Research on invertebrate assemblages at the Warra LTER Site

R. Bashford[1]*, R. Taylor[1,4], M. Driessen[2], N. Doran[2] and A. Richardson[3]
[1]Forestry Tasmania
[2]Department of Primary Industries, Water and Environment,
GPO Box 44, Hobart 7001
[3]School of Zoology, University of Tasmania,
GPO Box 252-05, Hobart 7001
[4]Current address: Parks and Wildlife Commission,
Palmerston, Northern Territory 0831

Abstract

Four major invertebrate projects are being undertaken at the Warra Long-Term Ecological Research (LTER) Site in a collaborative program involving several organisations. The projects include research into altitudinal variation of invertebrate assemblages, the development of operational prescriptions for the management of wet eucalypt forests for sustainable wood production, and the determination of indicators of global forest health. A range of other short-term projects has also been undertaken on invertebrates.

Introduction

Four major projects that have a focus on invertebrates are currently being undertaken at the Warra LTER Site. Two of these are aimed at developing operational prescriptions for the management of wet eucalypt forests for sustainable wood production. The third has been established to monitor invertebrate assemblages along an altitudinal gradient. The fourth comprises several sub-projects contributing towards international efforts to develop a greater understanding of global patterns of biodiversity, carbon cycling and to monitor the impacts of climate change on biodiversity. Warra has also become a focus for other research on invertebrates, attracting many entomologists and invertebrate specialists from Tasmania, interstate and overseas. Their collective efforts are helping to further our understanding of the region's invertebrate biodiversity and efforts to develop long-term ecologically sustainable forest management.

* Corresponding author
e-mail: dick.bashford@forestrytas.com.au
robertj.taylor@plmbay.pwcnt.nt.gov.au
michael.driessen@dpiwe.tas.gov.au
niall.doran@dpiwe.tas.gov.au
alastair.richardson@utas.edu.au

A. Silvicultural Systems Trial (SST)

The SST is investigating alternative silvicultural systems for the management of wet eucalypt forests for wood production (see Hickey *et al.* 2001). The component of this trial that involves invertebrates aims to (i) determine the structure and diversity of invertebrate assemblages on treatment and control areas and (ii) monitor the successional pathways of invertebrate assemblages following disturbance from a range of silvicultural treatments.

Invertebrate monitoring sites have been established in a range of coupes (Table 1). Within each coupe an invertebrate monitoring site has been established in each of two surveyed botanical plots with contrasting floristics and topography (Figure 1). Each monitoring site contains

