Australian Government
Department of the Environment and Water Resources

Marine and Tropical Sciences Research Facility (MTSRF) June 2007 Milestone Report

Project 2.5ii.2 : Climate Change – Scaling from trees to ecosystems

Project Leader: Dr Michael Liddell, James Cook University

Summary

The project has commenced and produced the anticipated results for year.

Objective (a) has analysed 6 years of flux data (including 2006-2007) and demonstrated that the lowland rainforest is susceptible to low water availability in the dry season, particularly during drought years. When the forest receives less than 1m of rainfall in the dry (and associated transition) season then a significant reduction in daytime productivity (carbon flux) occurs. When the forest receives more than 1m of rainfall then the amount of rainfall in the wet season (and associated transition) becomes a limiting factor. Above 2m of rainfall in the wet season (and given > 1m of rainfall in the dry) the forest operates at a regular level of productivity. The flux data sets have been placed on the Ozflux web site.

Objective (b) has demonstrated that leaf-litter productivity is spatially variable on the site and this appears to be linked to water availability. Leaf stomatal conductivity g_s is being monitored. Preliminary results have indicated a marked seasonal dependence in g_s and also that only some plants are able to strongly control their stomatal conductance. In light of these results reduced water availability is expected to significantly influence the survivor species of the lowland rainforests by 2100, where severe long dry seasons have been predicted by the CSIRO. On-going research aims to narrow down which tree species are likely to survive these future extreme dry seasons.

Objective (c) has shown that the crane site has marked spatial variability in soil/rock composition, depth of soil, nutrient status and most importantly water availability. To correctly understand the canopy level variations in productivity we must be able to follow the basic drivers of plant success in the rainforest.

Follow up work will refine the spatial variability in water availability and commence the temporal monitoring program to look at seasonal variations in soil moisture. The installation of bore monitoring and soil water monitoring in 2007-2008 will be pivotal in developing an understanding of how water availability controls productivity in this lowland rainforest system.

Objective (e) has carried out insect sampling / identification throughout the year. A report written earlier in the year based on prior sampling demonstrated that beetle abundance was highest in the dry season and decreased under conditions of intense precipitation. This finding, if generalised to the other insect assemblages found in the canopy, indicates an insect problem may develop under future climate regimes in the dry season. High foliage-feeding insect abundance when combined with water stress is expected to reduce tree survivorship in rainforests influenced by climate change.

A further project meeting has been held to discuss the progress to date. Each of the sub-projects dealing with Objectives (a), (b), (c), (e) have completed their research activities without major difficulties during year one of the project. In the final milestone the delivery is concerned with providing end of year reports on the first 12 months of activities.

For reference: Milestone extracted from Project Schedule

Report 3 submission:

- End of year report on the results of the basic biophysical data (fluxes of carbon, water linked to microclimate variables) required in understanding forest level response to climatic drivers (obj a).
- Evidence of the provision of first 5 years of data on the WEB for OZFLUX network end-users (obj a).
- End of year report on tree physiology and the risks and threats to lowland rainforest canopy tree productivity under changing rainfall and temperature scenarios (obj b) provided in conjunction with data from *OzClim* (Objective (c) from 5.2.ii.1.
- End of year report of the results on characterisation of the soil structure, soil chemistry and exploratory hydrology at the canopy crane site (obj c).
- End of year report on the magnitude and causes of inter-and intra-annual variation in insect populations and how they relate to ecosystem productivity and climate variability (obj e).
- Summary of communication activities undertaken through the course of year 1 of project, including any examples of application of the results by WTMA, DEH, EPA and FNQNRM.
- Plan of activities for out years.

Communications, major activities or events

During milestone reporting period

A project meeting was convened on 30/5/07. Minutes are attached as Appendix 1.

In June 2007 Dr Franks is attending an international conference at Cascade Locks, Oregon (USA) on "Innovative new uses of canopy cranes", hosted by the US Department of Agriculture (expenses covered by USDA). This invitation arose from prior publicity of our research activities at the Australian canopy crane research site, including MTSRF Project 2.5ii.2. Here he will present the preliminary data for MTSRF Project 2.5ii.2, together with associated work, with a view to attracting collaborative involvement in intensive forest ecosystem research between the Wind River canopy crane (Washington State, USA) and the Australian Canopy Crane (MTSRF Project 2.5ii.2).

In June 2007 Dr Nelson is visiting the laboratory and forest field site of Universite de Bourgogne and Insitut National de Recherche Agronomique to carry out collaborative work on C in forest soils. The project, funded by DEST- International Science Linkages, involves a PhD student, Anthony Gauthier, who is comparing transformations and movement of C through soils at the Canopy Crane site and a temperate forest site in Frabce (Breuil-Chenue).

During next milestone reporting period

The next project meeting is scheduled for June 2007.

Channel 10 will be visiting the Crane site on 27th of June to host a show on the program Scope which is a children's science show produced by Channel Ten in collaboration with CSIRO. Features of the MTSRF project will be presented to a young audience interested in science and technology.

Summary of Communication Activities during first year of the project

In total 4 project meetings have been carried out over the course of the project: 29/8/06; 29/11/06; 26/2/07; 30/5/07.

At the Rainforests and Catchments Operations meeting 1 (13/11/06) discussion was carried out with Penny Whetton (DMAR, CSIRO) from 2.5ii.1 Regional Climate Predictions for Tropical Rainforests to effectively link the Projects.

At the Rainforest and Catchments Operations meeting (13/11/06) discussion was carried out with Dr Ramasamy Suppiah (DMAR, CSIRO) from 2.5ii.1 Regional Climate Predictions for Tropical Rainforests on obtaining information from that project to aid in final outputs from 2.5ii.2.

The ongoing MTSRF project activities were discussed as part of a preliminary submission to NCRIS for infrastructure maintenance of the Canopy Crane research facility within the proposed TERN network.

A complete special issue of Austral Ecology was devoted to Australian Canopy Crane science and published in February 2007 - Austral Ecology Vol. 32 Issue 1 Page 1-112.

In this issue articles were published by several members of the MTSRF project team and the Program leader. Full details of the relevant papers and corresponding output objectives are presented in Appendix 2. This reported work in this issue involving the project team members was supported by transitional CRC Rainforest funding.

