Marine and Tropical Sciences Research Facility (MTSRF)
November 2008 Milestone Report

Project 2.5ii.2 – Climate Change: Scaling from Trees to Ecosystems

Project Leader: **Dr Michael Liddell, JCU.**

Summary

The project is continuing successfully. A further project meeting has been held to discuss the progress to date. Each of the sub-projects dealing with Objectives (a), (b), (c), (d), (e) have carried on their research activities without major difficulties. In this milestone report the delivery is concerned with providing an update of progress over the last 4 months of activities.

For reference: Milestone extracted from Project Schedule

Report 1 submission (November 2008):

Progress report describing:

- the seasonal fluxes of carbon and water from the Daintree rainforest in relation to climatic drivers (obj a).
- the physiological controls on rainforest tree productivity and water use efficiency (obj b).
- characterization of water uptake and C turnover at the canopy crane site (obj c).
- characterization of flowering / fruiting events in phenological monitoring program. (obj d)
- resource related fluctuations in insect populations inhabiting leaf litter on the ground and how they relate to ecosystem productivity, and resource quantity (obj e).
- Plan of communication products and events for year two and summary of any communication activities undertaken to date, including minutes of meetings/workshops if applicable.

Communications, major activities or events

During milestone reporting period

A further project meeting has been carried out on 3/11/08. See Appendix 1.

Media Outputs.

TV: Cassowary Documentary
16th May: Mike Liddell, Peter Grimbacher, Cassandra Nichols
Independent film maker. A documentary to be aired at the start of 2009 on ABC, BBC and potentially other European Channels. Aspects of the project mentioned that relate Cassowary habitat and climate change.

TV: Discovery Channel
Documentary 25th June : Mike Liddell, Cassandra Nichols
To be aired later in 2008 nationally and possibly in South-East Asia. Aspects of the project mentioned that relate to the longevity of the FNQ lowland rainforests under climate change.

TV: Chanel 7 / Chanel 9 News
15th July : Mike Liddell
MTSRF / SkyRail Phenology study launch

Newspaper: Cairns Post
17th July Mike Liddell
MTSRF / SkyRail Phenology study launch

Newspaper: Courier Mail
26th July
MTSRF project overview Mike Liddell, Cassandra Nichols
Aspects of the project mentioned that relate to the stability of lowland rainforests under climate change.

During next milestone reporting period

A further project meeting is scheduled for late January.

Sufficient media attention has been made available to the project in the first half of 2008 that planning additional communication outputs to the media has not seemed warranted.

After a short visit by Suzanne Long at the start of November the RRRC communication team are interested in carrying out further promotional activities for the project.

Project Results

Description of the results achieved for this milestone

The project is running on schedule.

Status of field sampling programs.

Objective a – Atmospheric Fluxes

The Eddy Covariance flux system at the Canopy Crane tower has been fully operational since the last progress report. March 2008 marked the seventh year of data collection at the Cape Tribulation Ozflux site. Due to new workplace safety requirements for the crane tower the data collection box, batteries, solar and calibration box for the flux system had to be replaced and moved to the outside of the crane tower. This work was completed without interruption to data collection. Damage has occurred to the net radiometer and this is scheduled for replacement by one without plastic domes – the latter suffering repeated attacks by cockatoos (apparently) which have finally destroyed the unit. The new radiometer will be put into operation when a new data collection system is deployed before the end of the year.

The Canopy Crane weather station has had only one significant fault this year when the relative humidity sensor needed to be replaced. There has been over 4.5 m of precipitation at the Crane site since the start of the year which make this a wetter than normal year (average 3.9m). Preliminary analysis of the flux data has indicated that the both the carbon and water fluxes are following normal seasonal patterns. Quantitative analysis of the 2008-2009 dataset will begin in April 2009.

The Discovery Tower site has had a number of minor problems that have delayed the deployment of the flux system. The design of the flux mast that goes at the top of the existing tower was carried out by a JCU engineer with very limited time to devote to the task which delayed the construction of the mast. The mast design has now been completed, the mast built and tested and installation is scheduled for November 22nd. As the Discovery Tower flux station is effectively a back-up flux site this has not proved a major impediment to the sub-project. The delay has proven useful in that minor vandalism by tourists of the weather station support structure 2 months ago forced a re-think of the mast structure. It has now been designed to minimise potential for tourist interference and limit access of visitors to both the mast and instruments. The Discovery Tower weather station has been running without problems since installation at the end of 2007. The rainfall data may only be regarded as semi-quantitative as tourists are still managing to deliberately interfere with the tipping bucket mechanism. We are actively working on solutions to this.