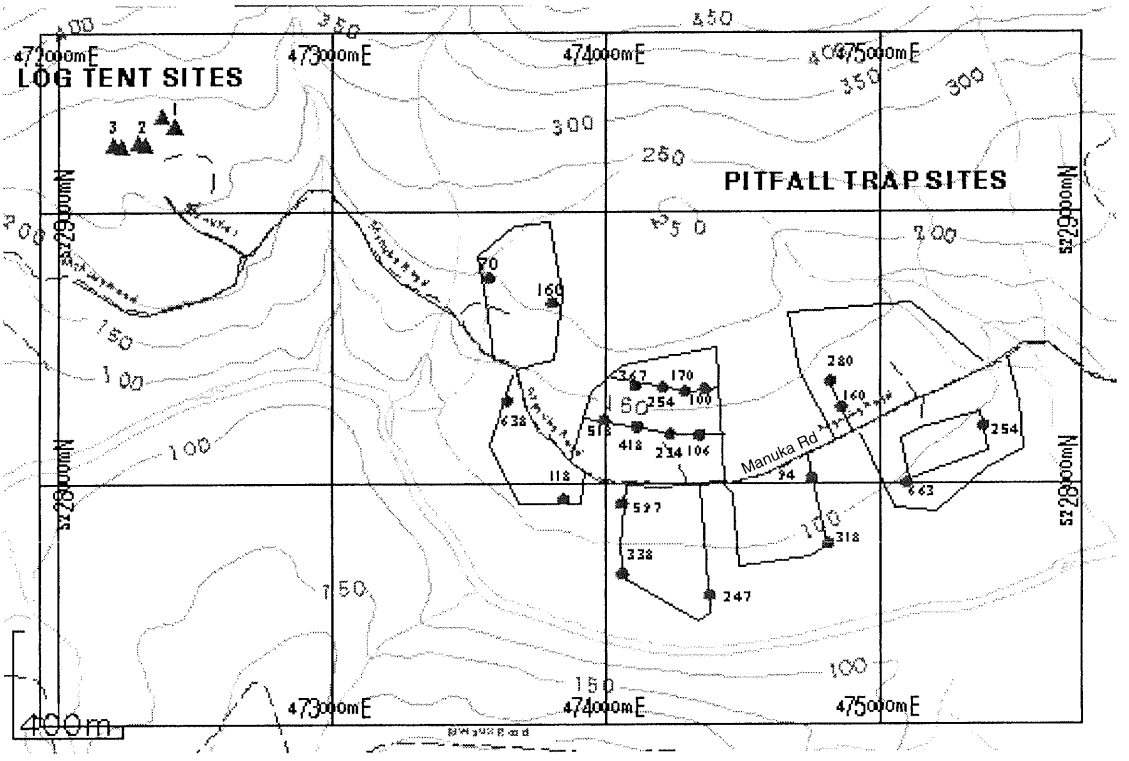

Figure 1. Sampling sites for the SST studies and log decay project at Warra.

Table 1. Program of trap establishment in SST coupes.

Coupe	Pre-logging treatment		Post-logging first treatment		Post-logging second treatment	
	Traps opened	Traps closed	Traps opened	Traps closed	Traps opened	Traps closed
WR001B	9/9/97	12/12/97	18/8/98	12/9/99	Oct-02	Sep-03
WR008C	12/9/97	17/10/99	30/8/01	active	Oct-05	Sep-06
WR008B	13/1/98	18/8/98	6/12/01	active	Oct-05	Sep-06
WR008H(A)	13/1/98	1/10/00	21/6/01	active	Oct-05	Sep-06
WR008H(B)	24/8/00	1/10/00	21/6/01	active	Oct-05	Sep-06
WR008J*	10/9/97	19/11/99	Sep-03	Aug-04	Oct-07	Sep-08
WR008E	23/8/00	active				
WR008I	23/8/00	active				

* Control

10 pitfall traps arranged in regularly spaced pairs (separated by 1–2 m) along a 50 m transect. At each end of the pitfall trap transect, a Malaise trap has been set up in an open insect flight path.

Pitfall traps (Photo 1) consist of a 15 cm length of 9 cm diameter PVC stormwater pipe sunk vertically into an augered hole in the soil. A 425 ml opaque plastic cup ('Cast Away' brand) is fitted inside the PVC pipe

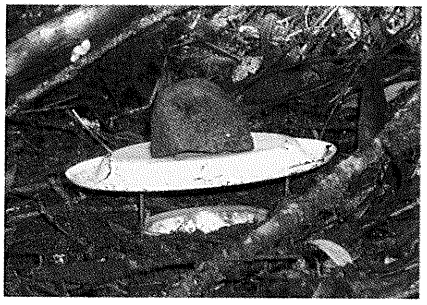

Photo 1 (left). Pitfall trap.

Photo 2 (below). Malaise trap.