Forecast variations to planned milestones

As part of the ARP2 submission the research plan for Objective (e) is being re-developed. This objective will move from being primarily an insect sub-project to primarily a phenology sub-project. The insect work that continues will relate to phenological changes in the canopy. On-going discussions are continuing with RRRC and interested parties to generate the appropriate outputs for the end-user groups.

Objective (d) which was due to commence in 2007-2008 financial year is being re-configured with brokerage by the RRRC. This objective needed co-funding by the AGO for a Ph.D. scholarship to carry out modeling that would allow up-scaling of the results of the project. Instead other modeling providers in the MTSRF programs will be approached to determine if the outputs from Objectives (a)-(c) and (e) Phenology will be able to be used in their MTSRF area modeling programs.

Plan of Activities for Out Years.

Objective	Targeted Activity	Completion Date
(a)	Atmosphere: Collection of the basic biophysical data (fluxes of carbon, water linked to microclimate variables) required in understanding forest level response to climatic drivers. Carry out preliminary Volatile Organic Carbon (VOC) measurements at the Crane site	June 2008
(b)	Tree Physiology: Collate 2007-2008 dendrometer and litter trap data. Analyse 2007-2008 leaf litter and fresh leaf* carbon isotopes. Analyse 2007-2008 leaf litter and fresh leaf N*. Collate 2008 canopy LAI data. Collate 2008 canopy leaf conductance data*. (*note this is contingent on crane access in 2008)	June 2008
(c)	Soil: Install monitoring bore(s) with depth loggers Complete installation of soil water monitoring sensors Monitor soil water and calculate water uptake from soil Monitor watertable Analyse soil and soil solution for C (amount and characteristics)	June 2008
(d)	Correlate the results from dendrometer and leaf litter trapping studies at the ACC site with results from the Wet Tropics for 2007	June 2008
(e)	Fauna and Phenology: Collect observational data of insect resource use in the canopy and on the ground. This will include making direct observations (from the canopy crane gondola) of insects feeding on and residing in particular resources. Other insect collecting techniques (leaf beating, bark sprays etc) will also be employed to make further insect-habitat associations. Phenological dataset collection will continue. Analyse Ordinal insect data (2000-2004) and relate it to phenological and beetle species data collected over the same time period. Correlations will be examined between variations in insect abundance and climatic variability.	June 2008

Project Results

DESCRIPTION OF THE RESULTS ACHIEVED FOR THIS MILESTONE

The project is running on schedule. Detailed descriptions of the year's results for each of the objectives are provided in this section.

1. Report on the fluxes of carbon, water at the canopy crane site linked to microclimate drivers

Summary

Initial analysis of 6 years of data collected using the eddy-covariance flux station at the Canopy Crane site has demonstrated that the forest is susceptible to water stress. In the drought years 2002, 2003 the daytime carbon flux at the site was reduced by 20% at the site. In contrast the water flux (latent heat flux) showed little change between the normal and drought years. The trigger to reducing the carbon flux (this measurement is dominated by photosynthesis during the day) appears to be a lower than normal rainfall in the extended dry period from April to October. The climate modelling results from CSIRO MTSRF project 5.2.ii.1 have indicated that for the Cape Tribulation region the reductions in rainfall during this period could be as much as 40% by 2070 (SRES scenario) which would indicate major problems in sustaining a viable rainforest in this region of high biodiversity.

Activities

March 2007 has marked the sixth year of data collection at the Cape Tribulation Ozflux site. The CSAT-3 anemometer which is a vital piece of the flux instrumentation started malfunctioning in July 2006. This was removed in October and the repaired equipment arrived back in mid November. Other than this the eddy covariance system has been fully operational throughout the last year. Other failures in equipment have included the net-radiometer and the all weather meteorological station, problems with these instruments (parrot and insect attack respectively) were readily rectified.
Data analysis for eddy covariance involves three stages: (i) initial pre-processing to remove bad data (rain interference, wind direction etc) and generation of 1 hour blocks of continuous data, (ii) processing to generate the carbon, water and sensible heat fluxes and finally (iii) post-processing to validate the quality of the data. The post-processing code was developed during the last milestone period using the program MATLAB®. This was a major undertaking requiring the writing of many thousands of lines of computer code. The final results are in the early stages of interpretation.

Results

The nature of the flux tower and the site at Cape Tribulation (hilly topography) mean that only the daytime fluxes may be quantitatively analysed at this stage. Later on in the project when the soil flux system is operational an estimate of night-time fluxes will, in principle, also be possible. The daytime carbon flux at the site is seen in Table 1 to be dramatically reduced in 2002 and 2003 which were years of significant drought in the Far North region of Queensland.

Table 1. Average values of daytime Carbon, Latent and Sensible heat fluxes. Carbon flux (μmol/m^2/s^{-1}), latent heat flux (W/m^2), sensible heat flux (W/m^2).

YEAR	2001	2002	2003	2004	2005	2006
Carbon Flux	-5.98	-4.85	-4.91	-6.09	-6.35	-6.18
Latent Heat Flux	200.01	205.01	196.48	188.06	186.68	183.03
Sensible Heat Flux	51.66	50.02	58.36	45.87	47.72	46.72
Latent + Sensible Flux	251.67	255.03	254.84	233.93	234.40	229.76

The flux data collection commenced in March 2003 and as such each flux year is March – February of the subsequent year. Analysis of the data clearly indicates that in the years of low water availability 2002, 2003 (see Table 2) the daytime carbon flux (fixation due to photosynthesis dominates respiration during the daytime) is reduced while in years of normal water availability (3.9m) an average daytime flux of around -6 μmol/m^2/s^{-1} is achieved.

The trigger to a significant decrease in the carbon flux would appear to be a reduction in available water in the dry season plus transition period 2 (extended dry season – see Table 2) where, if less than 1m of rain is available, the carbon flux will be dramatically reduced. In 2003 the substantial reduction in the amount of water available in the wet season (plus transition period 1) meant that 1m of rainfall in the extended dry period was insufficient to support a normal productivity of the forest (in comparison with 2005).

Given more than 2m of rainfall in the extended wet season and more than 1m of rainfall in the extended dry season a normal carbon fixation (-6.15 μmol/m^2/d) is seen for the forest which compares with values of around -4.03 μmol/m^2/d in the Brazilian Amazon (Vourlitis *et al*. 2004).

