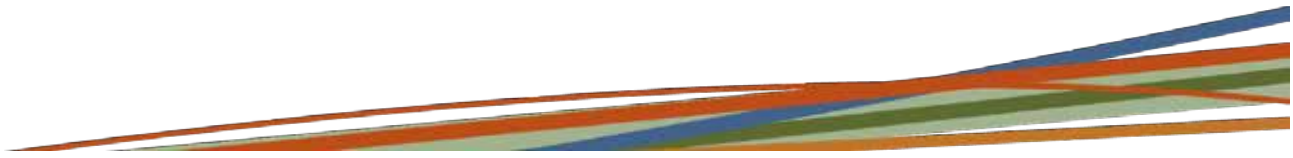
Annexure 1

TERN Australian SuperSite Network

NCRIS-2013 Monitoring Protocols

This set of documents is a reduction from the complete monitoring protocols that is to be implemented during the NCRIS-2013 contract period.

Please send any comments, corrections and suggestions to the TERN Australian SuperSite Network Coordinator (*mirko.karan@jcu.edu.au*)



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Tables and Figures

Annexure 1 Document Version Control

Vegetation Monitoring protocols prepared by:	DATE
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Further development: Suzanne Prober (CSIRO), Dan Metcalfe (CSIRO), Mike Liddell (JCU), Matt Bradford (CSIRO), Mirko Karan (JCU)	2014-01-21
NCRIS-2013 Reduction: Dan Metcalfe (CSIRO), Mike Liddell (JCU)	2015-05-13

REVISION	Version #	DATE	DESCRIPTION OF CHANGE
DRAFT	1.0	2014-01-21	
DRAFT	1.1	2014-01-22	Addition of data set naming protocols and data layouts
DRAFT	1.2	2014-03-23	Minor editing; changed Figure 2 Gentry transects/quadrats; added appendices for file naming and Gentry transect spread sheet
DRAFT	1.3	2014-04-14	Change to date format to ISO 8601 (YYYY-MM-DD)
Annexure 1	1.0	2014-06-12	Compilation into protocols for 2014-15 milestones for NCRIS2013
Annexure 1	1.1.1	2014-10-21	LAI protocol edits
Annexure 1	1.1.2	2014-10-29	avifauna protocol and plant isotope edits
Annexure 1	1.1.3	2014-11	soil protocol, plant genetic samples, DHP, DCP, photopoint edits
Annexure 1	1.1.4	2014-11-30	simplified TOC, image upload details added

1 Milestone deliverables for the NCRIS2013 contract period

ACTIVITY	PROTOCOLS	DELIVERABLES
Establish Core 1 ha (if required)	Section 3.1	
Vegetation Monitoring at the Core 1 ha		
• Complete Vascular Plant Species List	Section 4.2.1	Data
• Plant Vouchering	Section 4.2.2	Vouchers
• General Structure Description	Section 4.3.1	Data
• Abundance, Cover and Structure	Section 4.3.2-6	Data
• Above Ground Biomass	Section 4.4.1	Data
• Photopoints	Section 4.6	Images
• Leaf Area Index (Canopy)	Section 5,6, 7, 8	Data/Images
• Phenocameras	Section 14, 15	Images
• Coarse Woody Debris	Section 4.4.2	Protocol
• Plant Functional Traits - Recruitment	Section 4.5.3	Protocol
(each SuperSite to develop a suitable protocol for Coarse Woody Debris and Recruitment)		
Soil/Water Monitoring (if required)		
• Initial site and soil characterisation (if required)	Section 16	(Data)
• Physico-chemical analyses (soil pit + 9 cores) (if required)		(Data)
Ant Monitoring		
• Ant sampling pitfall traps	Section 18	Samples
Acoustic Monitoring		
• Acoustic Monitoring	Section 19	Recordings
Isotope and Plant Genetic Sampling		
• Sampling for Stable Carbon Isotope Analysis	Section 20.1	Samples
• Plant Genetic Sampling	Section 20.3	Samples
Avifauna Monitoring		
• Bird surveys (two or more)	(examples in Section 21,22)	Data
• Ornithologist developed bird survey protocol suitable for the SuperSite		Protocol

Draft protocols are italicized in the text. Where appropriate, protocols specific to vegetation types are indicated for forested areas, rangeland areas, grasslands, mallee and mulga

2 Quality Control of Data Input to the SuperSites Database

Quality Control and Quality Assurance measures to be used in the collection of field data will be outlined in the associated metadata entry.

Field data is submitted by SuperSite Principal Investigators or their representatives to the SuperSites Data Librarian (Data deposition through Morpho software will be disabled). Where possible, data is to be submitted in the recommended format (in some cases using standard template spread sheets).

The Data Librarian will prepare the dataset and metadata for publication through the SuperSite Database. This process may require the assistance of the SuperSite PI or representatives. The final metadata and data files are made available to the SuperSite PI for final checking. The SuperSite PI will acknowledge the correctness of the data and metadata entries by the prescribed mechanism. Acknowledgment of data ownership and final QA/QC checks are currently sent to the Data Librarian by email. An automated web based process is in development and will allow the SuperSite PI to access, check and give the final permission to publish via the click of a button.

TERN Australian SuperSite Network
VEGETATION MONITORING PROTOCOL

This is a cut back set of the complete vegetation monitoring protocols, to be implemented during the NCRIS-2013 contract period.

Vegetation sampling is to be completed within the course of the NCRIS-2013 period according to the milestone table.

Please send any comments, corrections and suggestions to the TERN Australian SuperSite Network Coordinator (*mirko.karan@jcu.edu.au*)

May 2014

Background

The vegetation monitoring protocol aims to provide generalized data that will be useful for describing each ecosystem, for detecting future change, and to contribute towards addressing cross-SuperSite level questions. These are currently listed as:

What are the current stocks and fluxes of energy, carbon, water and nutrients between the terrestrial (and aquatic) ecosystem components and the atmosphere/hydrosphere/geosphere.

1a. How are stocks/fluxes conditioned by management/disturbance/inter-annual variability?

1b. What are the key processes that determine ecosystem / non-biosphere exchanges?

1c. How are the key processes expected to respond to future environmental change?

1d. Are there general trends in changes in inter-annual stocks and fluxes across the network?

What are the current patterns and dynamics of terrestrial biodiversity (and aquatic).

2a. How is terrestrial biodiversity impacted by management/disturbance/inter-annual variability

2b. How will biodiversity be expected to respond future environmental change?

2c. Are there general patterns in changing abundance and/or biodiversity indices across the network?

3 Sampling Strategy

A two-tiered sampling strategy will be established at each supersite involving a core 1 ha plot and a set of additional plots that will be used to assess biodiversity and biomass. Currently we are specifying the nature of only the core 1 ha plot monitoring.

3.1 Core 1 ha plots

At least one core 1 ha plot will be established at the flux tower location to represent the vegetation in the tower footprint. This plot will include intensive measurement of soil, hydrological, vegetation, faunal and physiology variables as described herein. One hectare was chosen because it is the plot size already associated with many currently operating flux towers and other TERN facilities. Sub-sampling may be needed at some sites for intensive measurements. Measurements at these plots will provide descriptive data characterizing the functioning and dynamics of each ecosystem, contribute to questions 1a-d, and feed into AusCover and modelling projects such as CABLE.

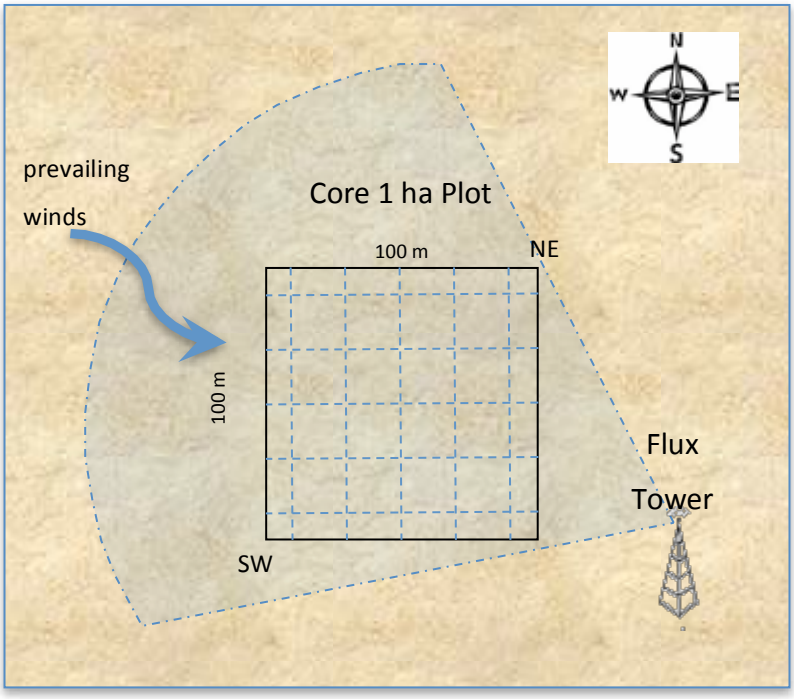


Figure 1: Schematic layout of SuperSite core 1 ha vegetation plot.

Plot Alignment and Marking

Standard plot alignment will be grid N-S, E-W with corners located using a Geographical Positioning System (GPS). Plot configuration and alignment can be modified if necessary (due to topography or limited area of land-type), ensuring a consistent area is assessed and plot dimensions and corners are recorded.

It will be important to notify data-users when plots are not of standard alignment and shape.

All plots will be permanently marked in at least two opposing corners (SW and NE) of each plot using steel star posts or similar and labelled with durable metal tags. For 1 ha plots, it is likely that additional permanent markers every 10 m along each edge and in the centre of the hectare, will facilitate regular data collection. Where coordinates are used to identify locations within the core 1 ha plot the 0,0 coordinate will be located at the SW corner.

4 Vegetation Measurement

4.1 Summary of Measurements for Core 1 ha Plots

Initial measurements at core 1 ha plots will be followed by annual monitoring for a subset of variables. Frequency of sampling for some measures might be increased after key disturbance or other events.

Essential components of this for the SuperSite 1 ha plot include assessments of vegetation Biodiversity; Abundance; Cover and Structure; Biomass; Plant Functional Traits and Photopoints.

- Full vascular plant composition will be recorded for each plot. As references for taxon identity, at least one voucher specimen will be lodged at the relevant state herbarium for each species that is recorded in the survey as a whole. Additional specimens should be collected for taxa with uncertain identity or of other specific interest.
- Abundance cover and structure are measured using different methods for rangelands and forests. A once-off general structural description will be undertaken. Additionally the three most dominant species per strata (ground, mid and upper) will be recorded, along with an estimate of cover for each stratum, a dominant growth form per species, and an average height class for each stratum. In forested areas measures will include direct measurement of all stems ≥ 10 cm DBH, RAINFOR Gentry transects for stems < 10 cm DBH and Seedling transects for stems < 1.5 m and > 0.1 m in height. In rangelands measures will include the direct measurement of stems ≥ 10 cm diameter at DBH + basal wedge measurements, Point intercept method and a Structural summary as described in the AusPlots Rangeland protocols (White *et al*. 2012).
- Height, diameter at breast height (DBH), and species for all live and standing dead woody plants ≥ 10 cm DBH will be measured across whole core 1 ha plots. In plots where small trees dominate, stems ≥ 5 cm DBH should be measured. Live or dead status will be recorded. Laser range finders may assist with measuring height. It is recommended (subject to funding) that this be carried out at the core 1 ha plot on all stems > 1 cm DBH. Recommendations for mallee and mulga can be found at 4.4.1.
- Coarse woody debris for the whole core 1 ha plot will be measured at the same time as floristic composition. Scores will include a class for diameter and for degree of decay. This measure is considered important for completing above-ground biomass estimates (in conjunction with basal area, height, and wood density data), and is also an indicator of faunal habitat.

