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

Marine and Tropical Sciences Research Facility Milestone Report, November 2009

Program 5ii: Climate Change: Rainforests and Catchments

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

Project Leader: Dr Michael Liddell, James Cook University (JCU)

Summary

This project is continuing successfully. A project meeting was 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 four months of activities.

Project milestones extracted from Project Schedule

Targeted Activity	Due Date
Report 1 submission – progress report describing: • The seasonal fluxes of carbon and water from the Daintree rainforest in relation to climatic drivers (Objective A); • The variations in rainforest tree productivity and water use efficiency (Objective B); • The characterisation of water uptake and carbon turnover at the Australian Canopy Crane site (Objective C); • The characterisation of flowering/fruiting events in phenological monitoring program (Objective D); • The resource related fluctuations in insect populations inhabiting leaf litter on the ground and how they relate to ecosystem productivity, and resource quantity (Objective E); and • A plan of communication products and events for Year 4 (2009/2010) and summary of any communication activities undertaken to date, including minutes of meetings/workshops if applicable.	1 November 2009

Communication, major activities, events

A further project meeting was convened on 4 November 2009. A further project meeting is scheduled for late January/early February depending on the project team's availability.

Media: 6 August: TV NZ Channel 3
Cassandra Nichols hosted the Channel 3 visit which had some limited coverage of the Project 2.5ii.2 research activities.

Visits: 21 September: Dr Liz Jazwinska, Australian Research Council
Cassandra Nichols presented the site visit and Dr Mike Liddell presented MTSRF-funded activities on campus.

24 September: Mr Andrew Reece, Science Policy Writer for Senator The Hon. Kim Carr
Mr Reece joined Sheriden Morris (RRRC Managing Director) in a visit to look at the project activities as part of an official visit to the RRRC Cairns Office.

27 September: The Hon. Rejoyce Mabudafhasi (South African Minister of Environment and Water)
Mr Mabudafhasi joined *Mellissa Jess (RRRC Research Program Manager) in a visit to look at the project activities as part of the 2009 Global Environment Fund Conference excursion to the Australian Canopy Crane.*

Status of field sampling programs

Objective A: Atmospheric Fluxes

The Eddy Covariance flux system at the Australian Canopy Crane tower has been fully operational since the last progress report. March 2009 marked the eighth year of data collection at the Cape Tribulation *Ozflux* site and the first year of data collection at the Skyrail Discovery Tower site. On 5 November the Cape Tribulation system data collection and computer system was replaced. A new type of radiometer (Kipp&Zonen NRLite) was installed as part of this operation to avoid problems with attack by birds.

Preliminary analysis of the flux data indicates that both the carbon and water fluxes are following normal seasonal patterns and that the Discovery Tower and Cape Tribulation data are quite comparable. Quantitative analysis of the 2008-2009 dataset will begin in February 2010 when study leave commences for the PI. Minor issues with water ingress into the solar controller at the Cape Tribulation system have been rectified. Currently a communications solution is being investigated for the Cape Tribulation system so that it can be put on the same web-access connectivity as the Discovery Tower system.

The Discovery Tower site flux system has been running reliably since the last report. As part of the arrangement for putting research results in front of the public a direct Ethernet connection was established between the flux system laptop (at the top of the tower) and a PC visualisation system located in the visitor centre at the base of the Tower. This worked successfully but the connection of the weather-station to the laptop on a permanent basis caused the power supply on the weather-station to fail. It took some time before the nature of the problem was established and so several months of weather data lack night-time values. This has since been rectified. Maintenance work has been on-going on the mast mount system prior to the wet-season.

The Terrestrial Ecosystem Research Network (TERN) has partly funded a technician as part of their funding of the *Ozflux* network. The PI appointed Nico Weigand who has a background in electronics to assist the project and he has been working on the Cape Tribulation and Discovery Tower systems over the last month.

Objective B: Plant Physiology

Data collection continues for leaf litter, dendrometer and xylem conductivity. All of these measurements have continued since Dr Franks' departure from the project. In April 2009 leaf-area index (LAI) measurements were initiated, these measurements are now ongoing every four months.