Table 2. Annual rainfall (mm) at Cape Tribulation.

RAINFALL	2001	2002	2003	2004	2005	2006
Wet + Transition 1	3992.2	1552.8	1270.4	3437.4	2253.4	3306.2
Dry + Transition 2	886.2	819.6	1061.3	1219.8	1072.8	2535.2
SUM (Mar-Feb)	4878.4	2372.4	2331.7	4657.2	3326.2	5841.4
ANNUAL (Jan-Dec)	3108	2430	2553.9	4990.8	2738	5944.6

Key:

Wet season: January to March

Dry season: August to October

Transitional 1: November to December

Transitional 2: April to July

In the table Wet + Transition 1 covers the calendar year before transition 1 i.e. for 2002 the 2001 Transition 1 is included with the Wet season of 2002.Rainfall data has been provided by the Bureau of Meteorology (BOM), Cape Tribulation Store station, 031012.

The outgoing energy balance (latent heat plus sensible heat flux) is essentially constant in 2001-2003 (mean 254 W/m^2) and then again in 2004-2006 (mean 233 W/m^2). The gap filling algorithms that are used in compiling the energy fluxes are different to those used for the carbon fluxes and in 2001-2002 patchy data was collected which required substantial gap filling. This may be the reason for an apparent change in the energy balance between the early years of the station and the later years where the data collection has become more reliable. Subsequent detailed analysis will clarify this but most importantly there is no significant change in the latent heat flux in 2002 and 2003 when compared with 2001 a year where water availability was not an issue. This would imply that the trees in the forest were able to access sufficient water to maintain transpiration during the dry seasons of the drought years. The cost of maintaining transpiration and reducing photosynthesis was readily visible in the forest at the time where very significant leaf fall occurred.

On going analysis will break down the seasonal variations in carbon fluxes and energy fluxes and cross-correlate these with other climatic variables.

References

Vourlitis GL, Priante N, Hayashi MMS, Nogueira JD, Raiter F, Hoegel W, Campelo JH. (2004) Effects of meteorological variations on the CO_2 exchange of a Brazilian transitional tropical forest. *Ecological Applications*, **14**, S89.

The flux data sets for 2001 - 2006 have been deposited on the Ozflux web site:
http://www.dar.csiro.au/lai/ozflux/monitoringsites/index.html
Navigate to Cape Tribulation / Data Sets

2. Report on the physiological controls on rainforest tree productivity and water use efficiency at the canopy crane site. (objective b)

Summary

Leaf turnover measurements involving the collection of litter-fall samples was commenced in January 2007. Dendrometer bands have been placed on 171 trees.

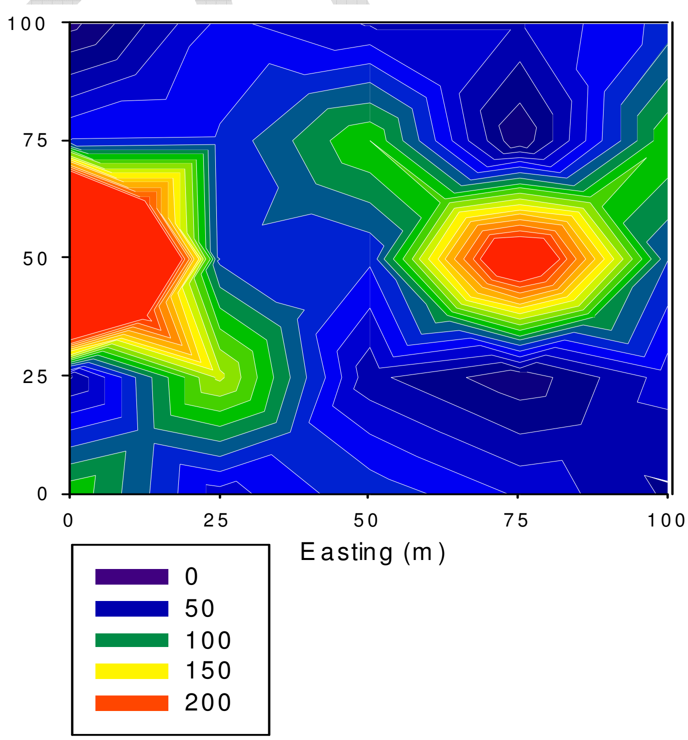
The aim of both of these sets of measurements is to determine above ground tree level productivity at the crane site. Initial results from the leaf-turnover studies indicate spatial variability appears to be linked to soil water availability. Leaf stomatal conductance gs measurements are at a preliminary stage (due to limited crane availability early in the study). These measurements, which will commence on a monthly basis in July 2007, will track the seasonal trends in gs of a range of trees in the forest. Prior work has indicated a marked seasonal shift in stomatal conductance for some, but not all, species.

Those species that are unable to control their stomatal conductance in the dry season are anticipated to be particularly susceptible to the climate change effects for this region where longer more pronounced dry periods are predicted by CSIRO DMAR MTSRF Project 5.2.ii.1 modelling.

Activities

Leaf turnover:
Leaf turnover data have now been collected for the months January – April 2007. A spatial compilation of total litter-fall across the 1ha study site over the four months shows a strongly heterogeneous pattern (Figure 1).

Figure 1: Spatial integration of total litter fall (grams dry weight) across the 1 hectare study site from Jan-April 2007.



