Australian Government
Department of the Environment, Water, Heritage and the Arts

Marine and Tropical Sciences Research Facility Milestone Report, March 2010

Program 5(ii): Climate Change: Rainforests and Catchments

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

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Summary

A further project meeting has been held to discuss project progress to date and to ensure a clear plan has been developed for preparing outputs for the final report. Each of the sub-projects dealing with Objectives (a), (b), (c), (d) and (e) have progressed without major difficulties. This milestone report provides an update of progress during the last four months.

This intermediate report provides a status snapshot of Project 2.5ii.2:

- The Cape Tribulation flux studies at both tower sites are proceeding. The Australian Canopy Crane site has now been in operation for nine years, making it one of the longest running *OzFlux* sites in Australia.
- The physiology/productivity sub-project has been concerned estimating changes in above-ground biomass more accurately; ongoing measurements of leaf litter and dendrometer bands are continuing. Beetles inhabiting the forest floor are reliant on leaf litter and the insect sub-project established that while there is large temporal variation in beetle abundance throughout the year it could not be correlated in a simple fashion with any of the microclimate variables measured on site over the four years of the study.
- The soil and hydrology sub-project has found high water uptake during the wet season and further work is proceeding to look at correlations with plant water use.
- The phenology sub-project has collected a year of data at both the canopy crane and Skyrail transect sites. Data analysis is proceeding on the large amount of digital data collected from the Skyrail transect (1,500 high resolution images/month) and early indications are that the methodology developed will be able to successfully track changes in flowering/fruiting phenology in response to climate change.

Project Results

The project is running according to schedule.

Status of field sampling programs

Objective (a): Atmospheric fluxes

The Eddy Covariance flux system at the Australian Canopy Crane tower has been operational for all but two weeks since the last progress report. The only downtime came about when the CSAT-3 sonic anemometer was removed for repair/overhaul and the replacement was installed. March 2010 marked the ninth year of data collection at the Cape Tribulation *OzFlux* site. A new netbook PC was installed at the crane site in November to store datalogger flux data. This has proven successful in the field and we are about to deploy the same model of netbook at the Discovery Tower (Skyrail) to ensure all systems are essentially identical in configuration. A phenocamera (pictured) has been installed at the Cape Tribulation tower and is recording images of the canopy on a 120-minute schedule (this is in the pilot stage of development).

The Discovery Tower system has had some issues with communications but these have been related to the PC driving the system and it is to be expected that these problems will vanish when the new netbook computer is installed later this month. A comparison of the fluxes between the canopy crane tower and the Discovery Tower has indicated a difference in the energy balance between the two sites during the wet season. At the Discovery Tower peak daily values in the sensible heat flux in January rarely exceeded 200 W/m^2; in contrast the canopy crane tower values greater than 300 W/m^2 were frequently encountered throughout the month. Further analysis of the data is in progress to determine if this is a general trend. Development has continued on the public visualisation system at the Discovery Tower. We are now using an Environdata product Webgen to log data from the weather station to the tower PC; the weather and flux data are provided via a network connection to a remote PC located in the visitor centre at the base of the tower. The remote PC has a graphic interface programmed using Python so that it looks modern and suits the requirements of the owners of the Daintree Discovery Centre. The Discovery Centre public relations team have been working on a presentation board to present the results of the MTSRF project to the public.

Objective (b): Plant physiology

1. Dendrometer measurements of stem incremental growth

In total, 170 trees with initial stem diameters at breast height (*dbh*) greater than ten centimetres were selected in the original design. Initial analysis was based on incremental growth assessed on four occasions; March 2007, March 2008, September 2008, and May 2009, these have been completed and were reported previously. Diagnostic evaluation of the data suggested that some measures may be unreliable. Full review of data to identify (and possible remove) unreliable data points is currently being undertaken. The final census will be completed in May 2010.

2. Change in biomass

Change in size is not necessarily reflective of change in biomass. This is because species differ in wood density, and because a small increment in *dbh* in an initially large stem will produce a much greater increase in biomass than an equal increment in an originally small stem. We have initiated collaboration with Dr Dan Metcalfe (CSIRO), who has an extensive database of wood densities for tree species from the Wet Tropics region. We are about to initiate coring of select species that are not available in the CSIRO database to enable the use of wood density in biomass calculations for the canopy crane plot.