1. Dendrometer measurements of stem incremental growth and change in biomass

The second survey of tree diameter increment (dendrometer band measurements) was completed in September 2009. This completes 2½ years' growth data for approximately two hundred individual trees at the study site. In the previous report, lack of data relating to, (a) tree height, and (b) site-specific and species-specific wood densities, were highlighted as potentially serious problems for analyses attempting to assess/estimate biomass using biometric data. Both density and height are required to get the best approximation of above ground biomass (AGB) using the allometric models of Chave *et al.* (2005).

Progress:

- All trees within the area accessible underneath the Australian Canopy Crane were assessed for tree height.
- Density measurements are to be made at the start of 2010 on trees in proximity the crane diameter at breast height (DBH) plot. Collaboration has been established with Dr Dan Metcalfe (CSIRO) to provide wood density estimates for species where it is impossible to get estimates from the study site.
- The CI has trained in the Quantreg procedure in the statistical package 'R' to undertake fitting the quantile regression fit (Cade & Noon 2003) of a modified Ricker function $y=\beta_0 X^{\beta 1} e^{\beta 1 X} \varepsilon$ to the relationship between DBH at first census and DBH at final census.

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

There are now 2½ years' ecosystem litter input 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.

Progress:

- Leaf litter data continues to be generated following collection, drying and sorting.
- A model spreadsheet has been developed to reduce time in reformatting data.
- Full analysis is pending the arrival of Oriana circular statistics package (Copyright 2009 Kovach Computing Services, Anglesey, Wales. All Rights Reserved. Portions copyright Addinsoft, Provalis Research, and Data Description Inc). The implementation of the leaf litter monitoring program at the outset may not to have anticipated the commitment required to generate meaningful tests of seasonality hypotheses. At completion of the project three years of (monthly) data will be available for analysis. This may result in large estimates of uncertainty and overall low power to discriminate alternative predictions. This dataset will become more informative as successive years are added. A decision has been made to continue data collection past December but in reduced fashion where all the litter will be pooled rather than separated into pools. This will continue as a crane core

activity rather than a MTSRF activity post June 2010 to enable trends in litter fall to be established versus climatic variability as this is a key indicator of changes in productivity.

3. Other

This project has initiated some new work on leaf biochemistry and herbivore species plant specificity (with Liddell) as a pilot. This work aims to investigate chemical constituents of common vines and their herbivores to look at potential change in defence chemicals as a response to changes in plant physiological performance – which in turn responds to climatic drivers. Vines have already been established as a component of the canopy architecture that is highly variable in tropical forests and these changes in vine abundance are currently attributed largely to climate change.

Progress:

- Initiated sampling and preliminary analysis of vine (*Aristolochea tragala*) and its obligate herbivore (*Ornithoptera euphorion*).

Objective C: Below-ground fluxes of carbon and water

The highest and lowest rates of water uptake that we have measured during the course of this project occurred in 2009. By the end of the long dry season, soil water contents were the lowest we have recorded (<15% at 0.1 and 0.75 m depth and <20% at 1.5 m depth), with water potential being <-633 kPa at all depths (Figure C1(a),(b)). Water uptake reached over 20 mm/day during the wet season, but by the end of the long dry season, it was less than 2 mm/day (Figure C1(c)). We now have a good picture of how uptake is related to environmental parameters. When the soil is dry, uptake is limited by the availability of soil water only. However, when the soil is wetter (>400 mm/2 m), other limitations, such as the distribution of water, and atmospheric conditions, become important (Figure C2).