Table 1 Summary table of essential measurements for Vegetation Protocol

Measure	Priority & frequency in core 1 ha plot
Biodiversity	
Vascular plant list, missing stems	Essential, annual
Voucher specimens	Essential, at least one per species, once only
	Build up local voucher collection for SuperSite
Abundance, Cover and Structure	
General structure description	Essential, once only
Direct measure stems ≥10 cm and height	Essential, every 5 years
Direct measure stems < 10 cm (forest/rangeland methods)	Essential, every 5 years
Above Ground Biomass	
Standing AGB	Essential, every 5 years
Coarse Woody Debris	*Protocol development for each SuperSite*
Plant Functional Traits (PFT)	
Recruitment - woody plants	*Evaluation of how to do this at each SuperSite. Where possible field trials.*
Photopoints	Essential, annual (AusPlots)
Leaf Area Index (Canopy)	Essential, biannual (peak season/low season)
Phenocameras	Essential, continuous (hardware supplied by AusCover)

4.2 Vegetation Biodiversity

4.2.1 Complete Vascular Plant Species List

A complete vascular plant species list should be taken for each plot. The plot should be systematically searched and the presence of every vascular plant recorded. Stems missing from earlier surveys to ne noted.

4.2.2 Vouchering Protocols

The identification, investigation and description of species can inform our understanding of their roles in ecosystem function. The identification of species-rich areas can be helpful to determine priority areas for conservation, particularly those areas acting as refugia in arid zone ecosystems. The decline in species richness in a plot or across similar plots is an indicator of pressures on the

environment and can help to define conservation measures or understand ecosystem processes. See Dugan *et al.* (2007) for a detailed method for surveying and collecting plant vouchers for morphological and DNA analysis for a large sampling area.

Guidelines for vouchering are available in the AusPlots Rangelands Survey Protocols Manual (White *et al*. 2012). Considerations should be made for the implementation of a sample bar coding system and the collection of additional vegetative samples for DNA and isotope analyses where required. Fertile specimens should be collected where possible.

4.3 Abundance, Cover and Structure

4.3.1 General Structural Description

A once-off general structural description according to the National Vegetation System (NVIS) level 5 (Australian Vegetation Attribute Manual, 2003), (http://www.environment.gov.au/topics/science-and-research/databases-and-maps/national-vegetation-information-system) will be undertaken. The dominant growth form, cover, height and species (3 species) per traditional strata (ground, mid and upper) will be recorded. Refer to http://www.environment.gov.au/node/18931; Table 4, for listings of cover estimations and growth form. Further structural data may be collected via the plant physiology protocol.

4.3.2 Abundance, Cover and Structure - Forest Areas

Forested areas are defined as having a closed canopy, complex vegetation structure, and a light or non-existent grass/sedge ground layer. Rangelands are defined as having an open or semi-open canopy, simple vegetation structure and a grass/sedge or open ground layer. Plots may fall between these two definitions and in this case a single method should be chosen or both forest and rangeland methods will need to be combined.

In **forested areas**, vegetation abundance, cover and structure are derived from:

- The direct measurement of all stems ≥ 10 cm diameter at breast height (DBH)
- RAINFOR Gentry transects for stems < 10 cm DBH
- Seedling transects for stems < 1.5 m and > 0.1 m in height

4.3.2.1 Direct Measure of Stems

The direct measurement of stems ≥ 10 cm diameter at DBH (see below)

4.3.2.2 RAINFOR Gentry Transects

While the direct measurement of trees ≥ 10 cm DBH captures the abundance, cover and abundance of the upper stratum, the Gentry transects (Torello-Raventos *et al.* 2013; Fig 2) measure:

Woody stems with diameter at breast height ranging from 1.0 cm to 10 cm (Mid-stratum).

All other plants < 1.5 m but > 10 cm in height, and < 1.0 cm DBH. (i.e. treelets, small shrubs and seedlings) (Subordinate).

It is recommended that at least six and up to 10, 50 x 2 m transects are established per hectare (Gentry, 1988; Fig 2A). No stems are marked, although re-assessment of the mid-stratum and subordinate layers are done on the same transects.

a) Mid stratum assessment using Gentry transects

For all woody species > 1.5 m high and DBH > 1.0 cm (but less than 10 cm DBH) and within 1 m either side of transect line measure the DBH, height and estimate crown area.

Crown area is measured as the crown radii from the centre of the stem to each of the four cardinal points at the distance furthest from the stem. Identify all individuals to species level where possible.

b) Subordinate stratum assessment using Gentry quadrats

For plants < 1.5 m but > 10 cm in height, and < 1.0 cm DBH.

At each 5 m interval of each transect, a 1 x 1 m quadrat is positioned (10 quadrats per transect, Fig 2B) to assess the subordinate stratum, Visually estimate 1) the total projected cover of both grasses/herbs and woody stems separately and 2) the projective cover of the dominant grass/herb species and woody species recording the species of the dominant grass/herb and woody plant in each case.

At completion of all 10 transects an area of 50 x 2 x 10 = 100 m^2 should have been sampled.

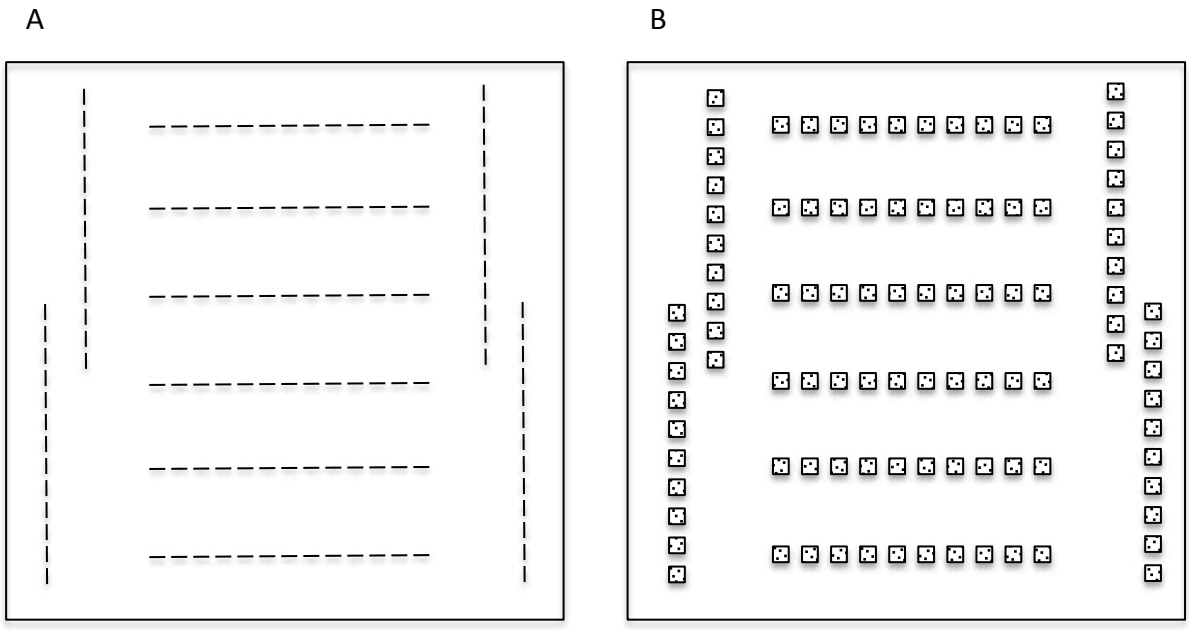


Figure 2: A recommended distribution of the sampling transects/quadrats within the plot. A) Each line represents a "Gentry transect". B) Each square represents a "Gentry quadrat".

4.3.2.3 Seedling Transects

Regeneration and turnover of stems < 1.5 m but greater than 0.1 m in height is to be monitored by establishing seedling transects.

A minimum of 6 transects of 20 m x 1 m are to be established on the plot in the layout represented in Fig. 2.

All stems < 1.5 m but > 0.1 m in height are to be marked with an aluminium tag and attached securely by copper wire. The position of each stem is recorded with a length and width coordinate along the transect. The species and height (length) of each stem to the top leaf is recorded.

4.3.3 Abundance, Cover and Structure - Rangelands

In **rangelands**, measures of abundance, cover and structure are derived from:

- The direct measurement of stems and basal wedge measurements
- Point intercept method
- Structural summary

4.3.3.1 Direct Measure of Stems and Basal Wedge Measurements

The direct measurement of stems ≥ 10 cm diameter at DBH (or diameter at 10 cm or ground level) (see 5.3.4 below) and basal wedge measurements as per AusPlots Rangelands Survey Protocols Manual (White *et al*. 2012).

4.3.3.2 Point Intercept Method

Point Intercept survey carried out as per AusPlots Rangelands Survey Protocols Manual (White *et al*. 2012) using 1010 points in year 1 at least.

4.3.3.3 Structural Summary

A structural summary and assessment of homogeneity is carried out as described in the AusPlots Rangelands Survey Protocols Manual (White *et al*. 2012) to provide an NVIS level 5 (association level) vegetation structural description.

For each of the three vegetation strata below, nominate in descending order the three most dominant species in each strata.

Upper Stratum - trees, tree mallee

Mid-Stratum - shrubs, low trees, mallee shrubs, tall grasses, grass trees

Subordinate Stratum (ground) - grasses, forbs, rushes, sedges, lichens, low shrubs, ferns, grass trees.

4.3.3.4 Plot Homogeneity - Rangelands

A "homogeneity measure" is recorded for each site. The homogeneity measure is defined as "a *record of the visual estimate (in metres) of the shortest distance from the plot centre to a vegetation community different to the one that you are sampling in".* Where there is uncertainty, it is recommended that this measure be an under-estimate, so be conservative in estimating the distance. Where it is not possible to directly observe the distance to a different community, then estimate the furthest distance that you are sure is the same community as the one you are sampling within.

4.3.4 Direct Measurement of All Stems ≥ 10 cm DBH - Forested Areas and Rangelands

All plots should conduct a direct measurement of diameter and height for all stems ≥ 10 cm DBH. For lightly forested areas, stems to ≥5 cm DBH should be measured to gain an accurate measurement of biomass, structure and cover. Stems to be surveyed are: trees, shrubs, palms, vines, ferns, strangler figs and standing dead stems (>45^0). In mallee and mulga sites stems >5cm measured at ground level (D0) or a height of 10 cm (D10) are to surveyed, tagged and mapped.

4.3.4.1 Stem Mapping

For ease of mapping and to ensure no stems are missed, stems should be surveyed within 20 x 20 m subplots starting at the south-west corner of the hectare.

It is recommended that each measured stem is permanently marked for re-measurement. Stems ≥ 10 to ≤ 30 cm at DBH are to be marked with a tag attached to stainless steel wire encircling the stem allowing enough wire for growth. An example of suitable numbered tree tags (1.2 mm thick tags are more weather/fire resistant) can be found here:
http://www.forestrytools.com.au/index.php?id=32

A line completely encircling the stem is to be painted at the point of measurement (POM) and the POM noted. Stems > 30 cm can either have the tree number painted on the stem or a tag and stainless steel wire tapped into the stem allowing for tree growth. Avoid using nails as they often cause abnormal swelling of the stem. When the stem is extremely large the POM can be marked with a line painted partly around the stem. Yellow paint has been found to be last longer as a POM marker. In cases where bark is likely to be regularly shed, simply note the POM. In later years where significant movement of the POM has been noted, due to stem growth or soil erosion, the team leader may decide to create a new POM but must record the change in POM in the data and mark the new POM.