Our initial analyses of above-ground biomass were calculated using the allometric models of Chave *et al*. (2005)[1] for wet forest stands and without knowledge of individual plant height distributions. New data on plant heights are being incorporated into the calculations although it is not known at present whether these will be used as a final product, since there is no temporal sequence of height estimation to match the dendrometer data series. Nevertheless, including height in a single survey will increase accuracy of the estimated above-ground biomass in this census period and the height data is available as a temporal series for the site *dbh* data. The last *dbh* survey was completed in May 2009.

3. Litter trap measurements to monitor and compare carbon storage and turnover across species

Three full years of leaf litter data are now available. The data were collected at approximately two-week intervals. Most of our time has been spent on preparing this data for analyses. This has involved construction of a database, checking and correcting data points, and generating the appropriate time variables that are required for circular statistical techniques. The database is now finalised and ready for analyses to begin.

Objective (c): Below-ground fluxes of carbon and water

Monitoring of soil water continued over the 2009-2010 wet season (Figure 1). Soil water contents have been high during most of that period. As a result, water uptake could be calculated on four days only due to frequent rain in the intervening periods. On those days water uptake was a very high 10-15 mm/day. Further evaluation of water uptake in the wet season is warranted.

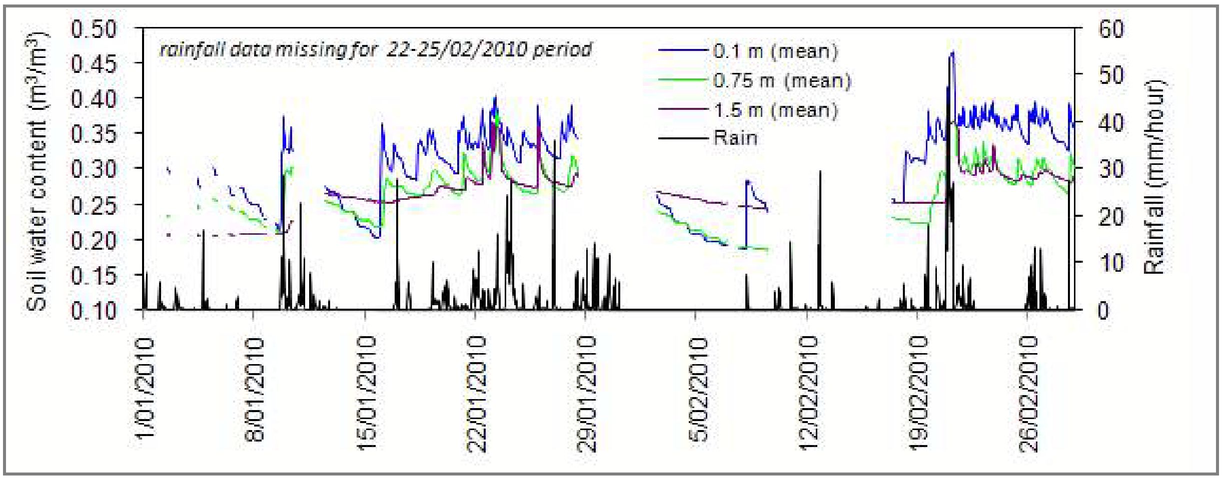


Figure 1: Rainfall and soil water content during the January and February 2010.

[1] Chave, J., Andalo, C. Brown, S., Cairns, M. A., Chambers, J. Q., Eamus, D., Folster, H., Fromand, F., Higuchi, N., Kira, T., Lescure, J.-P., Nelson, B. W., Ogawa, H., Puig, H., Riera, B. and Yamakura, T. (2005) Tree allometry and improved estimation of carbon stocks and balance in tropical forests. *Oecologia* 145: 87-99.

Some data from the soil pit was lost in June and July, and the system then started running normally again before the problem could be resolved. The problem was finally traced to a faulty deep cycle lead acid battery that drives the system which finally failed in late December 2009. Some data was lost in early January 2010. The old lead acid battery was replaced by a newer technology AGM battery mid February .Collection of water samples was completed at the end of December and samples have been submitted for analysis.

Objective (d): Flowering/fruiting phenology

Since January 2009, qualitative data on flowering and fruiting episodes (tree and species level) has been gathered from digital images at Skyrail and visually at the canopy crane site. With the continuing monthly collection, we now have one entire year of phenological data of fruiting and flowering events for the canopy crane and Skyrail sites plus replicate months across years for January and February. The number of digital images collected per month at Skyrail is, on average, some 1,500.

Vouchering of specimens (for species identification purposes) has continued at the canopy crane site and a total of 153 individual trees have now been vouchered. Three samples of each tree are being collected for the Australian Tropical Herbarium, the University of New England and a reference collection for the canopy crane site. Due to the extremely large number of individual trees within the Skyrail transect, vouchering will be restricted to the specific trees to be used for data analysis. To determine which trees they are and exactly where they are located within the transect will require two years' worth of prior data to be analysed. The collection of specimens from the Skyrail Transect will therefore commence sometime late in 2011 with the help of the herbarium and volunteers.