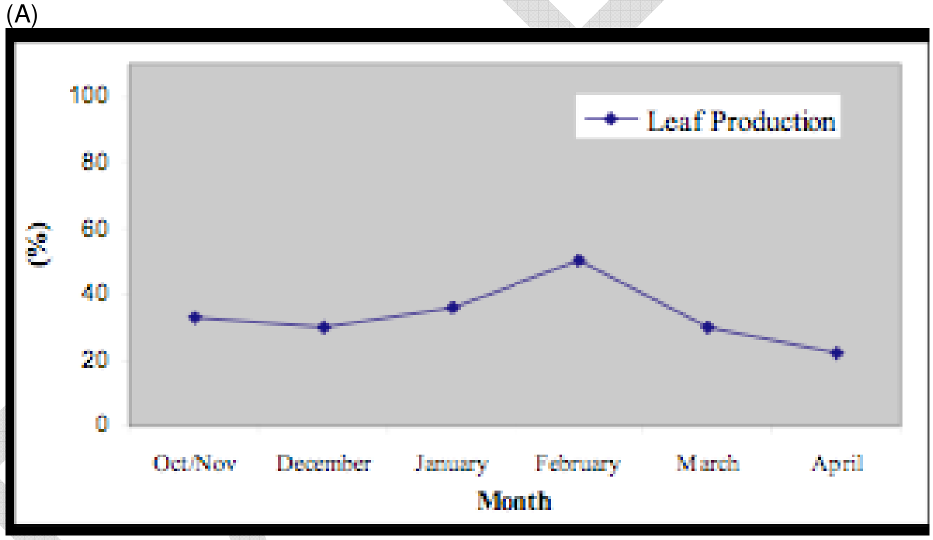
The period of litter-fall data collection is too brief to establish definite trends, but these preliminary results suggest some association with soil water distribution (*Objective (c) Figure 2*). Trends in leaf productivity at the study site, based on phenological observations, show marked seasonal variation (Figure 2) and, combined with the new leaf litter-fall data it is clear that the spatial and temporal patterns of leaf turnover at the study site are complex, requiring an extended sample time in order to establish trends and understand the relationships with other environmental variables.

Dendrometer bands:
Progress is on schedule. Banding of all 171 trees was completed in May 2007 and the first census is due to be completed in June 2008.

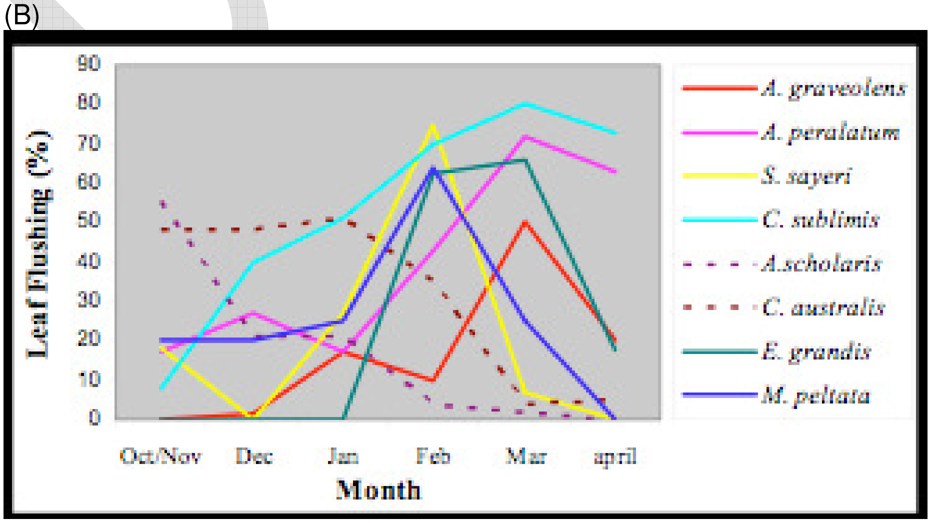
Analysis of plant material:
Leaf material from litter traps is being prepared and archived for elemental and stable isotope analysis. Fresh leaf material will be collected, dried and archived for similar analyses, commencing July 2007, in synchrony with canopy-level leaf measurements, which are also scheduled to commence in July (see below).

Figure 2. Wet season leaf production for eight dominant canopy species at the study site, showing temporal and inter-species variation (P. Franks and D. Ford, unpublished).

(A)



(B)



Canopy leaf-level measurements:

Following the purchase of equipment for measuring canopy stomatal conductance (Leaf Porometer), data collection was delayed due to the final stages of substantial maintenance work required on the crane. Following the resumption of crane operations in early May, trials of the new equipment were initiated, and data collection is scheduled to commence in July 2007, on a monthly basis.

It is anticipated that, as with leaf productivity and turnover (see above) there will be considerable variability across the dominant canopy species, and substantial differences between wet and dry season, as determined in preliminary surveys (Figure 3).

The results shown in Figure 3 demonstrate that tree species at the site differ in the degree to which they reduce stomatal conductance in the dry season, a protective adaptation that reduces water loss in dry conditions.

Stomatal conductance is strongly influenced by atmospheric humidity, soil moisture and access to groundwater, all of which are linked to patterns of local climate.

The dry season periods in the tropical rainforest region are predicted to become longer and dryer under all climate change scenarios looked at in the CSIRO-DMAR MTSRF Project 5.2.ii.1 modelling. Water availability to canopy trees is therefore expected to decrease in the future, in particular in the dry season. Reduced moisture loss via reduced stomatal conductance will not necessarily be able to prevent failure of the water conductivity of tree stems, and this reduction in hydraulic conductivity (K_s; Figure 4) can be fatal to trees over prolonged dry periods.

Several seasons of monitoring of stomatal conductance g_s are necessary in order to establish which species are most sensitive to seasonal and annual shifts in atmospheric and soil moisture. This information is essential for assessing the threats that climate change poses differentially to rainforest tree species in the wet tropics.

Figure 3: Stomatal conductance to water vapour, g_s, at midday in ten of the most dominant canopy species at the study site. Note substantial differences between species and reduction in the dry season (P. Franks and D. Ford, unpublished).