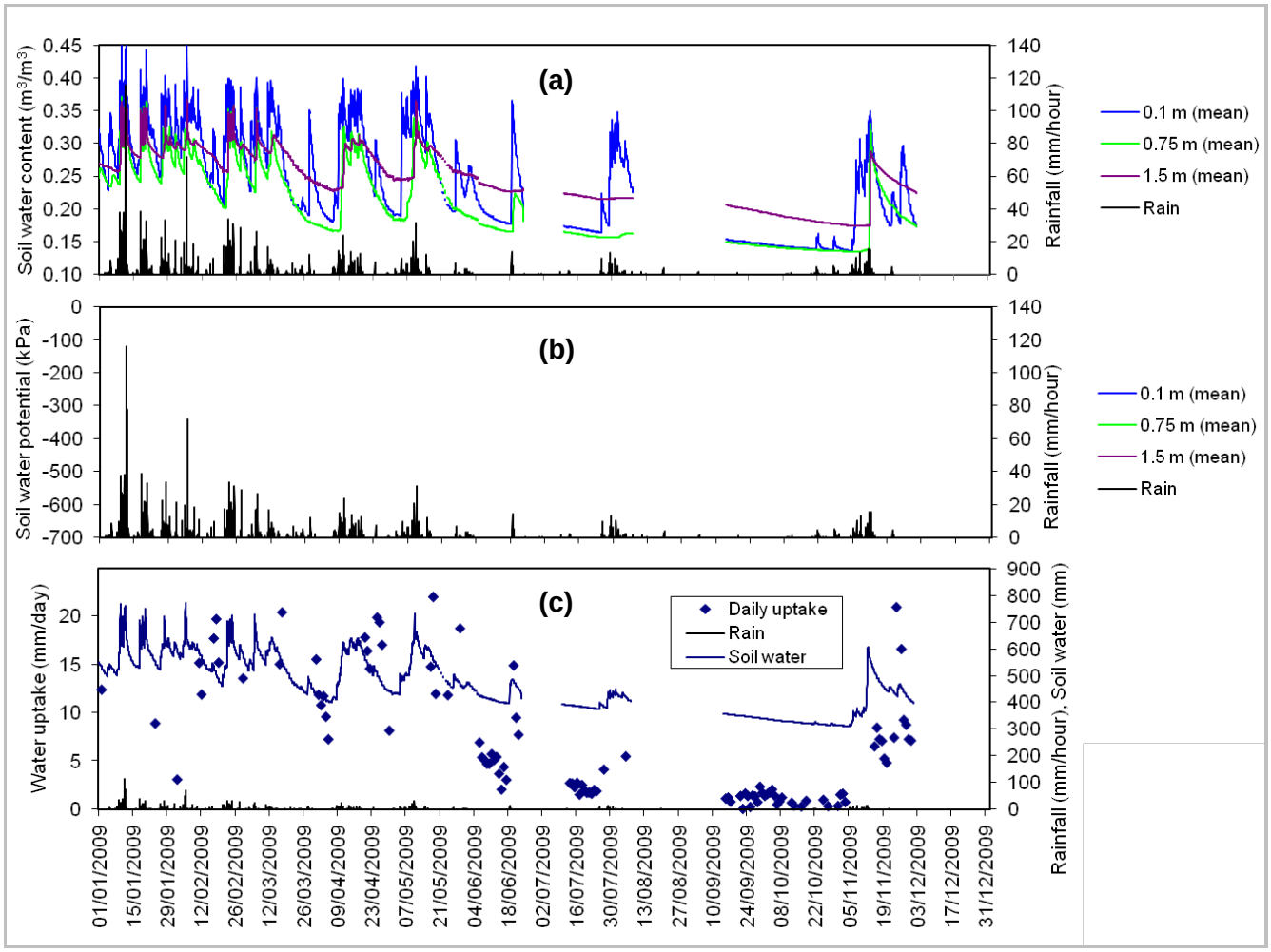

Figure C1: Soil water dynamics during 2009: (a) Soil water content; (b) soil water potential; and (c) Water uptake.