The Wacom graphics tablet purchased last year is now being used by Tore Linde to analyse the Skyrail data and highlight the trees undergoing either a fruiting or flowering event in the digital images. The scoring of trees for the presence/absence of buds, flowers and fruits is recorded in a main database and consists of the date, the event, species, species number and a unique tree label that is defined according to the position within the entire transect.

In the visual Skyrail census the location of trees is achieved by indicating the section between towers, e.g. tree label 20.1 would mean the tree is located between Towers 20-21 in the first tenth of this transect. With the digital images (Figure 2) the system developed is related but uses the number of metres between towers, e.g. tree label 20.28.8.217 would indicate the tree which is located 28.8 metres along the transect between towers 20-21 and it has a unique tree number of 217.

Figure 2: Flowing/fruiting events on rainforest trees between Skyrail towers 20 and 21.

It is clear that developing a stitched image of the transect between towers will become crucial to determining where the trees are located in between the towers in an efficient manner. This process is underway, but is taking longer than expected as the pictures need to be stitched together manually.

Two sets of data now exist for the Skyrail transect. The long term data set which has been collected visually by Tore Linde (visual Skyrail census) and the photographic digital data set collected by Cassandra Nichols (MTSRF digital census). Our next step will be to summarise the data between the two sets. Prior to this though, we need to determine if the two data sets are comparable. To achieve this we will look at two specific genera, *Syzygium* and *Eleocarpus*. These genera have been chosen for two reasons: firstly they are easily identifiable and so we can be confident that correct identification has been made during both the visual census and the digital data analysis; secondly, these are both important species ecologically. Both genera are food sources for a number of endemic fauna including cassowaries, spectacled flying foxes and musky rat kangaroos and they also provide a stable diet for numerous bird species. Therefore, the effects of climate change on these genera will be of significance if changes are found to occur in their flowering/fruiting regime.

To make the comparison the fruiting and flowering events of *Syzygium* and *Eleocarpus* recorded in the 2009 visual Skyrail census will be compared against the last twelve months of data analysed from the digital MTSRF census. If there is a strong correlation between the two data sets, we can be confident that the long term visual data set collected over the past twelve years is able to be collated with the digital data set and that the future visual censuses will be able to be directly compared to the digital images being recorded. This process will be on-going over the next few months as the analysis of the 2009 digital data set is completed. The latter has been enhanced by a Skyrail Foundation grant ($4,779) which has allowed Tore Linde to make more rapid progress by working at James Cook University Cairns on a weekly basis with his data analysis.

As there are now replicate months in the digital images for 2009 and 2010, we have begun to assess how reliable the images are year to year. We have analysed data from January 2009 and January 2010 between towers 7 and 8 to determine if the photographs are capturing the same fruiting/flowering events. A total of 21 photos covered the transect in the 2009 census while a total of 28 photos depicted the same transect in 2010. There were three trees that experienced the same phenological event in both years. Two of these were *Alphitonia petriei* (both budding) just above tower 7 and the Kuranda Highway and a large specimen of *Flindersia ifflaiana* just below tower 8 (flowering).

Events unique for each year were:

2009	*Syzygium tierneyanum* (fruits)	*Cassytha filiformis* (flowers)
	Elaeocarpus bancroftii (flowers)	*Musgravea heterophylla* (buds)
2010	*Schefflera actinophylla* (flowers)	*Flindersia acuminata* (flowers)
	Pleiogynium timorense (green fruits)	*Cryptocarya mackinnoniana* (flowers)

This is exactly the sort of information that we were hoping for in that we are able to track the same individuals year by year and, as expected, we will need a long term data set to accommodate multi-year variability and masting behaviour of some species prior to our analysis of climate induced changes in phenology.

Objective (e): Resource related fluctuations in insect populations

Summary

- Sampling of the leaf litter inhabiting beetles commenced in 2006 and concluded in December 2009, producing almost 8,000 beetles.
- Fluctuations in the density of leaf litter beetles were tested against fluctuations in climatic parameters for the period January 2006 to December 2009.
- Time series modelling showed that simple positive linear relationships between beetle density and temperature and relative humidity are unlikely to exist. Instead, the effect of climate in influencing temporal variation in beetle density is likely to be much more complex or weak.