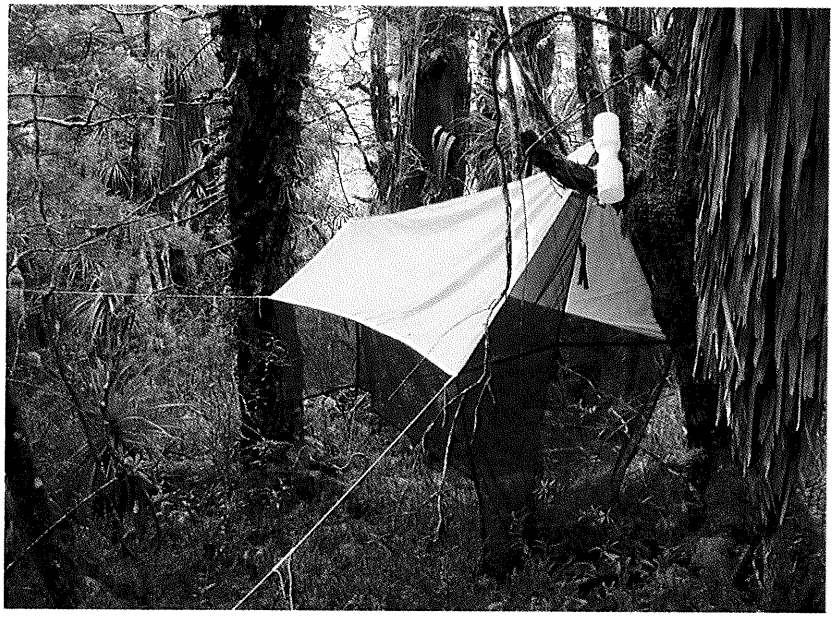

Photo 3. Light trap.

supported by the rim. To prevent rain filling the cup and to reduce debris entering the cup, an opaque plastic food container lid ('Genefac Plastics' brand) or plastic plate is supported 3 cm above the ground level by three bamboo skewers. Cups are charged with 100 ml of either 33% ethylene glycol (Castrol RadiCool®) or with undiluted ethylene glycol (Castrol) in closed canopy sites (i.e. pre-logging) and open sites (i.e. post-logging), respectively. Traps were relocated at the same postions within each site for post-logging sampling. Malaise traps (Photo 2) comprise a 28-gauge Terylene mesh tent with dark central panels and a light-coloured sloping roof. A collection bottle containing 70% ethanol is fitted to the apex of the roof.

In addition to the pitfall and malaise traps, light traps have been erected in coupes WR008J, WR008E and WR001B. The light trap used is the standard bucket designed for collecting flying insects attracted to ultraviolet light (Photo 3). The 12 volt gel battery usage of approximately 0.65 per amp hour allows 12 hours of operation. The traps are set on aluminium stands as described by Bashford (1999), which allow both height and position to be adjusted. They are charged with slow-release insecticide ministrip ('Sureguard' brand) with active constituent 186g/kg Dichlorvos (an anticholinesterase compound). The light traps are run for two nights a month during sample periods.

The second phase of sampling is planned for one year following the logging treatment, with subsequent sampling periods planned for every three years as the forest regenerates. Each sampling operation is conducted monthly in each treatment

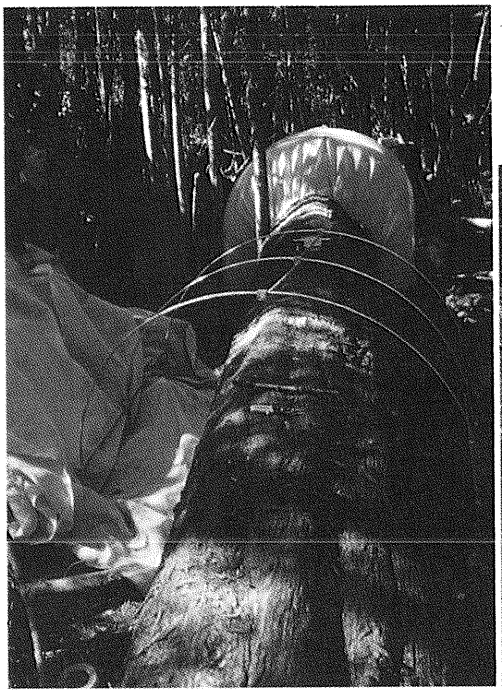

Photo 4. A tent under construction.

Photo 5 (below). Two completed tents.

coupe, and involves pitfall traps, malaise traps and light traps.

Table 1 shows the sequence of sampling within treatment coupes and control. Coupes have had monthly sampling for as long as possible in the pre-logging phase (about a year in treatment coupes; two years in the control coupe WR008J). Monthly post-logging sampling starts as soon as feasible after burning, and continues for 12 months.