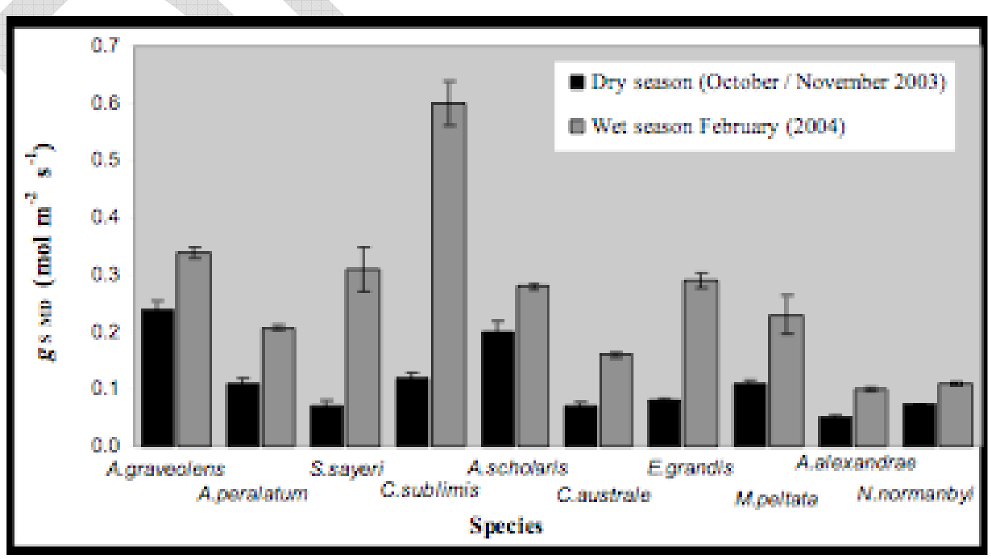
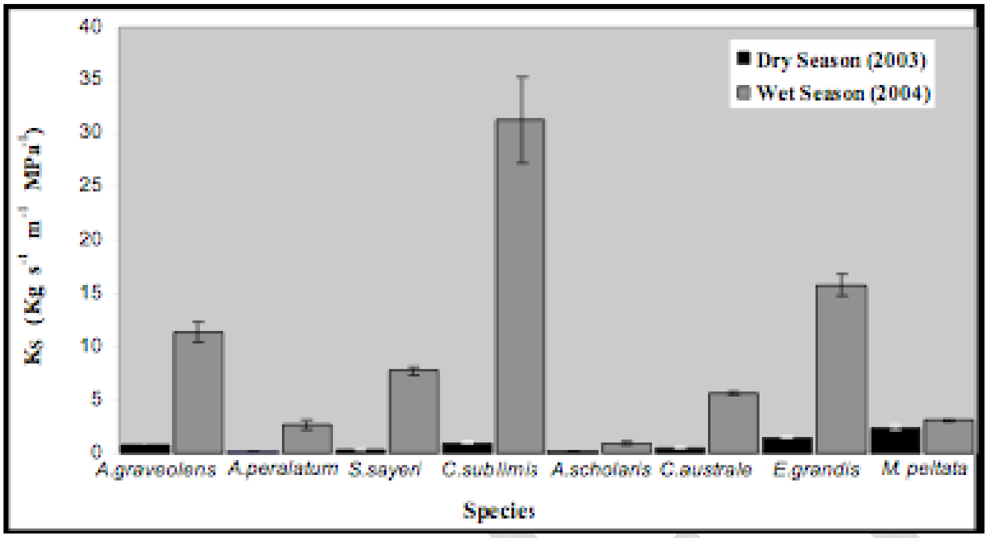


Figure 4. Species at the study site differ in their susceptibility to loss of stem function (xylem hydraulic conductivity, K_s) in the dry season (P. Franks and D. Ford, unpublished).



3. Report on basic soil structure, soil chemistry and exploratory hydrology at the canopy crane site. (objective c)

Summary

In order to quantify fluxes of carbon and water in the rainforest, we are characterizing soil properties that influence those fluxes.

A soil survey was carried out across the canopy crane site. Topsoil properties varied considerably across the site, with a fertile zone (high exchangeable cations, low acidity) extending from the centre to the north-east corner. Apparent electrical conductivity was used to estimate soil depth/rockiness. It showed a shallow/rocky zone along the southern edge of the site. Canopy cover was spatially correlated with soil properties, particularly soil depth/rockiness.

These initial results suggest that soil properties are therefore likely to influence transpiration and photosynthesis. The implication is that climate change effects (significantly reduced water availability in the dry season; Project 5.2.ii.1 outputs) will interact strongly with soil depth in influencing the success or failure of tree species in lowland rainforests.

Activities

Two soil sampling/survey programs were used to characterize soils at the site; ‘grid’ and ‘pit’. In the ‘grid’ sampling, soil properties measured at each point of a grid. The grid consisted of 25 points, on a 5x5 square arrangement, with each point 25 m apart, giving a total survey area of 100 x 100 m, centred on the crane base. The grid is the same as that used for litter traps. Soil samples were taken from the 0-0.1 m depth layer. In the ‘pit’ sampling, a pit was dug on the edge of the grid (site 2), and soil samples were taken at 0-0.1, 0.1-0.2, 0.2-0.4, 0.4-0.6 and 0.6-0.8 m.

All grid and pit soil samples were analysed (Methods from Rayment and Higginson, 1992) for: exchangeable Ca, Mg, K and Na (Method 15A1), exchangeable acidity and Al (Method 15G1), Colwell extractible P (Method 9B2), total C (Method 6B4), total N (Method 7A7), electrical conductivity (EC) and pH (both in 1:5 soil:water extract) and particle size distribution.

Apparent electrical conductivity (ECa) of the soil was measured at all grid points using electromagnetic (EM) meters. Apparent electrical conductivity is a function of soil salt, water and clay content, in decreasing order of importance. In this environment there is so little salt that we can ignore its contribution to ECa. The main feature of the soils is their very high content of gravel and boulders. We expect soil to have a higher EC than rock, due to higher water and clay content. Therefore, in this environment, we expect ECa to be a measure of the proportion of soil vs rock in the measured volume. Two EM meters were used (EM38 and EM31), each in two modes (H and V), to measure ECa to four different depths. The depth of influence is impossible to specify exactly, as it depends on the magnitude and depth distribution of EC. However, depths of influence are usually assumed to be approximately 0.8 m (EM38-H), 1.5 m (EM38-V), 2 m (EM31-H) and 4 m (EM31-V).

Soil water content was measured at all grid points using a Campbell 615 reflectometer with HydroSenseTM reader. It measures volumetric water content of the 0-0.3 m depth layer.

Samples have been taken from the pit in order to quantify the volumetric proportion of soil and rock at each depth. A rock tumbler is being built to separate the rock and soil.

Canopy openness was measured at all grid points using a Skye 660/730nm Ratio Sensor (SKR 110) and meter (SKR 100). It measures the red:far red ratio, which is highly correlated with leaf area index and percent canopy transmittance under overcast conditions (Capers and Chazdon 2004).