Stems are to be mapped within each 20 m x 20 m subplot to an accuracy of 0.5 m and then converted to geographic coordinates. In more open forests a high sensitivity GPS unit can be used to map the trees but only if this method is proven to be more accurate than by sighting or measuring off a post.

In mallee and mulga sites stems >5cm measured at ground level (D0) or a height of 10 cm (D10) are to be mapped and tagged for stand dynamic reasons.

4.3.4.2 Measuring Heights

Heights are to be recorded to the nearest 1 m (for trees) for each measured stem and are recorded as the length of the stem from ground to highest leaf, not height above ground level. Heights for easily visible and larger stems are measured using a laser range finder or measuring pole. The heights of all other stems are estimated by comparing to the measured stems.

4.3.4.3 Rules for measuring

1. Stems are measured in centimetres diameter at 1.3 m (breast height) from the ground on the uphill side of the stem.
2. Stems leaning > 45° are measured 1.3 m along the stem along the underside of the stem.

3. Vines are to be pulled away from the stem before measuring where possible. Where a vine cannot be pulled away from a stem or the tape cannot be slipped under the vine, the stem is to be measured with callipers.
4. Stems with a swelling or deformity that precludes taking a normal DBH measurement at 1.3 m will be measured above or below the deformity. If the deformity continues to < 1 m above the ground then the measurement is to be taken above the deformity. The point of measurement (POM) is noted and painted.
5. Stems with buttresses are to be measured at least 1 m above the highest buttress. Smaller specimens of particular species that are known to exhibit buttressing when they grow larger are measured at a higher POM to account for future buttressing. In this case the POM is decided on by the team leader.
6. Where the trunk is irregular, deformed or fluted at all heights, the POM should be at 1.3 m.
7. If there is a reason why no measurement can be made, a DBH must be estimated and noted. This occurs when stems have large and high buttresses and when large stems have many vines or strangler figs around them.
8. Stems that fork above 1.3 m will be measured below the fork where the stem is not swollen or deformed.
9. Stems that fork below 1.3 m will be treated as separate stems, at or close to 1.3 m. Order of measurement will be from largest to smallest stem.
10. Palms, ferns and grass trees are included if the stem is ≥ 10 cm DBH (at 1.3 m) below the lowest living leaf base.
11. Dead stems are to be measured and mapped but not painted and tagged.
12. Lianas/vines are measured 1.3 m along the stem after they leave the ground. The height of a liana will be the estimated length of the stem and will generally be higher than the host stem. They are mapped where they are considered to originate.
13. The total DBH of strangler figs with more than one stem (the usual case) will be estimated and the POM noted and painted.
14. Codes are recorded for unusual measurements: leaning > 45° (L), snapped above POM (S), near dead or sick (N), rough hollow or dead side at POM (R), multi-stemmed (M), estimated DBH (E), callipers used for DBH (C).

4.3.4.4 Rules for measuring mallee and mulga

Stem diameters are measured in centimetres at 10 cm (D10) from the ground on the uphill side of the stem with a diameter tape of caliper accurate to 0.1 cm. Stems with diameter <5 cm are not included.

Stems leaning >45 degrees are measured 10 cm along the stem along the underside of the stem.

Where there is a reason why no measurement can be made, a visual estimation of the D10 is made.

Stems with a swelling or deformity that precludes taking a normal D10 measurement are measured above or below the deformity. If the deformity continues to the ground then the measurement is taken above the deformity.

Where the trunk is irregular, damaged, deformed or fluted at all heights, the diameter is taken at 10 cm.

Stems that fork above 10 cm are measured below the fork where the stem is not swollen or deformed. Stems that fork below 10 cm are measured as separate stems, at or close to 10 cm.

Vines are measured 10 cm along the stem after they left the ground. The height of a vine is recorded as the estimated length of the stem and was generally higher than the host stem. Vines are mapped where they are considered to originate.

4.4 Above Ground Biomass

4.4.1 Standing AGB

Each 1 ha plot should use the most appropriate method of estimating above ground biomass and should attempt to incorporate DBH, height and wood density values and clip plots. For example, currently the most reliable estimates of AGB for rainforest are given by Chave, *et al*. (2005).

For biomass and stem growth measurements, the diameter should be measured at

1) a height that is consistently the highest point on the stem before branching (up to 1.3 m)

2) a height that can be applied to existing allometrics.

In forests, woodlands and some rangelands, a diameter measurement height of 1.3 m (DBH) should be used. For mallee, a diameter measurement height of 10 cm (D10) should be used, and for shrubland a diameter measurement height of 10 cm (D10) or ground level (D0) should be used. For some plots a combination of diameter heights and allometrics can be used.

4.4.2 Coarse Woody Debris

This measure is considered important for completing above-ground biomass estimates (in conjunction with basal area, height, and wood density data), and is also an indicator of fauna habitat.

Both plot-based and line intercept methods are available for the measurement of Coarse Woody Debris (CWD). Plot-based methods are useful for studies that compare stocks of CWD with inputs from tree mortality within existing one hectare permanent plots. Line intercept methods are useful for assessing questions about the stocks of CWD at larger scales – for example, for assessing the degree to which the plots are representative of the wider landscape. The efficacy and accuracy of the line intercept method has been favorably assessed in savanna against a plot based method (Rose, 2006).

4.4.2.1 CWD Line/Point Intercept Measurements

CWD can be measured at the same time as abundance or floristic composition via the line intercepts method using the AusPlots Rangelands protocol using at least 1010 intercepts per plot. Scores will include a class for diameter and for degree of decay (e.g. Grove et al. 2011).

4.4.2.2 CWD Plot-Based Measurements

Fallen dead trees and branches

The length and diameter at both ends of all pieces of fallen wood, including lianas, with diameter larger than 10 cm within the 1 ha plot should be measured. Note that:

- For logs tapering to less than 10 cm diameter, measurements are made only up to the point where the log tapers to less than 10 cm diameter.
- Branches greater than 10 cm diameter attached to fallen trunks should be measured separately, in approximately linear segments.
- Measurements of length are made to the plot border, regardless of whether the tree is rooted inside or outside the plot.
- For measurements at the bases of fallen, buttressed trunks, diameters are measured above the buttress.

Standing dead stems

The diameter of standing dead stems is measured at 1.3 m height, or the lowest part of the trunk without buttress roots. Note that:

- The height of the standing trunk should be measured with a laser range finder.
- If the trunk decreases in size to below 10 cm, the height should be measured to the point where it is 10 cm diameter.
- The small-end diameter of broken standing trunks can be measured from the log formed by the fallen top.
- The dimensions of major branches > 10 cm diameter still attached to a standing dead tree should be visually estimated.
- For stumps less than 1.3 m tall, the height and top diameter should be measured.

CWD Decomposition Classes

The state of decomposition should be classified in the field into one of 5 classes, based on simple characteristics of the dead wood. These classes are based on the standard five point decay class system used in Tasmanian lowland wet eucalypt forest (Meggs 1996) and incorporating the RAINFOR five point system for closed forest (Baker and Chao 2001).

Class 1: Recently fallen. Structurally intact or almost so; bark or small branches still attached; few signs of wood decay; wood mostly retains original colour

Class 2: Structurally less intact but still hard when kicked; small branches absent; little or no bark present; early signs of wood decay, bark loss or discoloration

Class 3: Clearly decaying but still supports its own weight; may be slightly soft when kicked; may be hollow in places; no bark; moss and fungi may be prominent

Class 4: Cannot support its own weight; soft to kick (but may still be hard in places; in which case may be extensively hollow); moss, fungi and invading roots likely

Class 5: No longer retains original shape; wood very soft or largely disintegrated; sometimes only outline visible beneath moss, invading roots.

Calculation of CWD Volume

The volume of dead palm trees and stumps should be calculated as a cylinder.

For other pieces, CWD volume, V (m^3) should be calculated using Smalian's formula as:

$$V = L\left[\frac{\pi\left(D_1/2\right)^2 + \pi\left(D_2/2\right)^2}{2}\right]$$

Where L (m) is the length of the piece of CWD and D is the diameter (m) at either end. Smalian's formula gives the correct volume if each piece of CWD is a frustum of a quadratic paraboloid or a cylinder.

If the log tapers too steeply, as in a frustum of a cone, then Smalian's formula can lead to an overestimation of volume.

Density of Decomposition Classes and Measurement of Void Space (Optional)

A range of studies have calibrated the subjective decomposition classes in different forests in Amazonia (Chao et al. 2008). The density values obtained for different decomposition classes are site specific but can be estimated from the species composition of the surrounding living trees (Chao et al. 2008). In humid, lowland neotropical forests, density of each CWD decay class (ρd, g cm^{-3}) is closely related to the plot-level living wood density (Chao et al. 2008). Thus, ρd was estimated as a function of the plot-average wood density of live trees. For estimating three decay class:

$\rho_{d=1} = 1.17\ [\rho_{BA\,j}] - 0.21$ and $\rho_{d=2} = 1.17\ [\rho_{BA\,j}] - 0.31$

where $\rho_{d=1}$ and $\rho_{d=2}$ represent the CWD densities in decay class (d) one and two, respectively, and ρBA j (g cm^{-3}) is the wood density of living trees of plot j, weighted by their basal area. For CWD in decay class three, the average value of density for debris in 'decay class three' from published studies of humid, lowland neotropical forests (0.29 g cm^{-3}) can be used, as suggested by Chao et al. (2008).

Calculation of CWD biomass

a) Calculation of decomposed wood density

Chao et al., (2008) gives estimated wood density values for different decomposition classes in tropical rainforests based on the wood density of surrounding forests. For most forests, however, site specific density for each decomposition class should be determined.

For the site-specific wood density calibration of the decomposition classes, samples are taken at 5 cm length intervals from the middle of each chosen piece of CWD (Fig. 3). At each interval, a wood sample at least 30 x 30 x 30 mm in one of four randomly chosen cross sectional directions (top, bottom, left, right; Fig. 4) is taken.

The volume of these samples is calculated by direct measurement using Vernier calipers in three length dimensions for a rectangular solid shape, or radius and length for a cylindrical sample. Volumes of irregular shape samples are determined by the water displacement measurement, to the nearest 0.5 mm, using a graduated plastic cylinder. For very decomposed CWD (class 4 or 5)

sampling is performed in situ with a sampling container of known volume. The samples are dried at 65°C, weighed, and density calculated as dry mass divided by fresh volume.