Collections of molluscs, spiders, carabid beetles, ants, rhaphidophorid crickets, vespid wasps, centipedes and millipedes have been sorted into morphospecies. Other groups have been sorted to Order. Australian and international specialists are currently examining some of these groups. Coleoptera catch totals for the pre-logging surveys are shown in Table 2. Two published papers on the introduced vespid wasps have arisen from this project so far (Matthews *et al.* 2000; Bashford 2001). Future work will focus on developing ecological sustainability indicators, based on invertebrate diversity, to compare silvicultural treatments.

B. Log decay project

The aim of the log decay project is to compare the long-term succession of invertebrates in larger diameter oldgrowth logs with those of smaller diameter regrowth logs (Forestry Tasmania 1999). This is a collaborative study involving Forestry Tasmania, the University of Tasmania and the CRC for Sustainable Production Forestry and complements the study by Yee *et al.* (2001). This project will involve long-term monitoring of succession patterns in the fauna of the sample logs. The study of Yee *et al.* (2001) is comparing the fauna of large (> 120 years old) and small (60–80 years old) logs in regrowth forest.

Successive rotations of 80–100 years on a harvested area will eventually lead to the disappearance of large diameter oldgrowth logs from the forest floor, to be replaced by smaller diameter regrowth logs. We do not currently know whether the smaller logs will provide comparable habitat for diverse invertebrate and microbial communities dependent on this decaying log habitat.

Table 2. Warra SST invertebrate sampling (pre-logging).

Coupe No.	Site No.	Number of samples	Pitfall Coleoptera		Malaise Coleoptera	
			Total	Mean	Total	Mean
September 1997 – September 1998						
WR008C	70 , 60	24	794	33.08	684	28.5
WR008H	170, 106	16	659	41.19	467	29.19
WR008B	280, 160	12	523	43.58	1437	119.75
WR001B	663, 254	8	377	47.13	939	117.38
WR008J	59, 338, 147	36	998	27.72	1281	35.58
Totals		96	3351	34.91	4808	50.08
October 1998 – September 1999						
WR008C	70, 60	24	291	12.13	250	10.42
WR008H	170, 106	24	292	12.17	360	15
WR001B	663, 254	24	2287	95.29	1955	108.61
WR008J	59, 338, 147	36	323	8.97	444	12.33
Totals		108	3193	29.56	3009	35.82

Table 3. Warra log decay. Numbers of Coleoptera and Hymenoptera collected in the first year after log establishment.

Time cut	Number of sample periods	Coleoptera		Hymenoptera	
		Total	Mean per period	Total	Mean per period
Regrowth logs					
May-99	38	531	14	152	4
Sep-99	20	111	6	13	1
Feb-00	6	150	25	37	6
Oldgrowth logs					
May-99	38	753	20	118	3
Sep-99	20	295	15	26	1
Feb-00	6	250	42	47	8

Six pairs of trees were felled within an unlogged mixed age forest adjacent to Blakes 1A (Figure 1). Two pairs of oldgrowth and regrowth trees were felled at three different times of the year and docked to a length of 18 m after felling. The first two pairs were felled in May 1999 (winter), the second two pairs in September 1999 (spring) and the third two pairs in February 2000 (summer).

Invertebrates are being sampled in emergence traps constructed on randomly allocated three-metre sections of each log.

Each trap consists of a shade-cloth tent, supported by an aluminium frame (Photo 4). Emerging adult insects are captured in one of three bottles; two fixed at the base of the tent, each on opposite sides of the log, and the third at the apex of the tent (Photo 5). Five emergence traps were erected in a chronosequence on each log; the first immediately after felling and then one every three months. Each trap will be left in position for two years and then opened for a two-year period to expose that section of the log surface to insect colonisation before

being closed again. This technique will allow the succession of log colonisation by insect assemblages to be tracked.