Results

The soil over most of the site is reasonably fertile, with moderate to high levels of available P, K, Ca and Mg (Table 1). Topsoil fertility was greatest in a zone extending from the centre to the NE corner of the site (Figure 1). Although results for organic matter content and clay content are not yet available, it is clear that organic matter content is largely responsible for soil fertility at this site, with contents of available nutrients tending to decrease with depth (Table 1).

Soil depth also varied across the site, with the rockiest area being along the southern margin (Figure 2). Canopy cover was related to soil properties, being highest in areas where soil was not rocky (EM31-H >6 mS/m), exchangeable non-acid cation content was high (>6 cmolc/kg) and exchangeable acidity was low (<1 cmolc/kg). One area had high canopy cover but did not fit those soil criteria; it however had unusually high water content, perhaps due to runoff from adjacent areas.

References

Capers, RS. and Chazdon, RL. 2004. Rapid assessment of understory light availability in a wet tropical forest. Agricultural and Forest Meteorology 123: 177 – 185.

Rayment, GE., and Higginson FR. 1992. ‘Australian laboratory handbook of soil and water chemical methods’. Inkata Press, Melbourne.

Table 1. Soil chemical properties in the pit.

Depth (m)	pH	EC	Col. P	Ca	Mg	Na	K	Acid	ECEC
		dS/m	mg/kg	cmolc/kg					
0.0-0.1	5.1	0.35	36	8.76	2.08	0.32	0.58	0.29	11.8
0.1-0.2	5.5	0.26	26	14.20	1.88	0.27	0.47	0.14	16.8
0.2-0.4	5.4	0.16	15	6.27	0.63	0.15	0.32	0.17	7.4
0.4-0.6	5.0	0.04	7	1.28	0.19	0.10	0.11	0.89	2.5
0.6-0.8	5.1	0.02	24	0.49	0.23	0.12	0.13	0.94	1.8

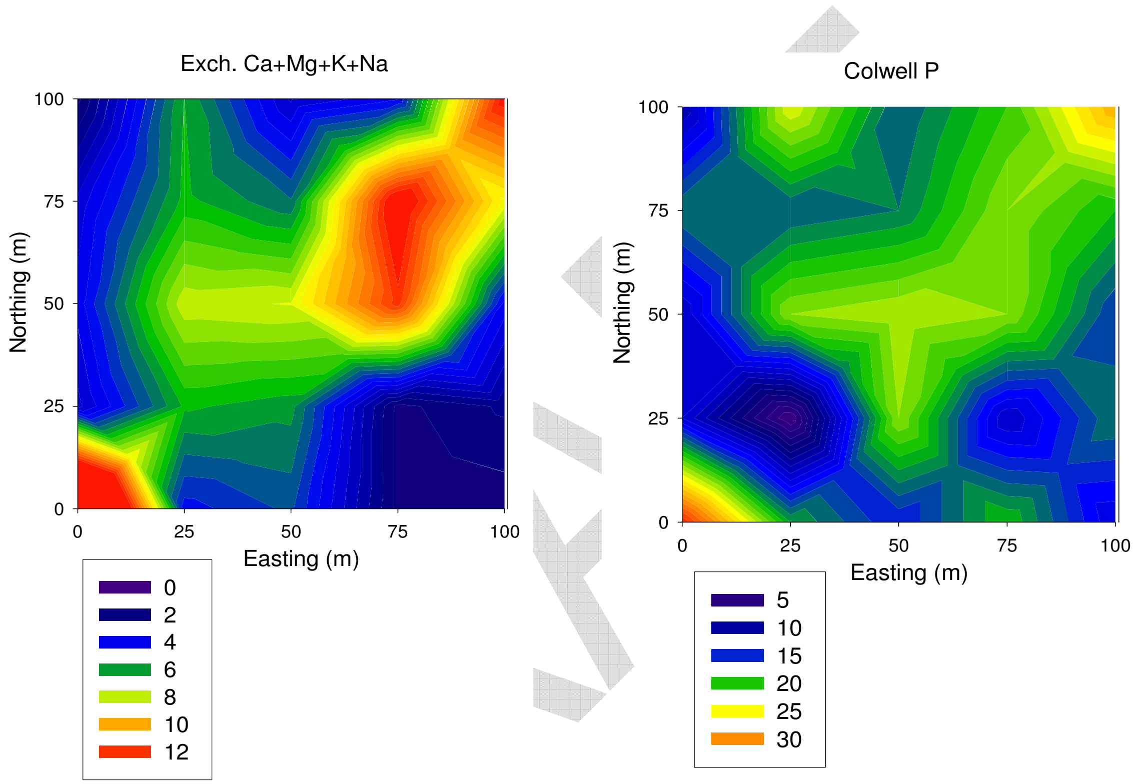


Figure 1. Exchangeable cation (cmolc/kg) and available P (mg/kg) content of soil (0-0.1 m depth) across the site. The survey is centred on the canopy crane base.