Figure 3: Sampling CWD for calibrating the density of different decomposition classes

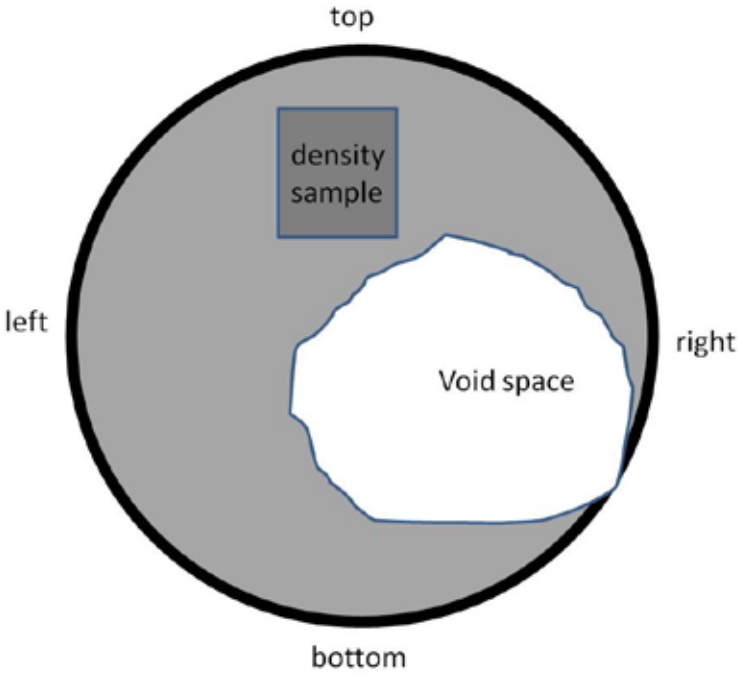


Figure 4: Position of samples for calibrating density of decomposition classes and definition of void space (dots)

b) Void Space

The proportion of void space of the different decomposition classes can be measured by taking cross-sectional pieces of a random sample of CWD pieces stratified by decomposition class.

Void space, defined as a region enclosed by more than 180 degrees of solid CWD, is measured as the proportion of the total area occupied by void space calculated using ImageJ software (available at http://rsb.info.nih.gov/ij/). Note that void space may extend to the exterior of the piece of CWD, for incompletely circular pieces of CWD.

Calculating the Mass of CWD

To estimate the mean mass of CWD, M (Mg ha^{-1}), in each decomposition class, n, external CWD volume (V, m^3) is multiplied by the mean proportion of solid wood (S = 1 – proportion void space) and by the wood density values (ρ, g cm^{-3} ≡ Mg m^{-3}) of the different decomposition classes. If void space, wood density and volume measurements for each plot or transect are not correlated (Baker et al. 2007), the standard error for M can be calculated assuming independent random errors (Taylor 1997), as:

$$SE(M)_n = (M)_n \left(\sqrt{\left(\frac{(SE_v)_n}{V_n}\right)^2 + \left(\frac{(SE_S)_n}{S_n}\right)^2 + \left(\frac{(SE_\rho)_n}{\rho_n}\right)^2} \right)$$

The mean total mass of CWD is calculated by summing the mass of each decomposition class, and the standard error calculated conservatively as the sum of errors of the constituent classes (Taylor 1997).

4.5 Plant Functional Traits

4.5.1 Site List of Plant Functional Traits

A site list of plant functional traits will be established; these will supplement those required by the plant physiology protocol, and are based on Cornelissen et al. (2003). Key whole plant traits include growth form, life form, plant height, clonality, spinescence and flammability; leaf traits include Specific Leaf Area (SLA), leaf size, leaf dry matter content, photosynthetic pathway; stem and below ground traits include wood density, bark thickness, diameter of fine roots and nutrient uptake strategy, and regenerative traits include dispersal mode, fruit shape, size and type, and resprouting capacity. Optional measures include leaf life span, diameter of fine roots, seed dry mass and nutrient uptake strategy. The scope of work at each SuperSite will be determined by local scientific questions being investigated and funding levels received.

4.5.2 Semi-Quantitative Estimates of Flowering and Fruiting

Semi-quantitative estimates of flowering and fruiting will be made monthly along selected, permanently marked transects for relating to recruitment dynamics, faunal abundances and seasonal climatic conditions.

For all vegetation types, a minimum of three 100 x 5 m transects should be established in the hectare. For each individual plant, reproductive effort is recorded within the vertical confines of the transect as numbers of ripe fruit and flowers on the plant and on the ground. In the case of a ground layer or shrub species dominating a transect, fruiting and flower effort can be estimated for the species as a whole at resolution of 1 m. Ideally fruit and flower numbers will be counted, however for expediency, a simple logarithmic estimation can be used: 1 = 0-10 fruit/flowers, 2 = 10-100, 3 = 100-1000, 4 = 1000-10000, 5 = 10000-100000. For final calculations, a midpoint of these ranges can be taken.

4.5.3 Recruitment of Woody Plants

This requirement is met for forested areas that employ Seedling Transects (4.3.2.3 above) in Abundance, Cover, Structure assessments.

Recruitment of woody plants will be scored annually in appropriate subsamples of the 1 ha plot, preferably matching transects, measuring fruiting and flowering. All recruits of woody plants will be counted, using appropriately designed classes if numbers are high (e.g. using a log scale). Individuals surviving to more than a specified height (site dependent) will be permanently tagged, mapped and measured for height each year. These data will provide an understanding of the demography of the dominant woody species and will link with fruiting, flowering and seasonal conditions. Each SuperSite will develop a suitable protocol to measure recruitment.

4.6 Photopoints

Photopoints will be **taken annually using the five point photopoint method to create reference images for the core 1 ha**. The **panoramic photopoint method** (4.6.2) **is to be used where possible (eg. rangelands)** to supply images for analysis at the University of Adelaide that produces 3D reconstructions to monitor change over time and provide an estimate of basal area and biomass.

4.6.1 Five Photopoint Method

Four photographs are to be taken at each of five photopoints on the hectare as shown in Figure 5. All photographic sequences to be preceded by an identifier photograph that includes location, date and photopoint number. Camera is to be mounted on a suitable tripod with the central part of the camera lens at 1.3 m. The photographic sequence should be taken between 10 am and 4 pm (where possible) to minimise sun and shadow effects.

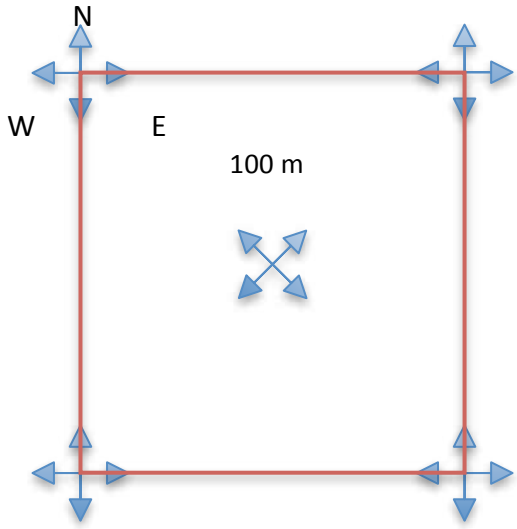


Figure 5: Photopoints for closed forest SuperSites

The photos at each corner are to be taken in the direction of the four cardinal compass points and the photos at the centre of the plot are to be taken in the direction of each corner. Vegetation within 1 m of the photopoint is to be removed or pushed aside.

4.6.2 Panoramic Photopoint Method

The AusPlots Rangelands Protocols Manual (White *et al*. 2012) describes the panoramic photopoint method in detail. This method may be the most informative in open forests/woodlands and rangelands. In summary, three photopoints are to be established

configured in an equilateral triangle (2.5 m sides) with the centre marked with a star dropper and the location recorded with DGPS (Fig. 6).

Camera Specifications

Use a digital SLR with minimum 12 megapixel resolution, ability to export raw images and a 24 mm focal length lens (AusPlots uses a Canon EOS 550D camera with a variable lens set at 24 mm). Record all camera details.

At each photopoint take photographic sequences in a 360° panorama, with up to 40 photographs with a minimum 50% overlap between consecutive photographs. All photographic sequences to be preceded by an identifier photograph that includes location, date and photopoint number. Photographic sequences are to commence with an image of the central dropper (height 1.3 m) with a line marked 25 cm from the top. Photographic sequence to end at the central dropper. Camera is to be mounted on a suitable tripod with the central part of the camera lens at 1.3 m. The photographic sequence should be taken between 10 am and 4 pm (where possible) to minimise sun and shadow effects.

In some sites where the vegetation is very dense it may not be possible to photograph the vegetation using photo-panoramas.

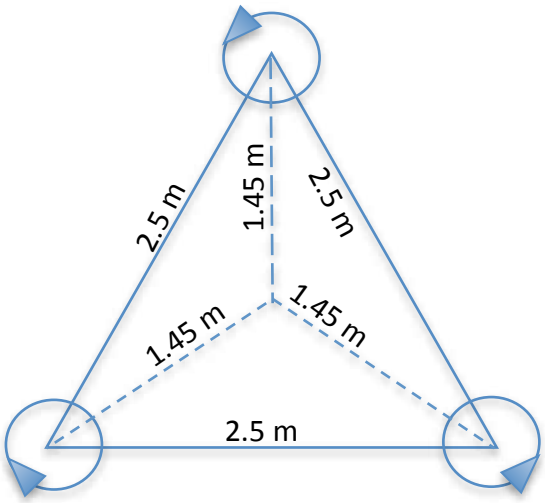


Figure 6: Photopoints for photo-panoramas in open forest/rangelands SuperSites

TERN Australian SuperSite Network
LEAF AREA INDEX MONITORING PROTOCOL

This is a cut back set of the complete LAI monitoring protocols, to be implemented during the NCRIS-2013 contract period.

LAI sampling is to be completed twice a year during the NCRIS-2013 period.

Please send any comments, corrections and suggestions to the TERN Australian SuperSite Network Coordinator (*mirko.karan@jcu.edu.au*)

May 2014

5 Canopy Cover / Understory Cover / Leaf Area Index

LAI vs Canopy Cover

Leaf area index (LAI) can be defined as the total one sided area of leaf tissue per unit area of ground and is a key derived parameter that is associated with water and light interception, radiation transfer, water and carbon exchange (Bréda, 2003). Canopy cover can be defined as the fraction of ground shaded by the vertical projection of tree crowns (Walker *et al*. 1981). In this document woody understory cover relates to canopy cover of vegetation **below 1.5 m in height**, ground cover relates to the canopy cover of non-woody vegetation (such as grasses, forbs and herbs) These measures may be used as proxies for actual canopy leaf area and actual understory, ground cover leaf biomass.

Canopy LAI

Leaf area index is the preferred measure of cover for vegetation and as a key variable used in total biomass estimation and in carbon cycling prediction models.

Leaf area index can be estimated using "direct" or "indirect" methods.

LAI Direct Measures

Direct methods include clip harvests in grasslands and litter fall traps for deciduous species as well as labour intensive destructive measures from trees and shrubs. One-off direct assessment methods are encouraged at all sites where possible, as they can be used for calibration of indirect measures. Direct measures can be conducted at a range of scales down to individual branches and used to create allometric equations that relate DBH or branch diameter to LAI (Bréda, 2003).

LAI Indirect Measures

Indirect measures of LAI include digital photographic methods using flat or hemispherical images, referred to respectively as DCP (digital cover photography) and DHP (digital hemispheric photography). A range of alternative technologies are also widely used such as the LI-COR LAI-2200 and the TRAC sensor system.

It is recommended that LAI measurements be carried out at each SuperSite using the most appropriate method for the vegetation type present as indicated in Table 2 below.

AusCover campaigns at most SuperSites have collected ground based LAI measurements using a range of different methods (DHP, CID Bio-Science CI-110 instruments and LI-COR LAI-2200). These LAI measures have been collected to validate aerial LiDAR datasets.