Activities

Sampling of insects inhabiting leaf litter was initiated in January 2006 and finished in December 2009. Sampling involved a monthly collection of five litres of finely sifted leaf-litter, collected from the ground at the crane site. This material was then run through Tullgren funnels for approximately twelve hours to extract insects, from which the beetles were removed, counted and stored in ethanol. Following the microhabitat sampling, beetle specimens were 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. Consequently specimens are still being processed. However, analyses have been conducted on fluctuations in overall beetle numbers and how these relate to fluctuations in climate.

Results

The monthly beetle collecting time series captured 7,909 beetles (January 2006 to December 2009). For this experiment a standard volume of fine leaf litter (five litres) was collected from the ground under the circumference of the canopy crane at Cape Tribulation. Standardising the volume of leaf litter, allows temporal variation in insect density to be considered independent of seasonal variations in leaf litter fall and volume (see objective b). This time series (Figure 3) shows both seasonal and yearly variation in beetle density. Climatic variables also show seasonal variation (Figure 4).

When the monthly beetle density counts were tested with simple linear regression against climatic data, measures of temperature and relative humidity were positively correlated (Table 1). Solar radiation, evaporation and total monthly rainfall were not significantly correlated with monthly beetle density counts (Table 1). It is particularly interesting that there was a positive linear relationship between beetle density and temperature and relative humidity (Figures 5), although the variation in beetle density explained by these climatic variables was only 29%. Taking all climatic variables (including one temperature measure – the maximum) simultaneously into account improved the strength of the correlation with beetle density (Table 1) although the variation explained was not much of an improvement over the combined influence of just maximum temperature and relative humidity (Table 1).

However, simple linear regression fails to take into consideration several important characteristics of time-series data. First, data observations for each variable are not entirely independent of each other. That is observations in one month are likely to be similar to neighbouring observations than would be expected by chance (termed temporal autocorrelation). These potential problems affect both beetle and climatic data. Second, time lags may operate in the responses of dependant variables. Third, there is co-linearity among predictor variables. Consequently some more robust analyses that account for these problems were conducted using the *Time Series Modeller* routine in the statistical package

SPSS. A model was constructed with all the climatic variables as potential explanatory variables (except mean temperature and minimum temperature). This model explained 58.1% of the variation however; none of the independent variables were identified as significant predictors. From this analysis we can conclude that any simple relationship between temporal variation in beetle density and any climatic variable is likely to be spurious. Climate is still likely to influence temporal variation in beetles but in a complex way, possibly interacting with other factors that display temporal variation such as leaf litter fall.

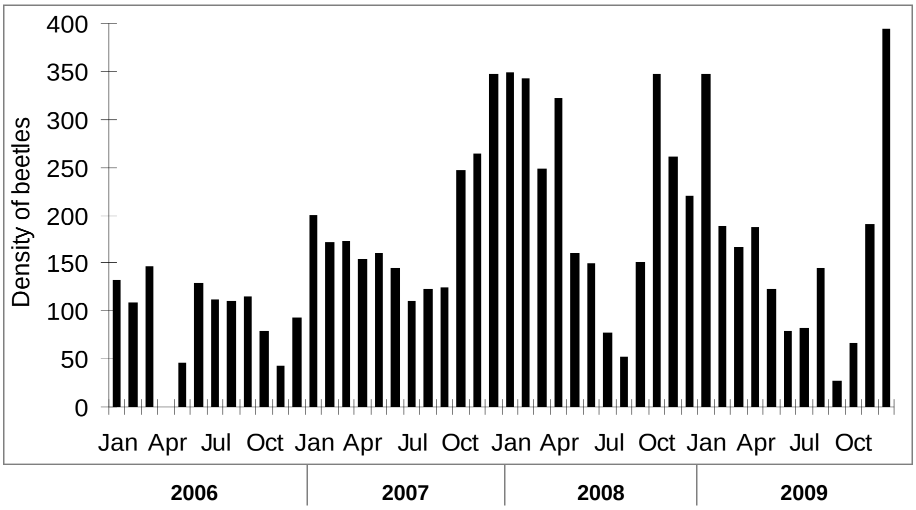


Figure 3: Temporal variation in the density of beetles extracted from monthly collections of leaf litter (five litres) from the ground at the Australian Canopy Crane Research Facility, Cape Tribulation.