Insects captured in emergence traps are collected each month while the tents are in position. Collections are being sorted into Orders. Ordinal counts for Coleoptera (beetles) and Hymenoptera (ants, bees and wasps) for the first two years are shown in Table 3.

C. Warra - Mount Weld altitudinal transect invertebrate studies

This is a collaborative project between Forestry Tasmania, Department of Primary Industries, Water and Environment (DPIWE) and the University of Tasmania, and has subsequently been accepted by International Biodiversity Observation Year (IBOY) as a satellite project. Invertebrate assemblages along an altitudinal transect from Warra Road to Mount Weld (see Brown *et al.* 2001) are being monitored in the long term. The rationale for the project is that long-term processes, such as climate change, may be detected by a shift in the altitudinal distribution of invertebrate assemblages.

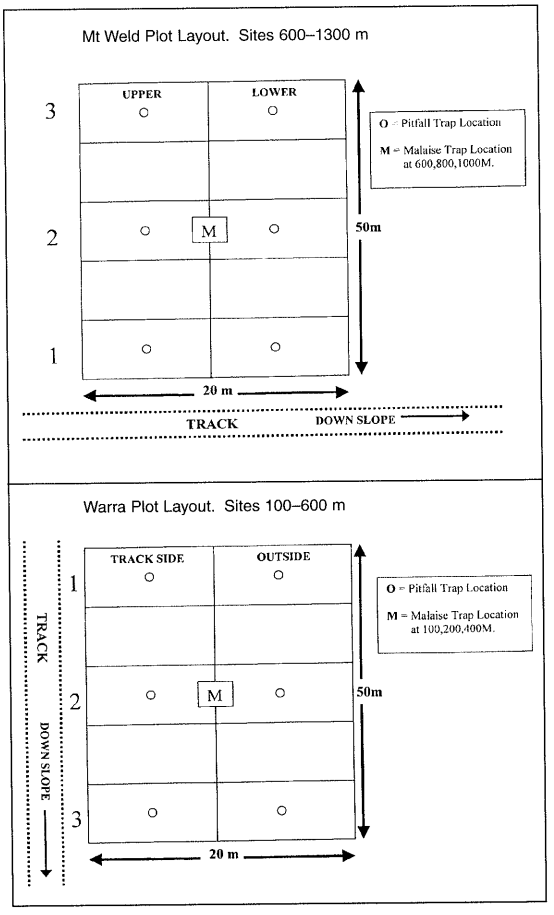

Figure 2. Plot layout of pits and Malaise traps within the 50 m x 20 m permanent plots on the altitudinal transects.

At each 100 m contour between 100 and 1300 m, a 50 m x 20 m floristic plot has been established. Within each of these plots, ground-dwelling invertebrates are being sampled using six standard pitfall traps in a 2 x 3 grid (Figure 2). In six plots (at 100, 200, 400, 600, 800 and 1000 m), Malaise traps have been used to sample aerial insects. They were placed where there were two suitable trees to attach them as near as possible to the centre of the plot (Figure 2). Sampling was done for three months in summer/autumn 2001, and a further four months will be sampled in spring-summer 2001/2002. Thereafter, sampling will be conducted at ten-yearly intervals unless a natural disturbance event occurs such as fire.

All specimens from the first sampling period have now been sorted to ordinal level (species level for molluscs and spiders). Figure 3 shows the assemblage composition for ground-dwelling invertebrates at each plot for the six most abundant orders.

D. International Biodiversity Observation Year (IBOY) Projects

Warra is a core site in the Asian Forest Ecosystems section of the IBOY program, and is a satellite site for further IBOY projects.