Comparison of microclimate information between the two sites has indicated that there is similar rainfall but higher solar insolation (fewer cloudy days) at the Discovery Tower and so we are expecting to see higher productivity at the Discovery site when compared with the Canopy Crane site.

Objective b – Plant Physiology

Preliminary findings are indicating significant relationships between the physiology of water use and the partitioning of carbon and nitrogen in leaf structural tissue.

Further chemical analysis (carbon isotopes, %N, %C, C/N ratio) completed on six dominant canopy species so far suggests that different tree species in the rainforest canopy exhibit different water-use strategies and that this may be linked to different nutrient investment strategies. This has several important implications for the productivity and floristic structure of the canopy under future climate change scenarios. First, it provides a physiological basis for a differential effect of climate change on the dominant floristic elements of the forest canopy, identifying which floristic components of the canopy are likely to be favoured during a shift to drier or wetter conditions. This is a powerful insight because it provides a high resolution picture of the climatic sensitivities of this forest type, enabling an understanding of the ecological direction in which the forest may be moving from one year to the next, rather than having to wait until this is visually noticeable, by which time the forest may have transitioned catastrophically into a completely different type. Second, it highlights and characterises the important relationship between nutrients and water in this ecosystem, providing information about the effects on the forest when either or both of these elements become limiting.

The second survey of tree diameter increment (dendrometer band measurements) measured at the mid-year point, was completed in September 08. This completes 1.5 years of growth data for approximately 200 individual trees at the study site. Preliminary indications are of continuing significant rates of diameter increase in many individuals, with significant variation between tree species. The analysis to follow in coming months will determine and compare the relative growth rates across size classes and across species. This will highlight which tree size classes are accumulating carbon most rapidly, and which species within a given size class are growing most rapidly. Over time we will be able to determine also, in terms of growth rate, which species and size classes are most sensitive to inter-annual changes in climatic variables such as average rainfall.

The first 1.5 years of ecosystem litter input rates has been measured using the litter traps. This is providing a high-resolution spatial and temporal picture of the rate of deposition of litter at the forest floor in the lowland tropical rainforest at Cape Tribulation (Figure 1). Preliminary indications are that the input rates for leaf material (averaging about 5.03 tons/ha/yr) are at the low end of the typical range for lowland tropical rainforests. In the long term we aim to determine whether this is due to (i) lower than average forest standing biomass, (ii) nutritional limitations or (iii) climatic influences. Having the first full year of litter deposition rates and stem diameter measurements is an important cornerstone, but it is essential that several continuous years of measurements are obtained in order to properly characterise this forest type and detect climate-driven trends.