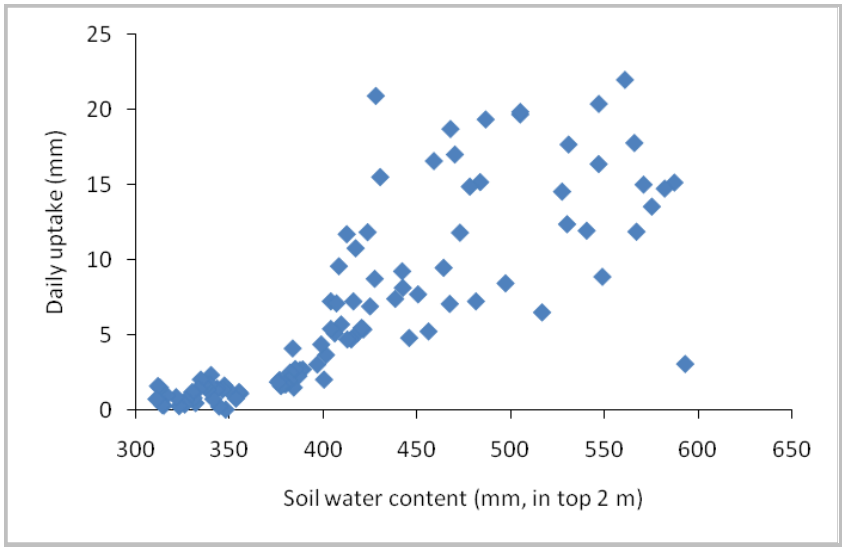

Figure C2: Water uptake by the forest in relation to water content of the top two metres of soil, during 2009.

Objective D: Flowing/fruiting phenology

The December data collection will complete a one-year phenological dataset of fruiting and flowering events for both the Australian Canopy Crane site and Discovery Tower sites. 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 Crane site. The number of digital images collected per month is on average 1,500. Cassandra Nichols collects the photographic data. There have been difficulties with back up storage of data due to hardware failure and thus it has now been decided that data shall be stored on two separate external hard drives, plus a DVD copy. The current system then is that Cassandra downloads onto a hard drive at James Cook University where Tore Linde then burns the data to DVD, Cassandra then puts a third copy onto a hard drive at the canopy crane research station.

To confirm species identification, vouchering of specimens has begun at the crane site with the aid of Stuart Worboys and PhD candidate, Craig Costion, from the Australian Tropical Herbarium (ATH). To date a total of 138 individual trees have been vouchered. Three samples of each tree are being collected for the Herbarium, the University of New England and a reference collection for the canopy crane site. Authorisation for collecting vouchers at Skyrail for both Tore Linde and Cassandra Nichols is currently being arranged by Darren Crayn from the Herbarium. This will commence in 2010.

Tore has begun scoring trees from the digital images for the presence/absence of buds, flowers and fruits. A database was created for each species and consists of the date, the event, species and a tree label. The tree label is defined according to the position within the entire transect. This is achieved by dividing the transect into sections between towers, e.g. Section 7 is all images taken between Towers 7 and 8. This section is then divided into tenths and the tree is allocated a number with the tower section, plus the tenth it is located in, for example, tree label 7.2 would mean the tree is located between Towers 7 and 8 in the second tenth of this transect. A complete stitched transect is being assembled where each individual tree is then marked with its ID to enable a complete data set to be developed. As this requires an individual to come into flower/fruit during a data collection this process may take some years (note the study is a ten-year study).

A $4,800 grant awarded by Skyrail in 2009 has provided additional personnel time required for the identification and scoring of trees from the digital images and provided a Wacom graphics tablet to speed up the process of analysing/recording data into the images. In addition to the allocation of time of one day per month provided by Skyrail for Tore to work on the data analysis the grant will allow Tore to carry out an additional two days per month which is necessary to deal with the backlog of data.

Professor Caroline Gross now has the previous set of visual phenological data collected by Tore since 1996 and will be working over the summer on the analysis of this data for publication.

Objective E: Resource related fluctuations in insect populations

Sampling of the leaf litter inhabiting beetles commenced in 2006 and concludes in December 2009.

A leaf litter manipulation experiment was completed in February 2009. Analysis suggests that the volume of leaf litter is an important determinant of beetle abundance but that beetle responses are complex.

Sampling of insects inhabiting leaf litter was initiated in January 2006 and is ongoing. 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 for approximately twelve hours to extract insects, from which the beetles are 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. Sampling for the beetle time series is due to conclude in December 2009. Further analyses on this data will be conducted when sampling is completed. A leaf litter manipulation experiment was initiated in September 2008 to investigate how the amount of leaf litter on the ground influences beetle abundance. Three treatments were tested among six replicate 3x3m plots. Leaf litter was excluded from plots with bird netting (mesh size 2x2 cm) suspended 100-50cm above the ground (exclusion treatment). Each of the leaf litter addition plots (addition treatment) received a monthly addition of sixty litres of sifted (to remove invertebrates) leaf litter collected nearby. Control plots were marked out but otherwise unaltered. The experiment was completed in early February 2009 when the leaf litter from each plot was collected and the insects inhabiting the leaf litter were extracted with Tullgren funnels.