1. Biodiversity Assessment Program in the Western Pacific and Asia Region (DIWPA-IBOY)

Warra is the southernmost site of about 100 forest, coastal and freshwater research sites

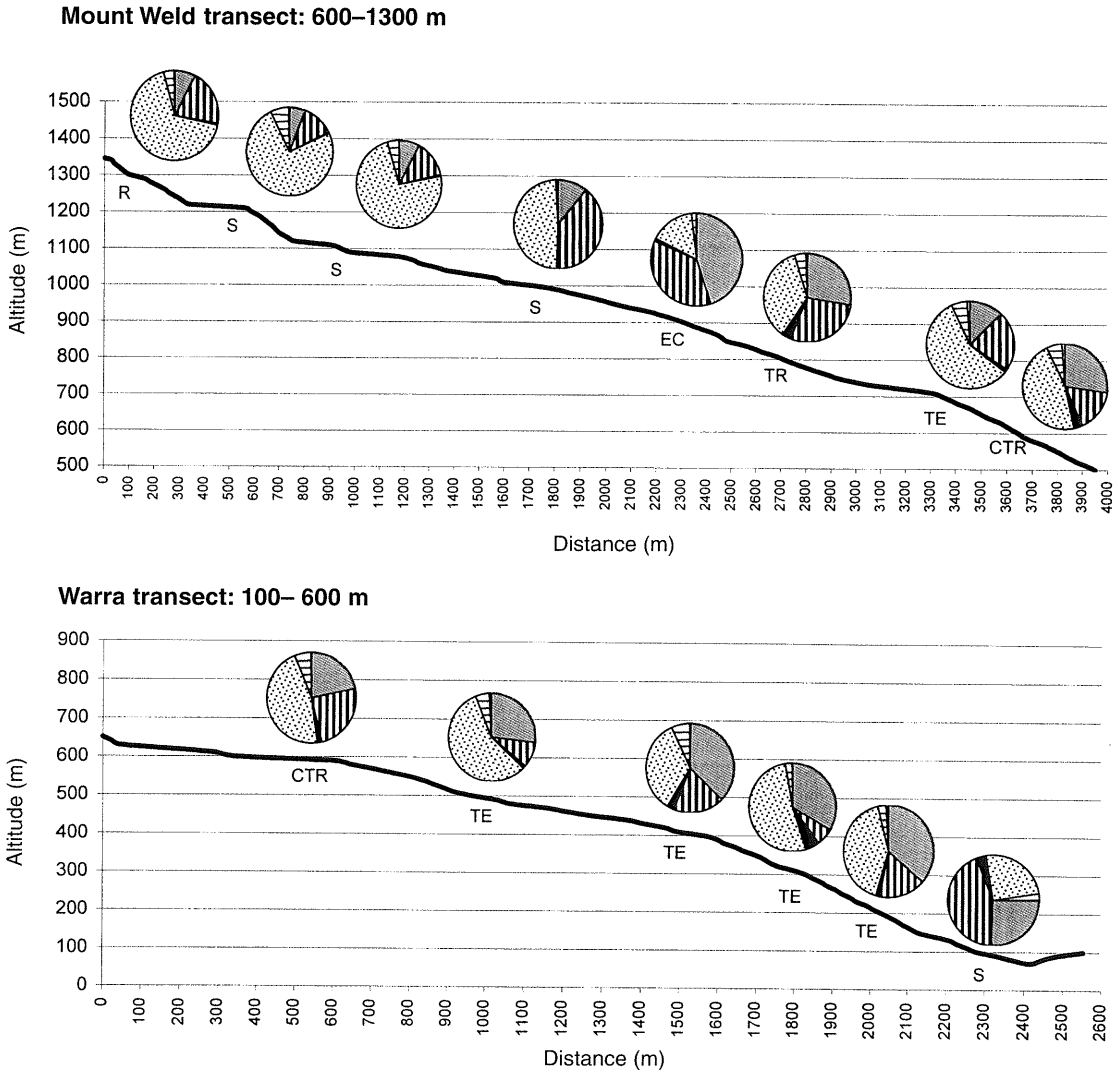

Figure 3. Section figure of the Warra and Mount Weld transects, illustrating the changes in composition of six major invertebrate groups, at each 100 m vertical interval. The floristic legend is from the PI-type map description for the area and does not necessarily apply to the individual plot.