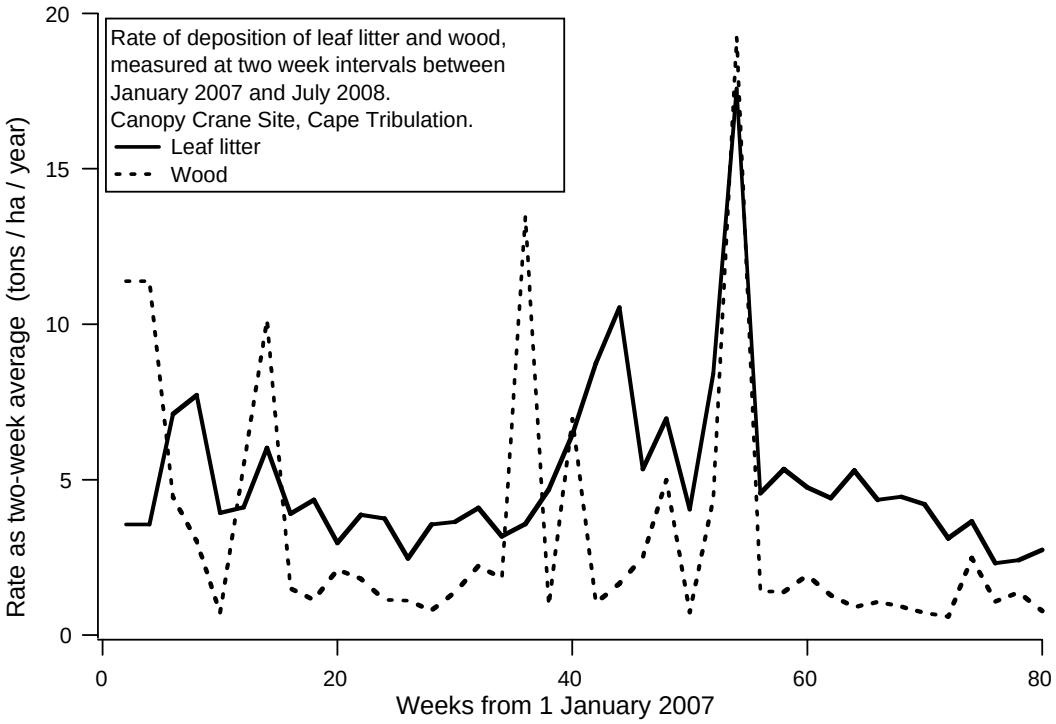

Figure 1. Rate of deposition of leaf and wood dry mass at the forest floor.

Objective c – Below-ground fluxes of carbon and water

As a result of on-going monitoring it is now possible to relate water uptake by the forest to availability of water within the soil profile. Daily uptake has been calculated for periods during which no rain fell. Uptake was related to a) total water content of the soil profile and b) distribution of the water within the profile. Immediately after rainfall uptake was greatest from the surface, whereas a week or so later uptake was similar from the three depths (Figure 2).

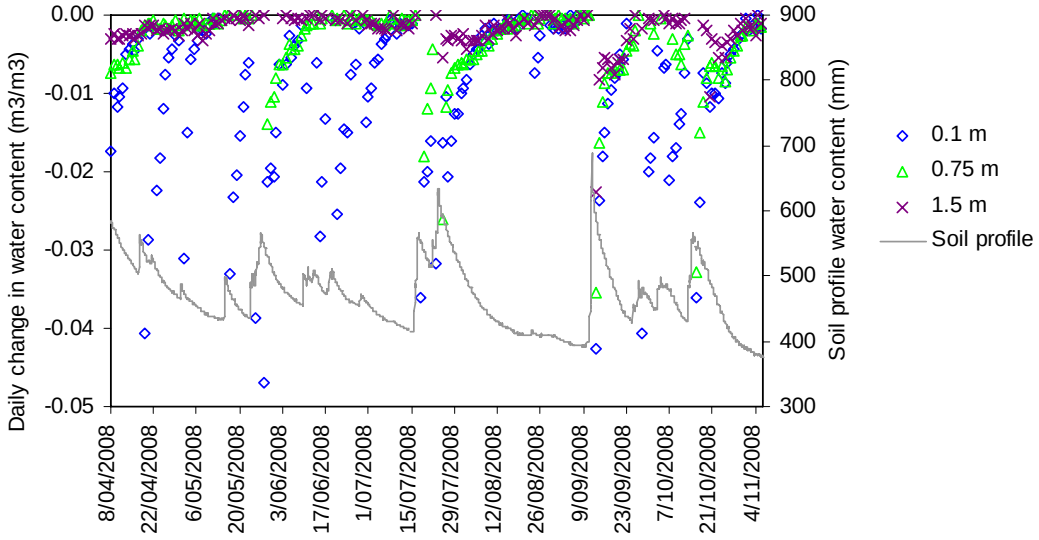

Figure 2. Daily change in soil water content (uptake by forest) from different depths, during periods in which no rain fell.

Monitoring of soil water continued through the dry season and results for the year to date are shown in Figure 3. During dry periods, water potential decreased most rapidly at 0.75 m depth, which is the depth with highest clay content (33%, compared to 18% at 0.1 m and 25% at 1.5 m depth). Although water potential has dropped quite low during the dry season, the values are still short of permanent wilting point (~-1500 kPa) throughout the profile.

Continuous recording of watertable depth commenced, in order to measure diurnal fluctuations for the calculation of groundwater uptake by the trees. Dr Marc LeBlanc, hydrologist at JCU, joined the project in order to make these measurements and calculations. Soil water samples were extracted from the profile for analysis of isotopic composition of water (to partition transpiration between uptake from the soil profile versus groundwater), dissolved organic C (to determine loss of C in soluble form) and nutrients.

