	0	
Cordemoya integrifolia	CORINT	Euphorbiaceae	34	93	
Cyathea borbonica	CYABOR	Cyatheaceae	22	0	
Cyathea cooperii	CYACOO	Cyatheaceae	24	0	Not native
Cyathea excelsa	CYACEX	Cyatheaceae	40	0	
Danais fragrans	DANFRA	Rubiaceae	94	1	Liana
Diospyros boutoniana	DIOBOU	Ebenaceae	2	6	
Diospyros neraudii	DIONER	Ebenaceae	5	1	
Diospyros revaughanii	DIOREV	Ebenaceae	1	0	
Diospyros tessellaria	DIOTES	Ebenaceae	447	679	
Doratoxylon apetalum	DORAPE	Sapindaceae	38	3	
Elaeocarpus integrifolius	ELAINT	Elaeocarpaceae	20	17	
Embelia micrantha	EMBMIC	Myrsinaceae	8	7	Liana

Erythrospermum monticolum var. amplifolium	ERMOAM	Flacourtiaceae	58	133	
Erythrospermum monticolum var. pyrifolium	ERMOPY	Flacourtiaceae	717	760	
Erythroxylum laurifolium	ERYLAU	Erythroxylaceae	28	86	
Erythroxylum macrocarpum	ERYMAC	Erythroxylaceae	47	70	
Eugenia elliptica	EUGELL	Myrtaceae	0	1	
Eugenia/Monimiastrum sp.	EUMOSP	Myrtaceae	139	225	
Fernelia decipiens	FERDEC	Rubiaceae	61	130	
Ficus mauritiana	FICMAU	Moraceae	22	0	
Ficus reflexa	FICREF	Moraceae	12	1	Liana / strangler
Flacourtia jangomas	FLAJAN	Flacourtiaceae	0	3	Exotic
Geniostoma borbonica	GENBOR	Geniostomaceae	7	0	
Grangeria borbonica	GRABOR	Chrysobalanaceae	66	29	
Harungana madagascariensis	HARMAD	Guttiferae	5	0	Not native
Hiptage benghalensis	HIPBEN	Malpighiaceae	0	0	Exotic
Homalium integrifolium	HOMINT	Flacourtiaceae	2	2	
Homalium paniculatum	HOMPAN	Flacourtiaceae	1	3	
Hugonia serrata	HUGSER	Linaceae	29	16	Liana
Hyophorbe vaughanii	HYOVAU	Arecaceae	4	0	
Labourdonnaisia glauca	LABGLA	Sapotaceae	50	117	
Labourdonnaisia revoluta	LABREV	Sapotaceae	0	4	
Lautembergia neraudiana	LAUNER	Euphorbiaceae	136	10	
Leea guineensis	LEEGUI	Leeaceae	6	1	
Ligustrum robustrum var. walkerii	LIGROB	Oleaceae	0	734	Exotic
Litsea glutinosa	LITGLU	Lauraceae	7	0	Not native
Litsea monopetala	LITMON	Lauraceae	1	0	Not native
Ludia mauritiana	LUDMAU	Flacourtiaceae	16	11	
Macaranga mauritiana	MACMAU	Euphorbiaceae	2	1	
Memecylon ovatifolium	MEMOVA	Melastomataceae	269	159	
Mimusops erythroxylon	MIMERY	Sapotaceae	42	16	
Mimusops maxima	MIMMAX	Sapotaceae	6	20	
Mimusops sp.	MIMSPP	Sapotaceae	4	97	
Molinaea alternifolia	MOLALT	Sapindaceae	15	1	
Murraya paniculata	MURPAN	Rutaceae	5	0	Not native
Mussaenda arcuata	MUSARC	Rubiaceae	144	0	Liana
Mussaenda landia	MUSLAN	Rubiaceae	43	0	
Myonima violacea	MYOVIO	Rubiaceae	63	63	
Nuxia verticillata	NUXVER	Buddlejaceae	68	22	
Ochna mauritiana	OCHMAU	Ochnaceae	266	24	