on a latitudinal transect extending from Siberia to Tasmania at which standard assessment protocols are being used to study global patterns of insect biodiversity. The project, which runs until September 2003, aims to compile as complete a dataset as possible of the insect diversity within a 200 m^2 plot, or series of plots totalling that area, within a specific forest type. At Warra the invertebrate plots within the SST will be

used for the project. Additional collection methods, such as window trapping, will be added to existing invertebrate traps to target additional insect guilds. The project organisers in Japan have provided a standard sampling kit. A manual of experimental protocols and a list of satellite projects are on the DIWPA web site at http://pc3.nrsunet.ocn.ne.jp/~exfor/toef/IBOYTOEF/SITE.html

2. Canopy Fogging (DIWPA-IBOY)

Warra is the southernmost site in a latitudinal transect running from Japan to Tasmania involved in a study examining the diversity of insects inhabiting the forest canopy. Canopy insects were sampled by fogging the tree canopy with the insecticide bioresmethrin (Reslin®) using a motorised backpack fogger (Echo MC9) (Photos 6, 7). Each tree was fogged with 10 litres of 0.4% bioresmethrin in water. Following insecticide application, the fogger was removed and a 10 m^2 catcher array placed in the canopy under the treated foliage (Photos 8, 9). The catcher was left in place for at least one hour. Insects falling into the collectors were washed into collecting bottles at the base of each collector using an ethanol spray. Insects were stored in 75% ethanol until sorting.

Canopy fogging was done in October 2001. The canopies of seven trees were sampled:

- Four *E. obliqua*, each sampled in the mid-upper canopy level (35–40 m) and the lower to middle canopy level (20–30 m);
- Two *Nothofagus cunninghamii*—one tree sampled at 20 and 35 m, and the bottom 10 m sampled on the other tree.
- One *Acacia melanoxylon* sampled at 25 m.

A second canopy fogging will be done in late February 2002.

Collected insects were sorted to Order, with beetles being further separated into morphospecies. There was a considerable difference in the total insect counts between the upper and lower canopy catches from *E. obliqua*, with the lower canopy harbouring many more insects.

3. Global Litter Invertebrate Decomposition Experiment (GLIDE-IBOY)

An international study co-ordinated by Colorado State University involves 20 countries in an investigation of global variation in the diversity of litter inhabiting invertebrates and their contribution to litter decomposition. All participating sites have been provided with standardised mesh bags containing gamma-irradiated grass straw (*Agropyron cristatum*) of known carbon/ nitrogen ratio. Half of the mesh bags contained moth balls with the straw to exclude invertebrates (control bags) and half contained just straw (treatment bags).

Two rainforest sites at Warra were chosen: one dominated by *Atherosperma moschatum / Eucryphia lucida*, and the other dominated by *N. cunninghamii*. At each site four plots separated by at least 10 m were established. In each plot, three replicates of paired mesh bags (treatment and control) were pegged in contact with mineral soil on areas cleared of vegetation.

One randomly selected pair of bags (treatment and control) was removed from each of the four plots at each site during October 2001, two months after installation, and in December 2001, four months after installation. The remaining bags will be removed 12 months after installation. After collection, the litter-bags were weighed, invertebrates extracted using Tullgren funnels (five days at 35°C), preserved in 95% ethanol in 10 ml vials, bar-coded, and sent to 'BioTrack' at Macquarie University for sorting. The litter-bags were then oven-dried (three days at 70°C), re-weighed, bar-coded, packed, and returned to Colorado State University for C:N analysis. The first two sets of samples have already been

Photo 6. Canopy fogging: fogger in canopy.