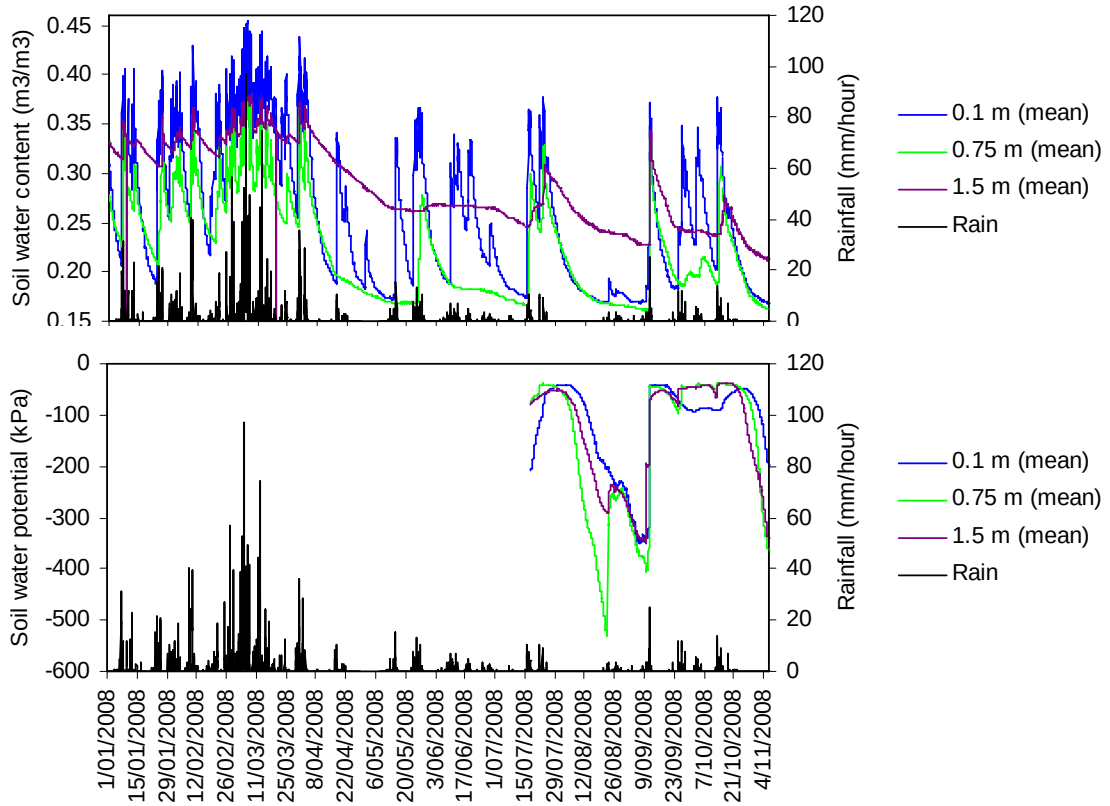

Figure 3. Soil water content (top), soil water potential (bottom) and rainfall (both) during 2008. Some rainfall data are missing in April-May.

Objective d – Flowering / fruiting phenology

This sub-project has now commenced and the focus of the first period has been on developing technical solutions to monitoring the above-canopy phenology using digital photography. Initially both digital SLR and the latest Sony digital HD video camera were trialled. On the basis of this comparison a Sony DSLR-A700P camera was purchased in June 2008. Trials are underway at both the Skyrail and Crane sites to determine the best methodology for collecting data. Currently, five trials have been carried out at the Skyrail on 16.07.08, 07.08.08, 03.09.08, 23.09.08 and 20.10.08. The image quality has improved significantly from the initial trial and a polarized lens has been purchased to assist with exposure issues.

Some aspects of the methodology have been established including camera angle, optimum camera settings and the most advantageous environmental conditions. However, there are still concerns about the amount of detail required from these photos for positively identifying small flowers and fruits. An expert from the ATH herbarium initially advised that the images collected were slightly ambiguous when we looking at small flowers and leaf structures. Since then, to determine if our equipment was the limiting factor, images taken by two photographers from outside the project with more advanced cameras and faster lenses were compared to those taken at the same time/location with our camera. The images taken by the professional photographer with a state-of-the-art camera showed no significant improvement over the images obtained using the Sony A700P. The best quality images we now have will next be examined by a botanical expert to determine how to use these images most effectively for field identification. The sharpest images obtained were those with a high focal length (high zoom) which restricts the field of view. If it is ascertained that we need to use high zoom then a larger number of photos will need to be collected to cover a given distance - which will in the end determine the size of the Skyrail transect we are able to work with.