The monthly beetle collecting time series has so far captured 7,339 beetles (January 2006 to September 2009). For this experiment a standard volume of fine leaf litter (five litres) is collected from the ground under the circumference of the canopy crane. Standardising the volume of leaf litter, allows us to examine temporal variation in insect density, independent of seasonal variations in leaf litter fall and volume (see Objective B). This time series (Figure E1) shows both seasonal and yearly variation in beetle density.

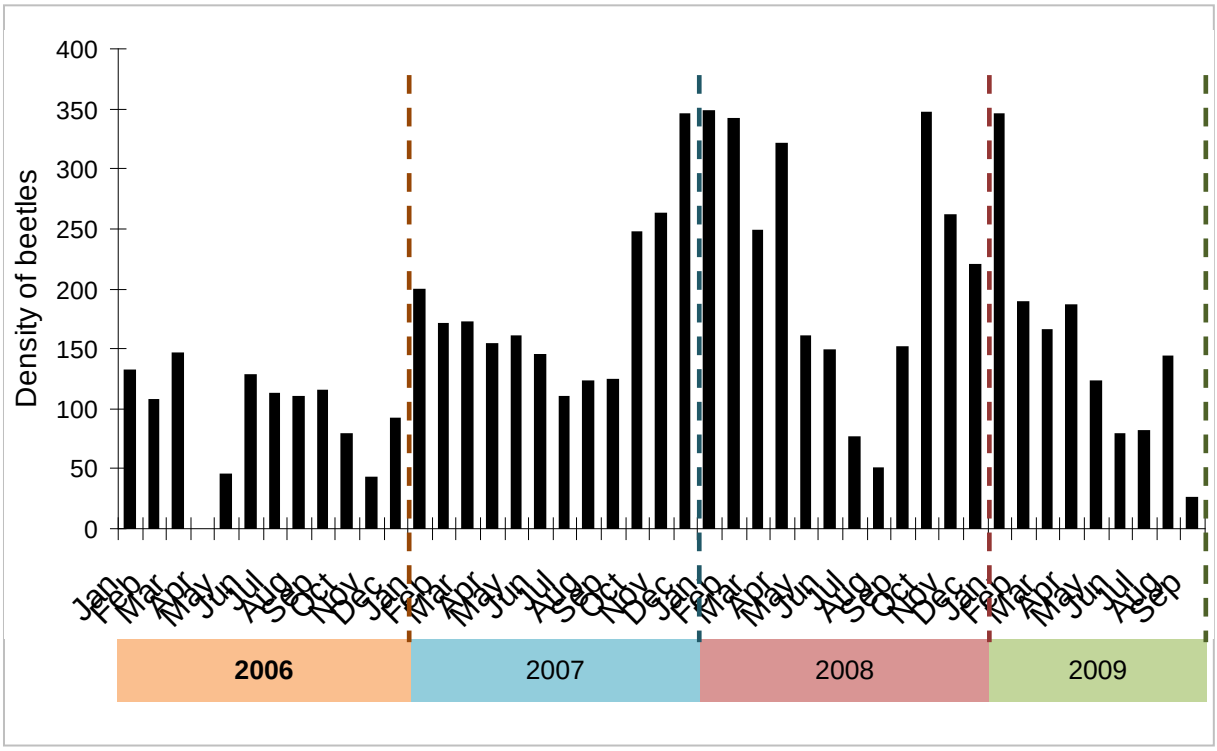

Figure E1: Temporal variation in the density of beetles extracted from monthly collections of leaf litter (five litres) from the ground at the Australian Canopy Crane Research Station, Cape Tribulation.

The leaf litter manipulation experiment, carried out between September 2008 and February 2009, captured a total of 3,337 beetles. The plots where leaf litter was excluded (average of 75% of leaf litter weight excluded) had significantly fewer beetles than control plots or plots where leaf litter was added (P=0.05, Figure E2). However, there were not significantly more beetles in the leaf litter addition plots than the control plots. These results show that leaf litter fall influences beetle population fluctuations although beetle responses to variations in leaf litter fall appear to show threshold responses. That is beetle abundance increases with leaf litter fall up to a point but above this level, additional leaf litter has little influence on beetles. Further analyses showed that beetle abundance was significantly correlated with coarse leaf litter dry weight (n=18, p=0.015, r^2=0.32; Figure E3) but not fine leaf litter dry weight (n=18, p=0.27, r^2=0.02). This result is initially puzzling because it suggests that the leaf litter addition treatment (which consisted of coarse leaf litter only) should have shown an increase in beetle abundance. However, overall this result confirms our interpretation that the beetles show a threshold response to leaf litter volume.