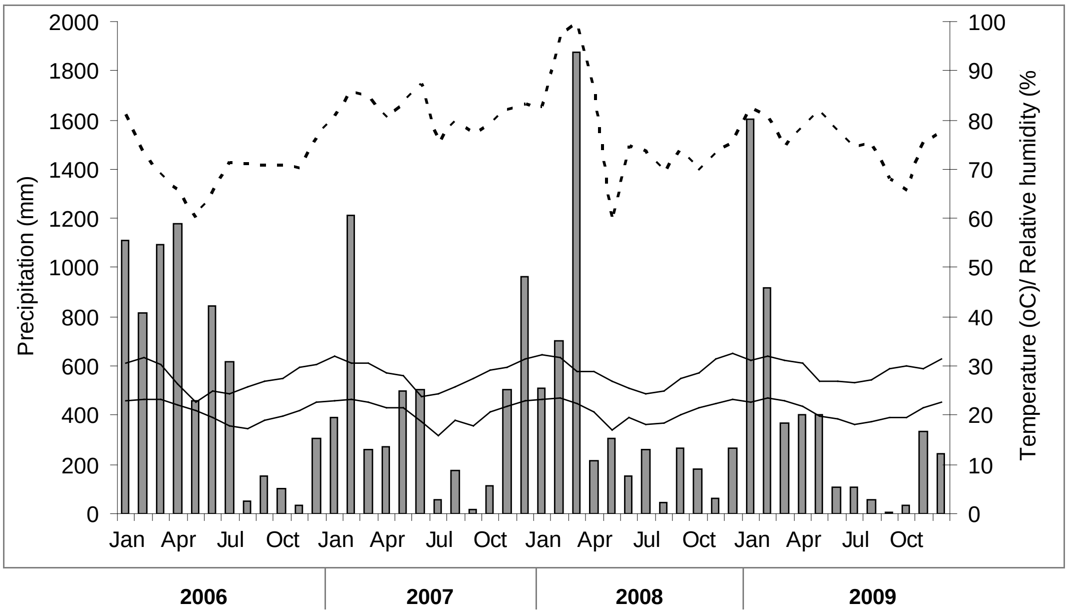
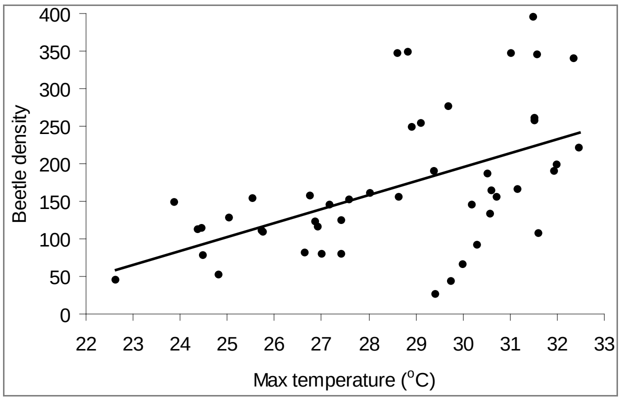


Figure 4: Total monthly precipitation (bars), mean daily minimum and maximum temperatures (solid lines) and mean daily relative humidity (dashed line) for the Australian Canopy Crane Research Facility, Cape Tribulation, between January 2006 and December 2009.

Table 1: Linear regression results between monthly beetle density values and climatic variables. *P* values of less than 0.05 are highlighted in bold font. *n* = 47 in all tests.

Climatic variable	R^2	*P*-value
Daily average:		
Mean temperature	0.28	**0.0001**
Maximum temperature	0.29	**<0.0001**
Minimum temperature	0.22	**0.0008**
Solar radiation	0.04	0.17
Relative humidity	0.29	**<0.0001**
Evaporation	0.00	0.69
Total monthly rainfall	0.05	0.12
All (multiple regression)	0.44	**0.0001**
Max Temp + RH	0.42	**<0.0001**



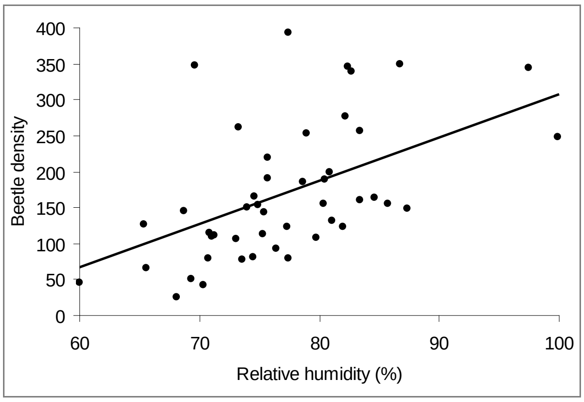


Figure 5: Relationship between two climatic variables and density of leaf litter beetles: maximum daily mean temperature (l*eft*); and mean daily relative humidity (*right*).