Stitching programs (software to enable seamless overlap of digital images) are also being trialled in order to paste together continuous sets of images collected between the individual towers of the Skyrail. This will allow the same sections of forests (and thus individual trees) to be compared each month even though the images are not being taken in exactly the same position.

Trials will continue at Skyrail to refine the methods with the aim to begin the first complete data collection at the beginning of January.

Two different methods of collecting images at the Crane site have been trialled. Of these the most effective method appears to be using trigonometry to define the exact position where each photo is taken. This results in an overlap of all photos so that a spherical picture taken from above the canopy can be assembled. The quality of the images for identifying fruits and flowers is still being assessed. To back up the digital photography we are using visual assessment which appears easier because of the rapid access that we have to the canopy using the crane gondola.

Trials will continue at the Canopy crane over the next month before commencement of complete data collection at the beginning of January.

Objective e – Resource related fluctuations in insect populations

Summary

1. A manuscript on the seasonality of beetle assemblages in relation to climatic conditions has been accepted for publication in the journal *Biotropica*.
2. Results from RRRC-funded field work and laboratory work suggest that populations of adult leaf litter beetles are showing within-year seasonal fluctuations and may be tracking the amount of leaf litter from the canopy. A leaf litter manipulation experiment has been initiated in order to determine whether seasonal fluctuation in leaf litter inhabiting adult beetles are driven by the seasonality of resources (leaf litter fall and organic input) or by climatic seasonality. Microhabitat sampling of insects inhabiting leaf-litter, logs and fruits continues after initial commencement in January 2006 and specimens are currently being processed so they can be identified to species level.

Activities

The manuscript documenting the seasonality of beetle assemblages (based on four years of sampling at the crane site (2000-2004)) has been accepted for publication in the journal *Biotropica*. This manuscript is expected to appear in the March 2009 issue.

Sampling of insects inhabiting leaf litter was initiated in January 2006 and is on-going. This involves a monthly collection of five litres of finely sifted leaf-litter, collected from the ground at the crane site. This material is then run through Tullgren funnels overnight to extract the insects, and the beetles are then removed, counted and stored in ethanol. Following the microhabitat sampling, beetle specimens are processed (removed from samples) and dry-mounted ahead of species identification. This process is very tedious and time consuming but it is essential for species-level identification. A preliminary comparison of the seasonality of leaf-litter inhabiting beetles and the seasonal dynamics of litter-fall currently being undertaken at the crane site (objective b), has been made.

A new, complementary experiment commenced in September 2008 at the Canopy Crane Research Facility, Cape Tribulation (see below for rationale). The amount of leaf litter in plots 3x3 m is manipulated to test if beetle populations respond to varying amounts of leaf litter input. In some plots leaf litter is added while in others it is excluded (using suspended bird netting). Control plots are also included (six replicates of each). One garbage bin of coarse leaf litter (sifted to remove the invertebrates) is added to each of the six leaf litter addition plots each month. The experiment will run until January or February 2009 after which the leaf litter within each of the 18 plots will be collected. The insects will then be extracted and the leaf litter for each plot will be quantified.

Results

So far the beetles extracted from leaf litter in 2006 and 2007 (3324 individuals) have been individually mounted, labelled and databased ahead of species identification. Specimen processing for the 2008 material is ongoing.

We present some preliminary results into the temporal variation of beetles inhabiting leaf litter on the ground for the period January 2006-October 2008. A total of 5518 beetles were caught over this time. The abundance of leaf litter beetles shows considerable variation both within and between years with adult beetle densities peaking during the summer months and minima occurring in late winter (Figure 4). Leaf litter fall data collected from January 2007 (objective b) are significantly temporally correlated with the abundance of leaf litter beetles (r^2= 0.37, P=0.006, n=19). Thus from these early results, beetles inhabiting leaf litter on the ground appear to be tracking resource availability. However, because the seasonality of climate is also expected to correlate with adult beetle densities, both climate and resources could be the cause of these patterns. We anticipate to resolve these competing hypotheses through the leaf litter manipulation experiment (see above).