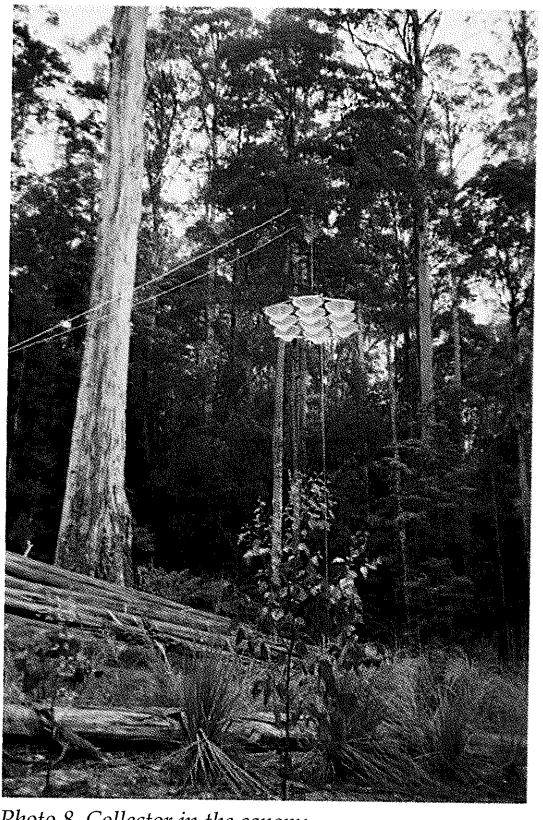

Photo 8. Collector in the canopy.

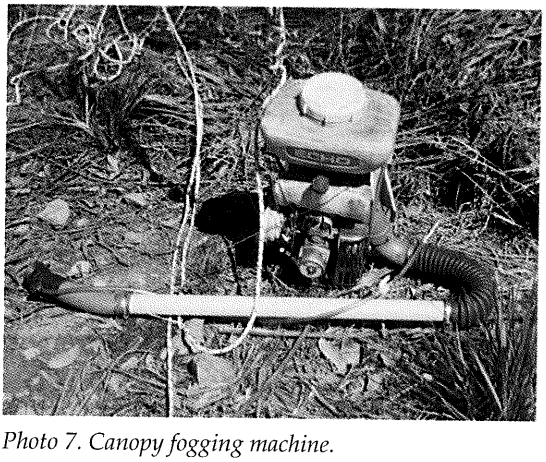

Photo 7. Canopy fogging machine.

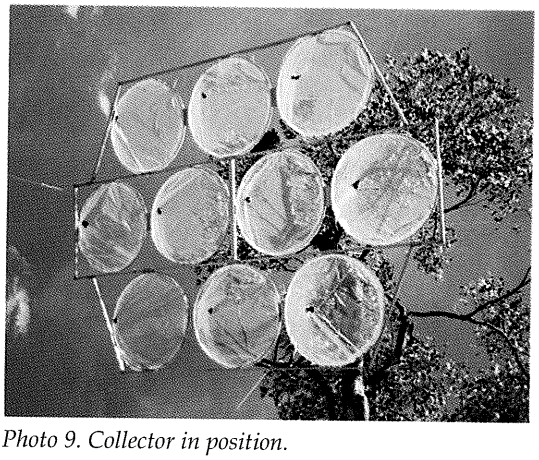

Photo 9. Collector in position.

processed. The remainder will be completed by late 2002. The data from all participating sites are to be stored on a centralised database of project findings, and will ultimately be accessible from the GLIDE web-page (http://www.nrel.colostate.edu/projects/glide/study_design.html).

E. Other Projects

Studies of invertebrates by specialists from outside the managing authorities (Forestry Tasmania and Department of Primary Industries, Water and Environment) are being encouraged. A research grants

scheme is operating to assist with field expenses associated with the projects.

Examples of projects currently being undertaken at Warra include studies on saproxylic insects and fungi (University of Tasmania, Hobart); scorpionfly taxonomy (Australian National University (ANU), Canberra; CSIRO, Canberra); bumblebee ecology (Tasmanian Museum and Art Gallery, Hobart); Hymenoptera taxonomy (ANU, Canberra); Diptera taxonomy (Smithsonian Institute, Washington); ecology of litter Coleoptera (University of Tasmaniat); spider taxonomy (Queensland Museum, Brisbane; Queen Victoria Museum, Launceston); mollusc capture techniques (Queen Victoria Museum, Launceston; University of Tasmania, Hobart); and earthworm taxonomy and ecology (ANU, Canberra).

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