Ocotea mascarena	OCOMAS	Lauraceae	67	20	
Olea lancea	OLELAN	Oleaceae	6	2	
Ossaea marginata	OSSMAR	Melastomataceae	0	3	Exotic
Passiflora edulis	PASEDU	Passifloraceae	0	1	Exotic
Phyllanthus casticum	PHYCAS	Euphorbiaceae	2	0	
Piper borbonense	PIPBOR	Piperaceae	8	3	Liana
Pittosporum senacia ssp. *senacia*	PITSEN	Pittosporaceae	25	0	
Pleurostylia leucocarpa	PLELEU	Celastraceae	113	84	
Protium obtusifolium	PROOBT	Burseraceae	288	52	
Psathura sp.	PSASPP	Rubiaceae	119	79	
Psidium cattleianum	PSICAT	Myrtaceae	1	12468	Exotic
Psiloxylon mauritianum	PSIMAU	Myrtaceae	6	9	
Schinus terebentifolius	SCHTER	Anacardiaceae	2	0	Not native
Scutia myrtina	SCUMYR	Rhamnaceae	49	14	Liana
Securinega durissima	SECDUR	Euphorbiaceae	344	211	
Sideroxylon cinereum	SIDCIN	Sapotaceae	1	2	
Sideroxylon grandiflorum	SIDGRA	Sapotaceae	5	16	
Syzygium commersonii	SYZCOM	Myrtaceae	17	37	
Syzygium contractum	SYZCON	Myrtaceae	0	2	
Syzygium glomeratum	SYZGLO	Myrtaceae	120	177	
Syzygium mamillatum	SYZMAM	Myrtaceae	14	1	
Syzygium mauritianum	SYZMAU	Myrtaceae	1	0	
Syzygium populifolium	SYZPOP	Myrtaceae	9	23	
Syzygium sp.	SYZSPP	Myrtaceae	0	6	
Tabernaemontana mauritiana	TABMAU	Apocynaceae	269	250	
Tambourissa peltata	TAMPEL	Monimiaceae	49	12	
Tambourissa sp.	TAMSPP	Monimiaceae	0	1	
Turrea oppositifolia	TUROPP	Meliaceae	84	1	
Turrea rigida	TURRIG	Meliaceae	1	0	
Vepris lanceolata	VEPLAN	Rutaceae	3	0	
Warneckia trinervis	WARTRI	Melastomataceae	103	252	
Weinmannia tinctoria	WEITIN	Cunoniaceae	0	1	
Xylopia richardii	XYLRIC	Annonaceae	36	11	

Edinburgh University Ecological Expedition to Brise Fer,
Black River Gorges National Park, Mauritius:
August 16th – November 1st 2001

Mauritian Forest Dynamics Phase II
Summary

By

Brian J Pickles
(Expedition Leader)

Purpose

The purpose of the two phases of this study was to gather detailed data from two areas of Mauritian Forest, one heavily invaded by exotic species (Phase II – 2001) and one in which all exotics had been removed (Phase I – 2000). In order to achieve this goal two permanent study grids were set up by the Edinburgh teams in which all Phanerophtyes (trees and vines) would be mapped, identified to species level (as far as possible), and have their dbh (diameter at breast height) recorded. This information could then be applied in the following ways:

i) Establishing a baseline from which to examine changes in forest structure over time.
ii) Collection of information on the spatial distribution of trees in an area containing the best-conserved native forest remaining in Mauritius. Providing a model on which to base forest reconstruction programs for the future.
iii) Establishing the similarities and differences between Mauritian forests and other forests studied elsewhere.
iv) Data will provide relevant information for studies of the faunal composition of managed and non-managed areas e.g. where released endangered birds are nesting, etc.
v) Data will give some idea of how similar the managed and non-managed areas were before management. Because of the slow rate of growth of native trees it is likely that adult composition is still similar to the situation at the time when management began. These data will allow us to establish how valid the non-managed areas are as controls.

Strengths

The thorough nature of this study has made comparisons possible between both the two study plots and areas of tropical forest found elsewhere (and this aspect of the project will be dealt with in a forthcoming journal article). Many of the rare native species would not have been found had a less comprehensive surveying technique been used.

Phase Two was carried out more quickly than expected due to familiarity with the flora gained in Phase One. This allowed the new team to gather extra data from each study area, resulting in additional information on sapling numbers and the contribution of dead trees to forest structure.

Weaknesses

Lack of replication. Mauritian forests have been so badly affected by exotic species invasion that there are few suitable sites for experimental replication. The thorough nature of the investigation also placed constraints on the total area that could be studied.

Achievements

i) Spatial mapping was highly successful and two detailed GIS maps showing the position of each tree as well as sapling, exotic species and dead tree densities have been constructed, one for each study area. Comparison between the two study plots suggests some interesting similarities and differences. Whilst the total basal area of native trees is almost exactly the same in each location, the distribution of trees among size categories varies.

ii) A new addition to the study during Phase II was the recording of dead native trees. The importance of dead trees varies considerably between the two plots. A marked increase in the number of dead trees was found in the Unweeded Plot, suggesting a negative effect of exotic species on native survival. This is what might be expected given the general state of forest degradation in Mauritius, but it has not been recorded in this way before. At this stage the specific cause and effect is still unknown.

Special findings

The Dodo tree (*Sideroxylon grandiflorum*) - Prior to this survey conclusive evidence for the natural regeneration of *S. grandiflorum* within recent times (*i.e.* the last few hundred years) has been lacking. During the mapping phase of this year's project two individuals of this species were recorded with dbh values of 10.0 cm and 6.0 cm. It seems most likely that these two trees germinated recently, within the last 150 years. This would have been prior to the introduction (c. 1940) and spread of invasive exotic plant species, but after the introduction of destructive animal species (ongoing since c. 1500's).

Appendix I – Expenses

Expected Expenses (Team of 4 individuals)

Travel: £3200
Subsistence: £4000
Equipment: £200
Vehicle Hire: £1000
10% Contingency: £840

Total: £9240

Actual Expenses

Travel: £2500
Subsistence: £3500
Equipment: £200
Vehicle Hire: £900

Total: £7100

Funding

Davis Fund: £2500
Barnson Bequest/Weir Fund: £1000
Royal Geographical Society (with IGB): £1000
University of Edinburgh Development Fund: £900
Personal Contibution (Team Members): £1700

Total: £7100