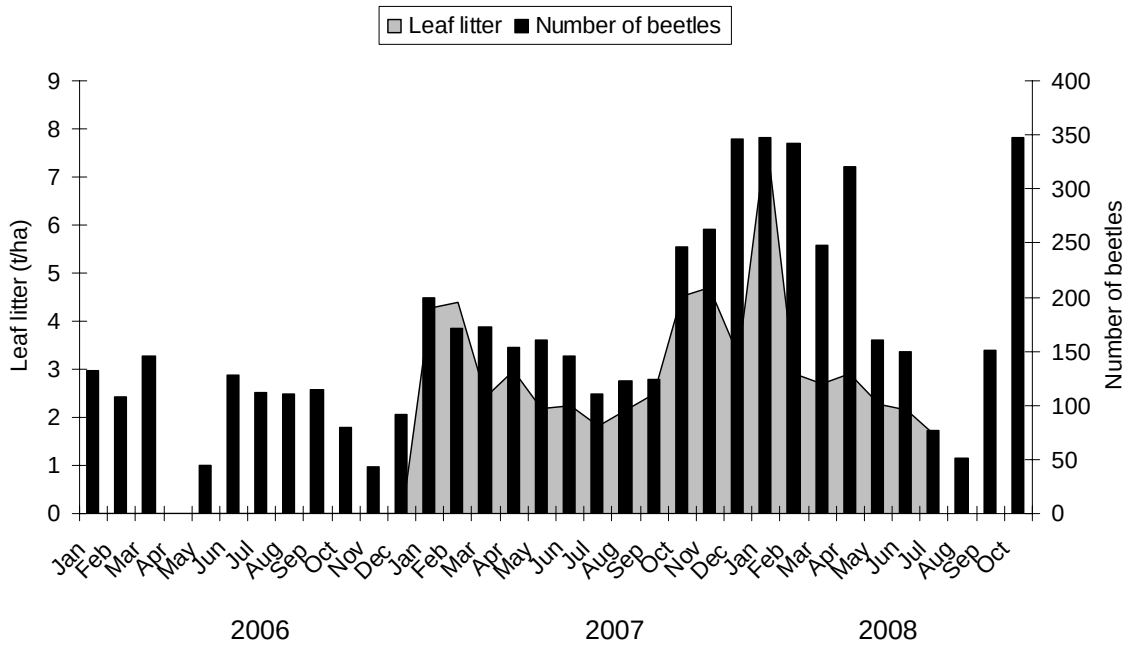

Figure 4. Temporal variation in the abundance of beetles (dark bars) extracted from 5 litres of leaf litter collected from the ground at the Canopy Crane Research Facility, Cape Tribulation. Leaf litter fall measured by material collected in litter traps (objective b) are also presented (grey area).

Appendix 1.

Minutes of Meeting Project 2.5ii.2 held 3rd November 2008 at 3.30pm.

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

Attendance: Michael Liddell, Paul Nelson, Cassandra Nichols, Carl Wardhaugh.

Liddell office (E1.112), Cairns

Apologies: Peter Franks, Peter Grimbacher, Caroline Gross

MJL briefed those present on the outcomes of the recent Crane Management meeting subsequent to the resignation of the crane driver.The new site staffing structure with Cassandra becoming Site Manager was discussed.

MJL explained the recent TERN outcomes whereby the Crane site will be transformed into a TERN supersite in TERN-2. A small amount of funding will go into the site in the next 2 years.

MJL updated the team members on the recent RRRC meeting, emphasising that members must make sure that all publications are put through the RRRC office early to ensure that the correct referencing is used for RRRC/MTSRF/DEWHA.

Following this discussion was mainly concerned with current research activities in each sub-project. Reports were made on the status of work in each area.

Objective a – Atmospheric Fluxes

Regular data collection is on-going with the eddy covariance system at the crane site.

On going work on the crane tower has involved repairing/replacing equipment installations.

Objective b – Plant Physiology

MJL reported briefly that PF had indicated everything was progressing according to schedule.

Objective c – Soil structure / hydrology

PN indicated that the soil system was now fully functional as Cassandra had managed to get the water potential sensors working. Data logging had commenced on the bores.

Objective d – Flowering / fruiting phenology

Cassandra explained that the Crane digital photography was more complicated than initially imagined and that along with the Skyrail transect further work was needed before a standard methodology was in place.

Objective e – Resource related fluctuations in insect populations

MJL reported that Peter Grimbacher had indicated that the ground based microhabitat study was going well and in particular the litter manipulation experiment was immediately

generating interesting results. Carl Wardhaugh indicated that his Ph.D. work was progressing well, in 5 months he had collected 23000 invertebrates from the canopy trees that were either flowering/fruiting on site.

Other Business

None.

The next meeting was scheduled for around 20th January.