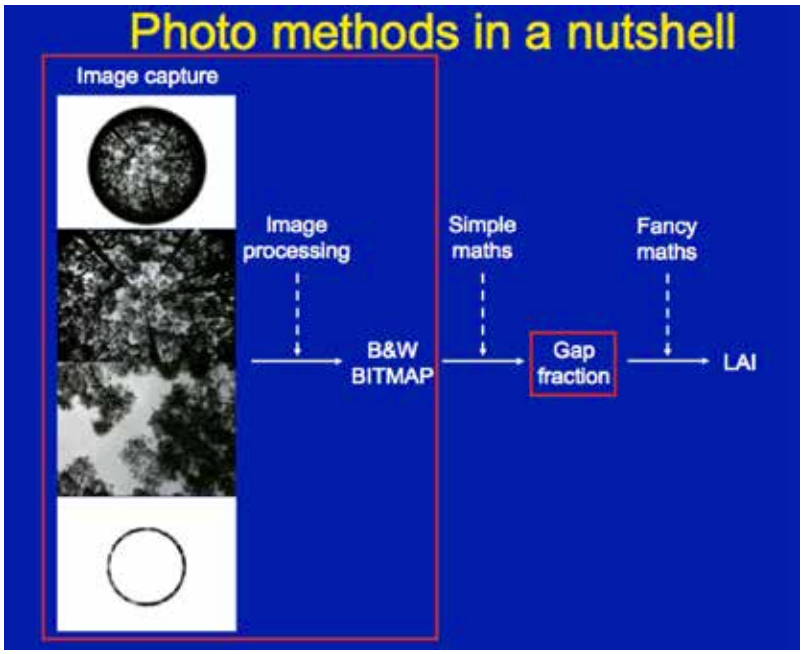


Figure 7: Photo methods in a nutshell

5.1 Recommended Methods for Different Vegetation Types

Table 2: Spatial and temporal sampling

Spatial sampling	Temporal sampling
100 m x 100 m core 1 ha plot, grid established in this 1ha plot depending on the method (DCP or DHP).	Initial measurements: Four times throughout the year to capture seasonal variation and to determine when to carry out the subsequent on-going sampling. On-going sampling: Twice a year at the times of peak and minimum biomass / leaf area.

Table 3: Recommendations of LAI and Cover methods for different vegetation

Vegetation	Method	References
Low sparse vegetation e.g. spinifex grasslands	*Point Intercept Method (PIM).* *Direct measures of LAI using Clip Plot harvests and destructive harvesting will be used to calibrate and validate PIM*	*AusCover Star Transect Protocol;* *AusPlots Rangelands Survey Protocols Manual (White et al. 2012);* *ABARES ground cover monitoring field manual (Muir et al. 2011)*
Short vegetation (4-8 m) *e.g. low banksia woodlands*	*Digital Hemispheric Photography (DHP)*	
Medium stature (10-40 m) vegetation with simple structure (single stratum) e.g. broadleaf eucalypt forest	Digital Cover Photography (DCP)	Pekin and MacFarlane, 2009
Medium stature (10-30 m) vegetation with dual structure (two strata) e.g. savanna	Digital Cover Photography (DCP) *Point Intercept Method (PIM) for understory cover.* *Direct measures of LAI using Clip Plot harvests for grasses will be used to calibrate and validate PIM* *Where there is dense grass cover (e.g. savanna) the PIM method becomes impractical for the grass component. An alternative procedure is used to measure the LAI of the grasses based on the LI-COR LAI-2200 (or LAI-2000) instrument.*	Pekin and MacFarlane, 2009 *AusCover Star Transect Protocol;* *AusPlots Rangelands Survey Protocols Manual (White et al. 2012);* *ABARES ground cover monitoring field manual (Muir et al. 2011)*
Medium - Tall vegetation with complex structure (multiple strata) e.g. rainforests	Digital Hemispheric Photography (DHP)	

Image Data storage

Raw image files will be stored on a dedicated SuperSite image data base with appropriate contextual and metadata. Image archiving instructions further below.

6 Digital Cover Photography

Digital Cover Photography (DCP) is recommended for medium stature (10-40 m) vegetation with simple structure. DCP was originally developed for sparse to moderately dense broadleaf forest and has also been tested in sparse savanna woodland. DCP is recommended for these vegetation types and has also been suggested for more dense forests (Pekin and MacFarlane 2009).

DCP Site Details

Photographs are taken along nine 100 m transects (10 m spacing) at 10 m intervals in the core 1 ha. Photographs are taken at the intercepts along the ten transects, totaling 81 positions (see Figure 8).

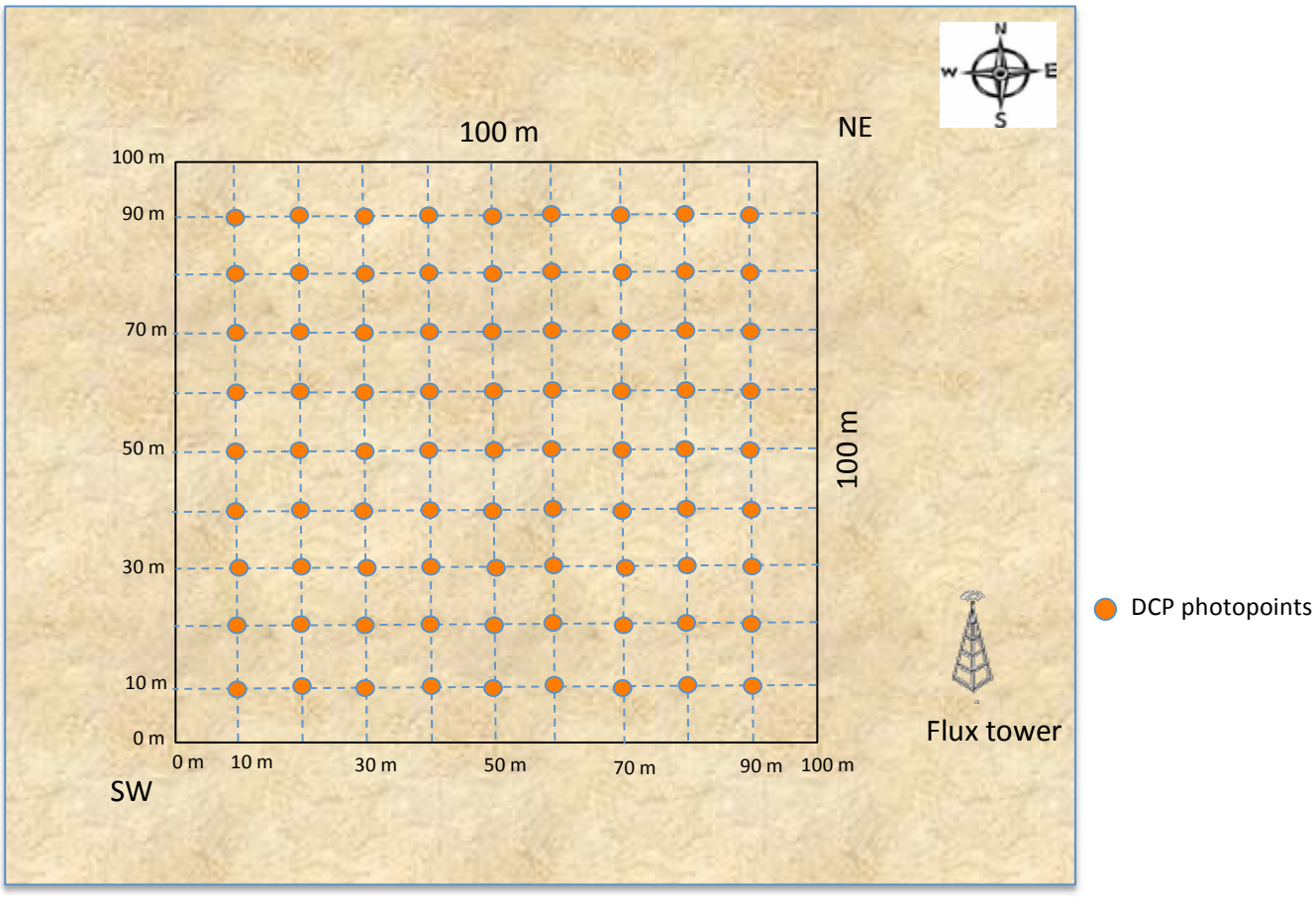


Figure 8: Positions for DCP photography within the core 1 ha plot.

Suggested Equipment for DCP

Lens - 50 mm prime lens (assuming 24 mm CCD/CMOS with 1.5/1.6 multiplication factor). RRP $150-$250. Alternatively, most DSLR cameras will come with a ~18-55 mm kit lens that will do fine.

Camera - DSLR camera with > 10 Megapixel sensor of 24 mm size. Use 'native ISO' where possible (100 or 200) or use ISO400 (even ISO800 if you really have to) in dark and windy conditions to increase shutter speed by one stop. Aim for aperture at least f8.0 to get good depth of field.

For the fixed angle (prime) lens an internal motor is needed to drive the focus of the lens if it doesn't already have one; Nikon's original 50 mm prime lens was a 'D' lens that had no motor but they've since released a 'DX' 50 mm prime that does. The kit lenses are DX and can be used with cheaper cameras.

Advantages of DCP

1. DCP can be carried out during daylight hours, not just dawn and dusk, especially in dense vegetation and at higher latitudes.
   There can be problems with excessive sunlit foliage in sparse vegetation at low latitudes, however, this can be dealt with by switching from a single-channel, grayscale-based analysis to a three-channel, colour-based analysis. This gives you more useful working hours in a day and has significant safety implications as well, as pre-dawn starts are not necessary.
2. The analysis and hardware are simple and cheap. MATLAB code for doing the analysis based on MacFarlane *et al*. (2007) is available, DCP software version 3.12 (Macfarlane 2011; Macfarlane and Ogden, 2012).

DCP provides estimates of foliage projective cover and crown cover that are very accurate (perhaps more so than LAI estimates). DHP doesn't provide this data.

6.1 DCP Protocol for Determining Leaf Area Index

Protocol adapted from Nicolas Boulain and Derek Eamus, University of Technology, Sydney

Image Acquisition

Photographs are taken along nine 100 m transects (10 m spacing) at 10 m intervals in the core 1 ha.

Images are acquired with the camera looking towards the sky at the nadir (0°) using a tripod mount and level **(ensure images are recorded in raw format)**.

Basic Data Required

The following data **must** be recorded for data management purposes:

Geographic coordinates (longitude, latitude) at the beginning and end of each Transect

Operators: who collected the data

Date: consistent format (dd/mm/yyyy)

Start Time: hh:mm when transect started

End Time: hh:mm when transect completed

Plot name/Transect number (starting from SW corner):

Photo number for last photo at each point:

Azimuth of camera top (0 for top of camera at north):

Camera make:

Camera model:

Lens details:

Height photos taken at (in cm):

Before starting each transect, take a picture of a white paper sheet with the date, the location and the transect number.

Field Equipment Checklist

100 m tape measures (ideally x 3)

Camera

Tripod or monopod

GPS – preferably differential, or GPS accessory interfaced camera.

Vertical camera mount

2 axis bubble levels

Field sheet

Compass

6.1.1 Data Collection Process

1. Lay out plot

This protocol is designed for data to be collected in conjunction with fixed marked 100 m transects in the core 1 ha.

2. Take a GPS reading at the beginning and end of each transect.

It is best to use survey-grade differentially corrected GPS if possible. The horizontal error from a handheld GPS can be in the range of 2 m to 10 m and can cause problems when validating high spatial resolution products, such as airborne LiDAR.