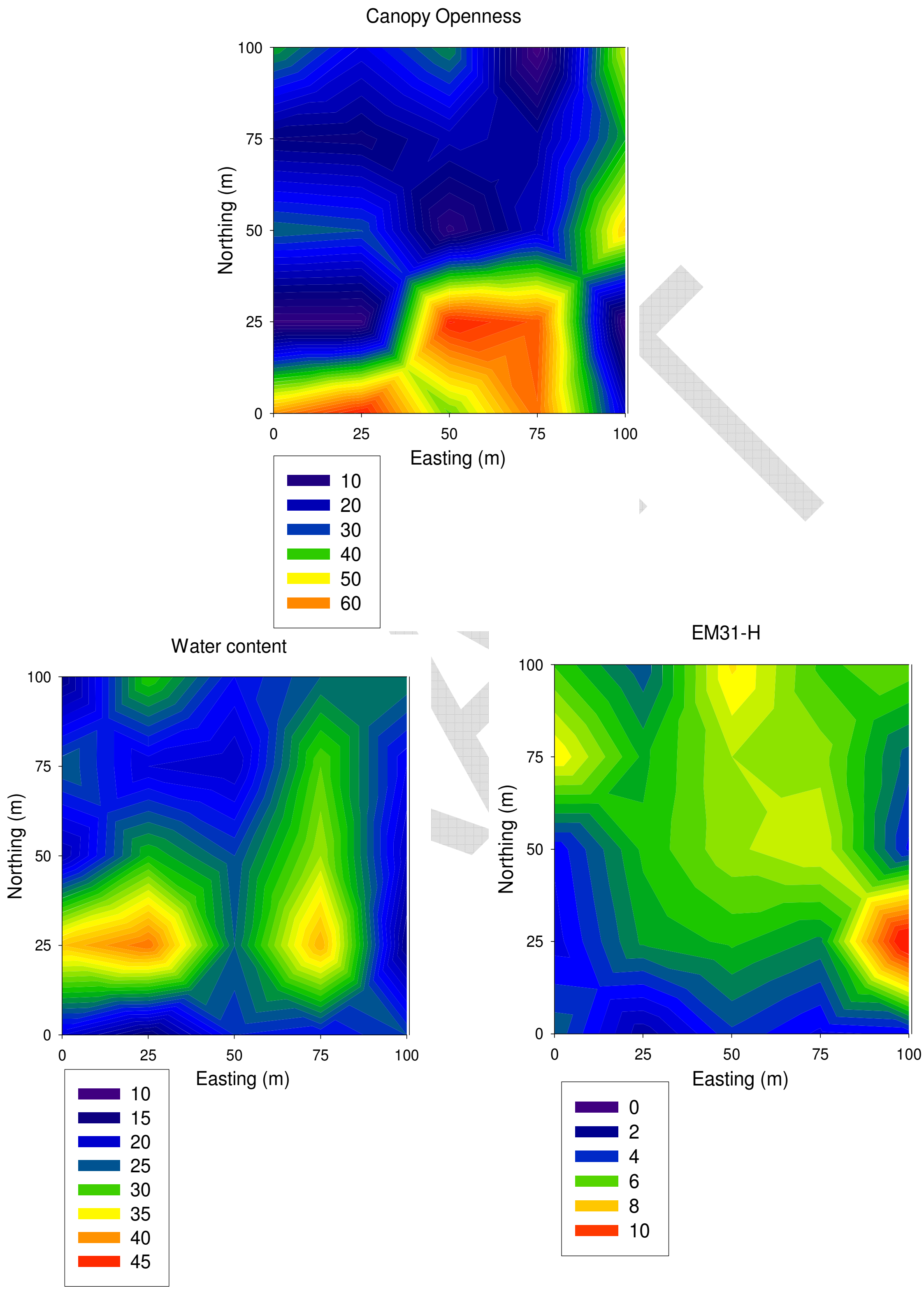


Figure 2. Canopy openness (%), soil water content (0-0.1 m depth, volumetric %), and soil ECa (mS/m, EM31-H) across the site. The survey is centred on the canopy crane base.

4. Report on the magnitude and causes of inter-and intra-annual variation in insect populations and how they relate to ecosystem productivity and climate variability. (objective e)

Summary

Microhabitat sampling of insects inhabiting leaf-litter, logs and fruits was initiated in January 2006 and specimens are currently being processed so they can be identified to species level. The sampling of flying insects in the canopy, an on-going exercise since 2005 at the crane site, was suspended in April 2007 and the large backlog of samples are currently in processing. A manuscript on the seasonality of beetle assemblages in relation to climatic conditions was submitted to a top journal (*Proceedings of the Royal Society B: Biological Sciences*) where it was unfortunately rejected. It is now undergoing further revisions and additional analysis prior to submission to a more appropriate journal. The conclusions to come out of this study which was completed at the commencement of the MTSRF project were that beetle seasonal activity is strongly correlated with climatic factors. Surprisingly beetle abundance was at a maximum in the late dry season and high rainfall appears to suppress beetle activity. Under the longer drier climatic conditions which are suggested from the 2100 WRE and SRES scenarios (DMAR June report Project 5.2.ii.1) for the dry/transition seasons insect abundance may significantly influence the ability of trees in the lowland rainforest to survive these periods of stress.

Activities

The microhabitat sampling of insects was initiated in January 2006 and is on-going. Leaf-litter, woody debris and fruit consuming insect-sampling was initiated on a monthly basis in situ, at the crane site. During each sampling visit, five litres of finely sifted leaf-litter was collected from the ground throughout the crane site. This material was then run through Tullgren funnels overnight to extract the insects, and the beetles were then removed and stored in ethanol. Beetles inhabiting woody debris were sampled by firstly spraying insecticide onto logs, and then collecting the beetles that emerged and fell onto a white collecting sheet. Two logs were sampled in this way each month. Beetles inhabiting fruits were collected from the ground in a haphazard way each month. Any plants producing fruits that had fallen to the ground were searched (for beetles in the fruits), and the fruit-beetle associations were noted, with the beetles collected and stored in ethanol.

Following the microhabitat sampling beetle specimens are being processed (removed from samples) and dry-mounted ahead of species identification. This process is extremely time consuming but it is essential for species-level identification. Quantification of the seasonality of leaf-litter inhabiting insects will complement the quantification of the seasonal dynamics of litter-fall currently being undertaken at the crane site (objective b), and a joint manuscript is planned in the future.

The seasonal dynamics of the insect assemblages inhabiting the leaf-litter, log, and fruit microhabitats, will be compared to the seasonal dynamics of the flying assemblages, sampled with the malaise-flight interception traps.

The sampling of flying insects in the canopy and the ground, at the crane site was suspended in April 2007. Five malaise-flight interception traps in the canopy and five traps on the ground had been continually run since October 2005. These samples are currently in processing.

The insect resource use in the canopy research has been initiated in June with Carl Wardhaugh (Ph.D. student) commencing at the crane site. At this stage careful tree selection is being carried out to fit in with the on-going plant physiology and previous malaise trap work. Once this is completed the study will involve making direct observations (from the canopy crane gondola) of insects feeding on and residing in particular resources. A variety of different insect collecting techniques (leaf beating, bark sprays etc) will be employed to make further insect-habitat associations. Variations in seasonality and how this fits in with changes in microclimate will be investigated.

The phenology work is at the design stage with the selection of trees involving discussions with the CSIRO in June. Experimental data collection will commence in July.