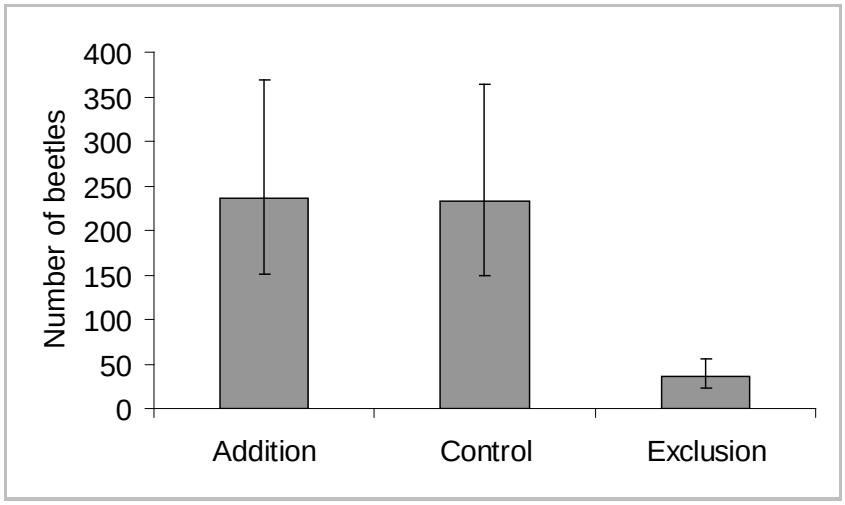

Figure E2: Preliminary results of beetle abundance among leaf litter manipulation treatments near the Australian Canopy Crane Research Station, Cape Tribulation. In this experiment the leaf litter was added ('Addition'), excluded (with bird netting) ('Exclusion') or unaltered ('Control') to six replicate 3x3m plots over five months.

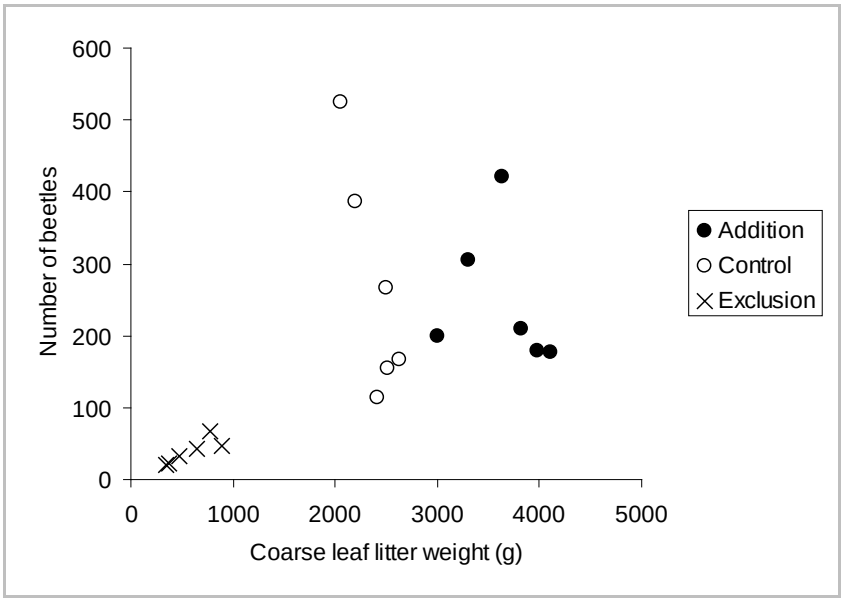

Figure E3: Preliminary results of beetle abundance and coarse leaf litter weight among leaf litter manipulation treatments near the Australian Canopy Crane Research Station, Cape Tribulation.