3. Record site details on field sheet

Record the following details on the field sheet:

Plot name/Transect number (starting from SW corner):

Field operator names/initials

Date

Start time

Camera and lens details

Height photos taken at

Orientation of camera to north

Photo format **(raw)**

4. Take photos

Ensure photos are stored in the raw format. Take photos at 10 m intervals along each transect. **Make sure all required photo details (photo numbers, height and time) are recorded on the field sheet in the appropriate location.**

6.1.2 Camera setup

Ensure the following settings are used for the photographs:

Exposure - Exposure set at -1 (1 f-stop below automatic exposure and at automatic exposure).

Format - Set the camera to take the photos in **raw format.**

Image Resolution - ensure the total number of pixels in the image is as high as possible (e.g. 12 MP). Take photos in raw format as this will default to the cameras maximum resolution.

Level camera - Make sure that the camera is reasonably level. Ideally the camera should be within 10 degrees of horizontal. Slope doesn't matter for DCP because of the narrow FOV lens. The camera doesn't 'see' very far uphill or downhill. Don't work on steep slopes (> 15^{o}). If available, use a tripod with a bubble to level the camera. If the terrain is lumpy use a monopod.

Alignment - Align the camera so that magnetic north is aligned with the top of the photograph.

Camera height - Images should be taken at a standard reference height that is appropriate for the site. Typically this is at breast height (1.3 m above the height of the ground surface). However, if there is an understory at this height, it is good to have photos above the understory and below it (e.g. at 1.4 m - if 1.3 m is the height of the understory, and 0.5 m). Also, if branches extend to the ground (like at a jack pine sites), then it is good to take the photo from as close to the ground as possible to capture most of the leaf area.

6.1.3 Recording of Data in the Field and Ordering the Files Subsequently

The photos taken in the field will initially be stored on the memory card and downloaded to a computer each day after the fieldwork has been completed.

Create a folder for each date of measurements.

In each date folder, create sub-folders by transects. Once collected sort the images and place them in the appropriate folder. Back up the files as soon as they are off the camera.

6.1.4 LAI Computation Using DCP

It is recommended to analyse images with DCP software version 3.12, written by Craig MacFarlane (CSIRO) or to use the DCP batch processing (requires Matlab®) by Nicolas Boulain (University of Technology Sydney).

To compute the canopy LAI, images are analysed with a MATLAB program based on algorithms obtained from MacFarlane *et al*. 2007. The program computes the fraction of cover porosity based on the fraction of foliage protective cover and the fraction of crown cover for each image.

The LAI is then calculated from the fraction of cover porosity.

The fraction of foliage protective cover is calculated as: ff = 1 - (totalgaps/totalpix)

The fraction of crown cover is calculated as: fc = 1 - (bigaps/totalpix)

The fraction of cover porosity is calculated as: Φ = 1 - (ff/fc)

Finally the LAI is calculated as: $LAI = - fc * \ln(\Phi)/k$

with k the beer-lambert extinction coefficient, $k = G(\theta)/\cos(\theta)$

Choose a process method (convenience)

6.1.5 Analysis Process using McFarlane Interactive DCP-313 GUI

As a single (blue) channel of the RGB image is processed to create a grey-scale, contrast stretching of the blue channel is recommended (Macfarlane *et al*., 2014) and can be achieved using the RAW2JPG MATLAB script (available at http://www.tern-supersites.net.au/index.php/publications-and-resources/resources-for-supersiteusers) before saving in JPG format prior to analysis.

DCP LAI software download

RAW2JPG and "Leaf Area Index DCP-313 Image Analysis Software" are executables compiled using the 64-bit version of Windows OS and the MATLAB 2014a. They require a 64-bit Windows OS and 2014a version of the MATLAB Compile Runtime (MCR.exe available from mathworks.com.au) to use.

Download and install the RAW2JPG and DCP-313 executables from the SuperSites Resources web page (http://www.tern-supersites.net.au/index.php/publications-and-resources/resources-for-supersiteusers). This may take a while if you are also downloading the MATLAB Component Runtime (MCR.exe) file.

To install RAW2JPG download the RAW2JPG_Installer.exe found in the folder: COMPILE_64bit, execute and follow the instructions. This will install the application in the following location: C:\Program Files\RAW2JPG. The application itself (RAW2JPG.exe) along with a file named 'dcraw.exe' will be installed at C:\Program Files\RAW2JPG\application. Move the dcraw.exe file to "C: \dcraw\".

For DCP-313, download the Leaf Area Index DCP-313 Image Analysis Software files from the SuperSites portal (http://www.tern-supersites.net.au/index.php/publications-and-resources/resources-for-supersiteusers) and follow instruction in readme.txt file.

DCP LAI image pre-processing for analysis using RAW2JPG

It is important to make sure there are no spaces (including "-" in the path to where the image files are stored on the computer, including the name of the image file.

The user can alter the fraction of pixels to saturate at each end of the histogram; this could be used to overexpose clouds and increase the heterogeneity of the background sky. The default is to saturate 1% of pixels at both ends of the brightness histogram.

The RAW2JPG application will use the functionality of dcraw to convert the raw DCP images to 'pgm' format which can be opened by MATLAB. The application will then contrast stretch

(Macfarlane *et al*., 2014) the blue channel of the raw image only. The resulting image is saved in JPG format ready for analysis by DCP-313. RAW2JPG can also apply an optional gamma correction (typically 2.2) to improve later pixel classification.

Detailed Instructions:

Open the **RAW2JPG** program

Select **Image type** as "Cover"

Click on **Adjust gamma** (this improves pixel classification, especially of imperfect images)

Leave the **Stretch limit** on the default setting

Click on **Run** and select the raw DCP images using the shift key to select multiple files.

This results in the JPG output files (using same names as originals - if camera JPG images are stored in the same folder then they will be overwritten) deposited in the same folder, ready to be used with the **DCP-313** software.

The RAW2JPG converts a raw image to a JPG format canopy image via the following workflow:

1. Read metadata from raw file using DCRaw functionality.
2. Convert raw image to 16 bit pgm format using DCRaw functionality.
3. Select the blue channel of the image.
4. Contrast stretch the image (or mask) such that 1% of pixels are saturated at each end of the brightness histogram (i.e. 1% of pixels are pure black and 1% of pixels are pure white).
5. Apply a gamma adjustment if selected.
6. Save the resulting image as an 8 bit JPG file.

Quick Guide to DCP Version 3.12.

The software is configured and run via a GUI that looks like this:

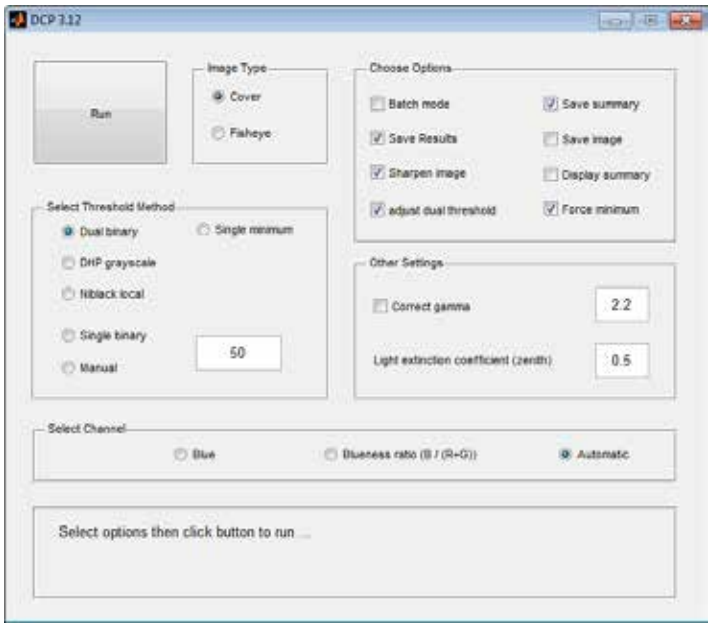


Figure 9: Guide to DCP Version 3.12

When the 'Run' button is pressed most options will be greyed out and the current file being analysed, as well as the analysis time remaining, will be displayed in the text box at the bottom.

Image type: Cover or fisheye. Select 'cover' for non-fisheye images taken with a 70 mm equivalent (or similar) lens, and select 'fisheye' for fisheye images. The 'fisheye' routine is a bit of an afterthought. It does not analyse the images - it only classifies the pixels and saves a bitmap file. The user also needs to alter the settings for the fisheye lens within the code to use this properly.

Select Channel: 'Traditional' analysis of canopy images uses the blue channel of the RGB image. Images that are badly affected (more than a couple of percent) by reflected sunlight from the canopy will often give better results if the 'blueness index' is used instead. This is calculated as B/(R+G) then rescaled to 0-255. The Automatic channel selection will distinguish between images taken in overcast and clear sky based on the blueness index value of the open sky sections of the image and automatically use the blue channel for overcast images and the blueness index for clear sky images. I don't recommend the blueness index unless images are badly affected by reflected sunlight.

Select Threshold Method: There are six threshold methods. Read Macfarlane (2011) for more details of the threshold methods.

1. The Dual binary method applies a different threshold to small and large gaps within the image (see Options to alter the choice of threshold that the Dual binary method uses for small gaps).
2. The Single binary method applies a single threshold to the whole image. The user can specify the threshold as a percentage of the distance between the two corners. 50% is the default. 0% will select the lower corner as a threshold and 100% will select the upper corner as a threshold.
3. The DHP grayscale method is the method described by Leblanc *et al.* (2005) and used in the DHP software. The gap fraction of mixed pixels is based on their linear distance between the lower and upper threshold values (25% and 75% of the distance between the lower and upper corners).

4. The Niblack local method applies a local threshold (Niblack 1986) to the mixed pixels. Pixels whose mean brightness is above the local mean (5 × 5 square neighbourhood) are classified as sky and other pixels are classified as canopy. My experience is that this method introduces odd textural variations within the canopy region, and I wouldn't recommend its use.
5. The Manual method fixes the threshold at a specified digital number, which is entered in the same box used for the Single binary method just to confuse you. That is, if Single binary is selected then the number in the box is a percentage (0-100) but if Manual is selected then it's an absolute grayscale value (0-255). The Manual method can be used to analyse tricky images if the optimal threshold value has already been determined, or for analysing many images with the same threshold. For dealing with tricky images it's usually easier to use the interactive version of DCP.
6. The minimum method uses the least frequent grey level between the two corners as a threshold. It is particularly well suited to classifying pixels using the 'blueness' index.

Select Options:

1. Batch mode. The name is a bit misleading. DCP can analyse batches of images regardless of whether you select this or not. If it is not selected then DCP will prompt you to select one or more images within a folder. If it is selected then it will prompt you to select a single folder, and then analyse all images in all the immediate sub-folders of the selected folder.
2. Save results. Saves an Excel file (results.xls) containing the results for all images. Note that a comma-delimited text file (results.txt) is written during processing regardless of whether this option is selected. Don't forget to rename them before starting a new batch analysis or they could be over-written. The files are saved in a sub-folder of the folder where the images are contained called 'done', unless 'batch' mode is selected in which case they are saved in the original folder selected.
3. Sharpen image. Applies a sharpening filter to the blue channel or blueness index to improve contrast between foliage and sky. Sharpened images tend to have a larger gap fraction, but fewer mixed pixels, than unsharpened images. Purists don't like it – I've always used it because it improves image analysis. The relevant code is:
   b=imfilter(b,fspecial('unsharp',0.1),'symmetric').
4. Adjust dual threshold. The published version of the dual method uses the 25% and 75% thresholds, and these are the defaults in DCP. If this option is selected then the software will automatically detect whether images are taken in clear sky or cloudy sky conditions, and adjust the threshold applied in small gaps from 25% to 50% for clear sky images. It doesn't affect the processing of images taken in overcast conditions. I recommend using this.
5. Save summary. Saves a PNG file for each image that displays the blue channel (or blueness index) of the original image, the classified image (foliage black, small gaps white and large gaps mid-grey) and the image histogram. On the histogram the peaks are indicated by green asterisks and the corners by black asterisks. Depending on the threshold method selected, red asterisks indicate either the mid-point between the corners, the manual threshold, the minimum between the corners, or the 25% (50%) and 75% thresholds. The summary sheets are saved in a sub-folder called 'summary'.
6. Save image. Saves the classified image as a black and white bitmap. They take a lot of disk space so only select this if you really want them. I use this to create classified images for analysis in other software. You would need to use it for fisheye images.