Results

In late February 2007 Peter Grimbacher and Nigel Stork submitted a manuscript of insect seasonality: "The wet season suppresses activity of a diverse Australian beetle assemblage inhabiting tropical rainforest", for publication to *Proceedings of the Royal Society B.*, but was unfortunately it was rejected. This manuscript was based on four years of sampling at the crane site (2000-2004). They are currently revising this manuscript with the view to submit it to another journal in the near future.

The results that came out of this study are contradictory to the widely held view of seasonal variations of insect abundance in tropical rainforests. A majority of tropical studies suggest that the peak period of insect activity and diversity corresponds with the wet (rainy) season. They tested if this was true of a beetle assemblage from lowland tropical rainforest at Cape Tribulation, Australia. The assemblage consisted of 29,986 beetles sorted into 1,473 species, collected over a four year period (45 temporal samples), using combined Malaise and Flight Interception traps at five locations, and at both ground and canopy levels. Over the four-year time period, fluctuations in the abundance and species richness of canopy- and ground-caught beetles, and those grouped by feeding guilds, were strongly temporally correlated. These groupings include species occupying very different types of habitats, and with a variety of life-history strategies, such as those with short or long larval stages. Because these groups are temporally in phase, it suggests that the mechanism causing beetle seasonal activity is likely to be the same for the entire assemblage. They propose that only climate would be likely to exert such an over-arching influence.

Beetles were caught throughout the year, but most species (61%) were present for 6-8 months. Surprisingly, the majority (60%) of the 124 more abundant species (those with ≥45 individuals) displayed peak periods of activity during the late dry season (September-November), while only 5% of species were most active in the three wettest months (February-April). This result is not in agreement with the majority of tropical studies of insect seasonality. Plots of beetle activity showed non-linear relationships with climatic parameters although it was impossible to definitively show which particular aspect of the climate was most important as they were all intercorrelated. They suggest that periods of high precipitation may actually suppress beetle activity and that the differing results of this study from that of previous studies, can be reconciled if insect-climate relationships are thought of as upper and lower threshold responses. They suggest several possible causal mechanisms to account for these results. Excess moisture: may cause flight avoidance, could favour alternative life-stages that are more susceptible to desiccation such as eggs and larvae, may lead to disease outbreaks (eg. fungal) which directly reduce adult beetle populations, and may force adult beetles to migrate elsewhere until more favourable conditions return.

APPENDIX 1

Minutes of Meeting Project 2.5ii.2
30 May 2007, 2pm Liddell office (E1), Cairns

Project 2.5ii.2. Climate Change: Scaling from trees to ecosystems

Attendance:
Michael Liddell
Peter Franks
Paul Nelson
Peter Grimbacher.

The discussion was mainly concerned with current research activities in each sub-project. Reports were made on the status of work in each area in preparation for the end of year Milestone report.

Objective a – Atmospheric Fluxes
Regular data collection is on-going with the eddy covariance system. The slow response temperature/humidity sensor was replaced due to drift. Coding has commenced for the quality control (QC) analysis of the processed flux data using the MATLAB program. On going work on the tower has involved repairing/replacing weather damaged equipment installations.

Objective b – Plant Physiology
The litter trap sampling is being carried out regularly at fortnightly intervals, detailed analysis at a species level was abandoned in favour of simply grouping the material into general categories – leaf, wood, fruit, flower. Dendrometer bands are now all in place on 171 trees. With the crane operational again the leaf porometer work has been initiated and exploratory sampling is underway to determine how the regular sampling program will be carried out.

Objective c – Soil structure / hydrology.
Soil/rock separation from original soil pit was found problematic and a new soil sorter has been designed and is currently being fabricated. Design of the soil water content, water sampling, temperature logging system to be installed in a major soil pit has been completed and the instrumentation ordered. Installation will commence in July (due to delays in the delivery of parts from the USA). Further soil samples have been collected for analysis. Soil analytical results have been returned from the 25 sample sites.

Objective e – Insect population variability
The ground based microhabitat study is on-going with samples being collected at monthly intervals. The new Ph. D. student (Carl Wardhaugh) has begun research at the crane site and is currently selecting trees for his study into the seasonal resource use by insects in the canopy.

Other Business
MJL briefed the group on the outcomes from the RRRC Rainforest and Catchments Steering Committee Meeting (5/07) following discussion with Sheriden Morris (RRRC). In particular the importance of making the outputs from the sub-projects (Objectives) link with other MTSRF projects was stressed. MJL to initiate discussions with other project leaders.
The next meeting was scheduled for around 20 June to fit in with the departure of Peter Franks on sabbatical later in June.

APPENDIX 2

Articles published in the Australian Canopy Crane Special Issue of Austral Ecology Vol. 32 Issue 1. February 2007 written by the MTSRF Project 2.5ii.2 team members and Program 2 leader S. Turton.

Editorial: Dynamics and processes in the canopy of an Australian tropical rainforest
Nigel E. Stork
Objective (e)
pages 2–3

Australian tropical forest canopy crane: New tools for new frontiers
NIGEL E. STORK
Objective (e)
pages 4–9

Temporal and spatial variation in an Australian tropical rainforest
MELINDA LAIDLAW, ROGER KITCHING, KYLIE GOODALL, ANDREW SMALL AND NIGEL STORK
Objective (e)
pages 10–20

Assessing the above-ground biomass of a complex tropical rainforest using a canopy crane
MICHAEL J. LIDDELL, NICOLAS NIEULLET, OTÁVIO C. CAMPOE ANDMARTIN FREIBERG
Objective (a)
pages 43–58

Importance of drought on the distribution of the birds nest fern, *Asplenium nidus*, in the canopy of a lowland tropical rainforest in north-eastern Australia
MARTIN FREIBERG AND STEPHEN M. TURTON
Objective (b)
pages 70–76

Vertical stratification of feeding guilds and body size in beetle assemblages from an Australian tropical rainforest
PETER S. GRIMBACHER AND NIGEL E. STORK
Objective (e)
pages 77–85

Ant mosaics in a tropical rainforest in Australia and elsewhere: A critical review
NICO BLÜTHGEN AND NIGEL E. STORK
Objective (b)
pages 93–104

Tropical rainforest canopies and climate change
NIGEL E. STORK, J. BALSTON, G. D. FARQUHAR, P. J. FRANKS, J. A. M. HOLTUM AND M. J. LIDDELL
Objectives (a, b, d, e)
pages 105–112