7. Display summary. If selected, the analysis will pause after each image is processed and display the summary sheet (Option 1 above). Analysis will not continue until the user presses a key. I almost never use this anymore. It was useful during development and before I wrote the manual version of DCP.
8. Force minimum. Forces the threshold method to be 'Binary minimum' if the blueness index is used for analysis rather than the blue channel. I find that the binary minimum method is the most reliable when the blueness index is used, and I use this option together with the automatic selection of blue or blueness. Does not affect threshold method of images analysed using blue channel.

Other Settings:

1. Gamma. This only applies to fisheye images. It can be used to back-correct the gamma function of images so that the digital numbers linearly approximate actual radiances.
2. Light extinction coefficient. This only applies to cover images. It is used to calculate LAI from crown cover and crown porosity.

7 Digital Hemispheric Photography

Digital Hemispheric Photography (DHP) is recommended for short vegetation (4-8 m) e.g. low banksia woodland, complex (multi strata) and tall vegetation (> 40+ m) using images taken 20 m apart (MacFarlane *et al*. 2007).

DCP analysis of these types of vegetation areas can be problematic. DHP has been used to measure canopy structure in boreal forests (Fournier *et al*. 1997) and light environment in temperate rainforest (Weiss 2000) and is used by AusCover for calibration and validation of LiDAR derived products (http://data.auscover.org.au/xwiki/bin/view/Field+Sites/Data+Collection+Resources).

DHP Site Details

Photographs are taken along six 100 m transects (20 m spacing) at 20 m intervals in the core 1 ha.

Photographs are taken at the intercepts along the five transects, totaling 36 positions (Figure 10).

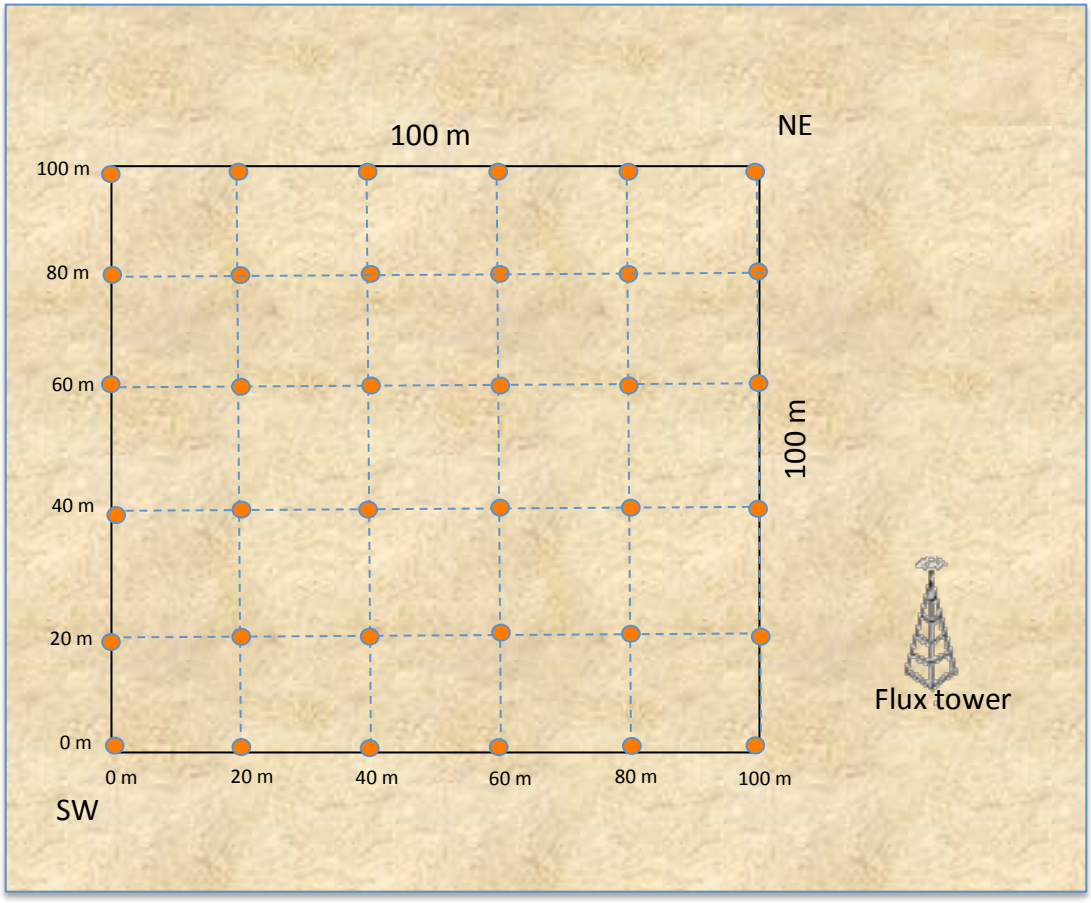


Figure 10: Positions for DHP photography within the core 1 ha plot.

Suggested Equipment for DHP

Lens - Sigma 4.5mm F2.8 EX DC HSM Circular Fisheye. RRP $1250 but may be available for less than $700. Mounts available for Nikon, Canon, Sigma, Sony/Minolta

Camera - DSLR camera with > 10 Megapixel sensor of 24 mm size. Use 'native ISO' where possible (100 or 200) or use ISO400 (even ISO800 if you really have to) in dark and windy conditions to increase shutter speed by one stop. Fisheye lenses have nearly infinite depth of field so aperture is less critical but don't go too wide or vignetting will occur – once again f8.0 or narrower is advised. Sigma's 4.5 mm lens is an 'EX' lens same as Nikon's DX so no camera focus motor is needed.

The AusCover protocol document outlines the process for the collection of hemispherical canopy photography used at the validation SuperSites (AusCover Digital Hemispheric Photography Protocol).

7.1 DHP Protocol for determining Leaf Area Index

Protocol adapted from the AusCover protocol for determining LAI. [http://data.auscover.org.au/xwiki/bin/view/Field+Sites/Hemispheric_Protocol Matt Paget 2013/04/30)]

Image Acquisition

Photographs are taken along six 100 m transects (20 m spacing) at 20 m intervals in the core 1 ha. Images are acquired with the camera looking towards the sky at the nadir (0°) using a tripod mount and level.

IMPORTANT NOTE: Hemispherical canopy photographs are best collected in diffuse lighting conditions, when the sky is uniformly grey (e.g. around dawn and dusk when the sun is below the horizon, or on days with 100 % cloud cover). Images cannot be acquired when there is significant moisture in the air; condensation, mist/fog and rain affect light and therefore image quality.

The quality of DHP images for analysis purposes is compromised if taken at other times, particularly around solar noon. If it is only possible to take pictures during sunlight conditions, it is possible to mask out the influence of the sun, but this is not ideal and will bias the gap fraction estimates. Try not to have fluffy clouds in the images either, as the brightness of clouds can reduce leaf cover at the edges of the leaves. In addition, hemispheric photos should not be taken in windy conditions.

Basic Data Required

The following data **must** be recorded for data management purposes:

Geographic coordinates (longitude, latitude) at the beginning and end of each Transect

Operators: who collected the data

Date: consistent format (dd/mm/yyyy)

Start Time: hh:mm when transect started

End Time: hh:mm when transect completed

Plot name/ Transect number (starting from SW corner):

Azimuth of camera top (0 for top of camera at north):

Camera make:

Camera model:

Lens details:

Height photos taken at (in cm):

Before starting each transect, take a picture of a white paper sheet with the date, the location and the transect number. Commence each transect running South-North from the South-West corner of the plot.

Field Equipment Checklist

100 m tape measures (ideally x 3)

Camera with hemispheric lens, preferably a circular fisheye lens

Tripod or monopod

GPS – preferably differential

Field sheet

Compass

Data Collection Process

1. Lay out plot

This protocol is designed for data to be collected in conjunction with fixed marked 100 m transects in the core 1 ha.

2. Take a GPS reading at the beginning and end of each transect.

It is best to use survey-grade differentially corrected GPS if possible because it is important that the gaps within and between trees lines up with the fractional cover estimated from LiDAR. The horizontal error from a handheld GPS can be in the range of 2 m to 10 m and can cause problems when validating high spatial resolution products, such as airborne LiDAR.

3. Record site details on field sheet

Record the following details on the field sheet:

Plot name/Transect number (starting from SW corner):

Field operator names/initials

Date

Start time

Camera and lens details

Height photos taken at

Orientation of camera to north

Photo format (**raw**)

4. Take photos

Ensure photos are stored in the raw format. Take photos at 20 m intervals along each transect. **Make sure all required photo details (photo numbers, height and time) are recorded on the field sheet in the appropriate location.**

Camera Setup

Ensure the following settings are used for the photographs:

Exposure - Exposure set at -1 (1 f-stop below automatic exposure)).

Format - Set the camera to take the photos in **raw** format

Image Resolution - ensure the total number of pixels in the image is as high as possible (e.g. 12 MP). Take photos in raw format as this will default to the cameras maximum resolution.

Level camera - Make sure that the camera is level. Ideally the camera should be within 10 degrees of horizontal. This becomes particularly important with large LAI (> 4) and steep slopes (> 15^{o}) and as a result don't work on slopes > 15^{o} (you would either have a shorter path length downhill and a longer path length uphill, assuming that your canopy height is constant and uniform as you move upslope. Or if you put the camera at an angle to the slope you violate the assumption that the foliage angle has a random azimuth distribution. The more you tilt the camera the worse you violate that assumption). If available, use a tripod with a bubble to level the camera. If the terrain is lumpy use a monopod.

Alignment - Align the camera so that magnetic north is aligned with the top of the photograph. Make a note of the alignment if there is any variation to this.

Camera height - Images should be taken at a standard reference height that is appropriate for the site. Typically this is at breast height (1.3 m above the height of the ground surface). However, if there is an understory at this height, it is good to have photos above the understory and below it (e.g. at 1.4 m - if 1.3m is the height of the understory, and 0.5 m). Also, if branches extend to the ground (like at jack pine sites), then it is good to take the photo from as close to the ground as possible to capture most of the leaf area.

Recording of Data in the Field and Ordering the Files Subsequently

The hemispheric photos taken in the field will initially be stored on the memory card and downloaded to a computer each day after the fieldwork has been completed.

Create a folder for each date of measurements.

In each date folder, create sub-folders by transects. Once collected sort the images and place them in the appropriate folder. Back up the files as soon as they are off the camera.

Hemispheric Photograpy Data Entry Form

Date (dd/mm/yyyy):
Time (hh:mm):
Plot Name:

Easting:
Northing:
Zone:
OR
Latitude:
Longitude:

Camera Make:
Camera Model:
Lens Details:
Lens Type (Infrared/Simple):
DPI (MP):

Point	Photo No f-2 exposure	Photo No f-1 exposure	Photo No automatic exposure
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			

Figure 11: Field data to be recorded

7.2 DHP Image Analysis

DHP LAI software download

RAW2JPG and MagicFish are executables compiled using the 64-bit version of Windows OS and the MATLAB 2014a. They require a 64-bit Windows OS and 2014a version of the MATLAB Compile Runtime (MCR.exe available from mathworks.com.au) to use.

Download and install the RAW2JPG and MagicFish executables from the SuperSites Resources web page (http://www.tern-supersites.net.au/index.php/publications-and-resources/resources-for-supersiteusers). This may take a while if you are also downloading the MATLAB Component Runtime (MCR.exe) file.

To install RAW2JPG download the RAW2JPG_Installer.exe found in the folder: COMPILE_64bit, execute and follow the instructions. This will install the application in the following location: C:\Program Files\RAW2JPG. The application itself (RAW2JPG.exe) along with a file named 'dcraw.exe' will be installed at C:\Program Files\RAW2JPG\application. Move the dcraw.exe file to "C: \dcraw\".

For MagicFish, download MagicFish_Installer.exe found in the folder: COMPILE_64bit.

Initial unpacking of the software takes some time as the MATLAB components are installed. During the program unpacking process you may get repeated "InternetReadFile Failed" error messages. Continue to press OK and persevere and there should be no problems.

DHP LAI image pre-processing for analysis using RAW2JPG

It is important to make sure there are no spaces (including "-" in the path to where the image files are stored on the computer, including the name of the image file.

To process fisheye images the user must specify (in pixels) the centre co-ordinates and diameter of the circular mask. Alternatively, the 'Create fisheye image mask' function will process a template image taken with the same camera and lens as the canopy images and store the centroid and diameter of the hemisphere to the Options panel, ready for analysis of the canopy images. The easiest way to get a good fisheye template is to put the camera, with fisheye lens equipped, inside a white bucket and take a photo. Ensure the image mask file is saved to the same folder as the images to be processed.

The user can alter the fraction of pixels to saturate at each end of the histogram; this could be used to overexpose clouds and increase the heterogeneity of the background sky. The default is to saturate 1% of pixels at both ends of the brightness histogram.

The RAW2JPG application will use the functionality of dcraw to convert the raw DHP images to 'pgm' format which can be opened by MATLAB. The application will then contrast stretch (Macfarlane *et al*., 2014) the blue channel of the raw image only, after first applying a circular mask to eliminate pixels outside the circular field of view of the fisheye lens. The resulting image is saved in JPG format ready for analysis by MagicFish or other software. RAW2JPG can also apply an optional gamma correction (typically 2.2) to improve later pixel classification.

Detailed Instructions:

Open the **RAW2JPG** program

Select **Image type** as "Fisheye"

Click on **Adjust gamma** (this improves pixel classification, especially of imperfect images)

Leave the **Stretch limit** on the default setting

Fisheye settings can be typed in manually, but can be ignored if you use a "white bucket photo" with the **Create fisheye image mask** which will populate these field as it create the mask.

Click on **Run** and select the raw DHP images using the shift key to select multiple files.

This results in the JPG output files (using same names as originals - if camera JPG images are stored in the same folder then they will be overwritten) deposited in the same folder, ready to be used with the **MagicFish** software. They should look like this:

DHP LAI analysis using MagicFish

For long term monitoring purposes the DHP LAI is calculated and reported using MagicFish software (C. Macfarlane) which analyses LAI in a zenith ring section of the image between the default angles of 52.5 and 62.5. At the zenith angle of 57.5° the light extinction coefficient is known and equals 0.91 (Bonhomme and Chartier 1972).

Detailed instructions:

Open **MagicFish** software

Select the **Fisheye image type** as **Circular**

Select **Threshold** (will not make much difference, especially with good quality images)

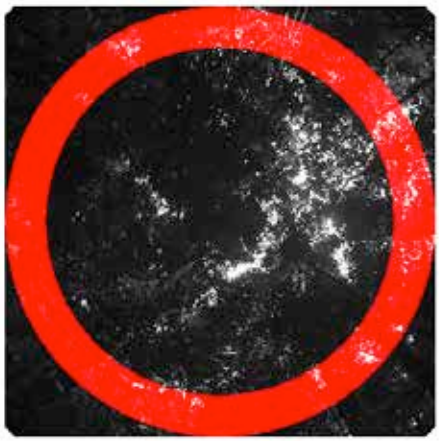
Select all **options**: **Sharpen image**, **Save Summary**, **Display segments**, **Save Detailed Results**

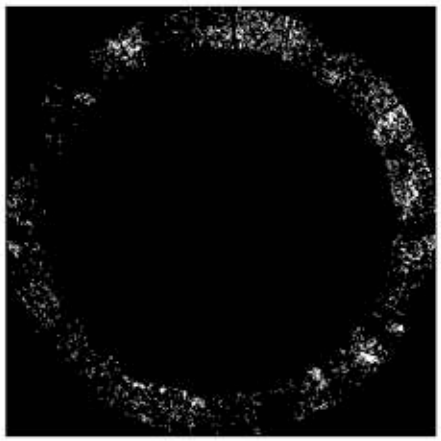
Leave the **Settings** as default values

Manually fill in **Camera Settings**: **X centre**, **Y centre** and **diameter** (of the JPG images created by RAW2JPG)- get these numbers by looking at Properties / Details information for the JPG files to be analysed. ie an image of 1224 x 1224 pixels has an X and Y centre of 613 and a diameter of 1224. Note that the images are one-quarter the size of the camera JPEG because only the blue pixels are used. This means that mask coordinates calculated from a camera JPEG will be incorrect.

Click Run and select the DHP images (JPEG format) using the shift key to select multiple files.

The summary images that result should look like this:





Results file:

The results file is also saved in a sub-folder called 'summary'. It contains the following columns:

Filename	**Name of the file**
Single/Manual Threshold	The threshold value you specified for the single or manual method. Will be zero if you used the dual classification technique.
Low Thd	Low corner detected using the Rosin method (see Macfarlane et al. 2007).
High Thd	Upper corner detected using the Rosin method (see Macfarlane et al. 2007).
GF	Gap fraction.
CP	Crown porosity (see Macfarlane et al. 2007).
FC	Foliage cover (see Macfarlane et al. 2007).
CC	Crown cover (see Macfarlane et al. 2007).
LAI_CC	LAI from gap size analysis (see Macfarlane et al. 2007).
LAI_Lin	LAI uncorrected for foliage clumping.
Log-Ave GF	Log-averaged gap fraction (used for Lang-Xiang method).
LAI_LX	LAI from the Lang-Xiang method.
No Azimuth segments	7.2.1.1.1.1.1 Number of Azimuth segments used to calculate LAI_LX (CM to add in program)

Advantages of DHP

1. Fewer images required to sample a plot e.g. for a 40 m x 40 m plot 25-30 DCP images are required compared to 9 - 16 DHP images.

2. May provide leaf angle distribution function (LADF). DHP theoretically provides both LADF as well as LAI using measurements at multiple angles. Calibration will be required as LADF is highly sensitive to stand structure (location of large gaps in the image) and correction for clumping can produce results (near spherical LADF) that do not correspond to actual leaf angles.
3. This method is very well represented in the literature indicating its wide acceptance even with its well documented limitations.

Disadvantages of DHP

1. The requirement to work in diffuse light of dawn or dusk and the added risks involved with travel to and from the site.
2. Expensive lens required.
3. Greater sky luminance heterogeneity and greater gap fraction variability within an image.
4. Doesn't provide an estimate of vertical cover.
5. Need to consider slope – don't work on steep slopes with large LAI.

8 Archiving Photographs in the SuperSites Image Data Base

Archiving of photopoint, photopoint-panorama and LAI photographs in the SuperSites Image Data Base is carried out manually by FTP using the instructions below.

As proprietary raw image file formats vary and the specifications are not publically available, there is a risk that the use of these formats for long term archiving may become problematic for analysis software. Images should be uploaded to the SuperSites image database in the raw format (/raw directory) as well as a JPG format versions used in analysis (/jpg directory).

Instruction for ftp upload of images

1. Download and install FileZilla (http://filezilla-project.org/download.php)
2. Open FileZilla and select 'File', 'Site Manager…'
3. Select 'New Site' and give the site a name (e.g. TERN Upload)
4. In the General tab, fill out the following details:

Hostname: raijin.nci.org.au

Port: 22

Protocol: SFTP (SSH)

Logon Type: Normal

Enter the **Username** and **Password** you have been provided

5. We don't need to worry about any of the other tabs, so select 'Connect' to connect to the upload site. **Note**: you will need to have internet access enabled to connect.

6. Once you have connected successfully you will be taken to your home directory on the server which appears on the right side of the screen. The left side of the screen is your local computer.

7. Double click on the appropriate directory and create directories as required using the directory structures below.

8. All image data from each sensor should then be dragged and dropped straight into the respective directory.

8.1 LAI Image Directory structure

/home/577/(user name)/lai/(supersite code)/(plot name)/(YYYYMMDD)/

Place both JPG and raw images into this folder.

8.2 Photopoint-Panorama Image directory structure

The directory structure for **Photopoint-Panorama Images** (3 x 360° panoramas from 3 points in the centre of the core 1 ha).

Panorama from position 1

/home/577/(user name)/panorama/(supersite code)/(plot name)/(YYYYMMDD)/pan1/

Panorama from position 2

/home/577/(user name)/panorama/(supersite code)/(plot name)/(YYYYMMDD)/pan2/

Panorama from position 3

/home/577/(user name)/panorama/(supersite code)/(plot name)/(YYYYMMDD)/pan3/

Place both JPG and raw images into these folders.

8.2.1 Panorama Image file names

File names can be left as they are when downloaded from the camera

8.3 Photopoint Image directory structure

The directory structure for **Photopoint Images** (N,S,E,W from corners and centre photos towards corners).

/home/577/(user name)/photopoint/(supersite code)/(plot name)/(YYYYMMDD)/

Place both JPG and raw images into this folder.

8.3.1 Photopoint Image file names

Corner photopoints: "([corner location[SW,NW, NE,SE])_(image name)_(direction [N,S,E,W])"
eg. for the South West corner photopoint images:
SW_DSC0002_N
SW_DSC0003_W
SW_DSC0004_S
SW_DSC0005_E

Centre photopoint: "C_(image name)_(direction of photo [SW,NW, NE,SE])"
eg.
C_IMG0016_NW
C_IMG0017_SW
C_IMG0018_NE
C_IMG0019_SE

8.4 Codes for Directories

User Name: is the one you have been supplied

SuperSite codes:

fnqr_cape_trib

fnqr_robson

seqp_samford

seqp_karawatha

tumb

cblp

wrra

vicd_whroo

vicd_wombat

clpm

alic

gwwl

lfld

plot name:

core_1ha

or user defined name eg. blackbutt, floodplain etc.

9 Understory LAI - Point Intercept Method

The components of the Understory will generally be measured by the Point Intercept Method (PIM) and this will include woody plants < 1.5m (Woody understory) and sparse grasses, forbs and herbs (Ground cover). From this an LAI Understory (PIM) is obtained.

LAI Understory (PIM) = LAI Woody understory (PIM) + LAI Ground cover (PIM)

Where there is dense grass cover (e.g. savanna) the method becomes impractical for the grass component and an alternative procedure is used to measure the LAI of the grasses based on the LI-COR LAI-2200 (or LAI-2000) instrument (see below).

LAI Undercover (LAI-2200)

LAI Undercover (LAI-2200) is used instead of the LAI (PIM) then in vegetation types with dense grass understory vegetation.

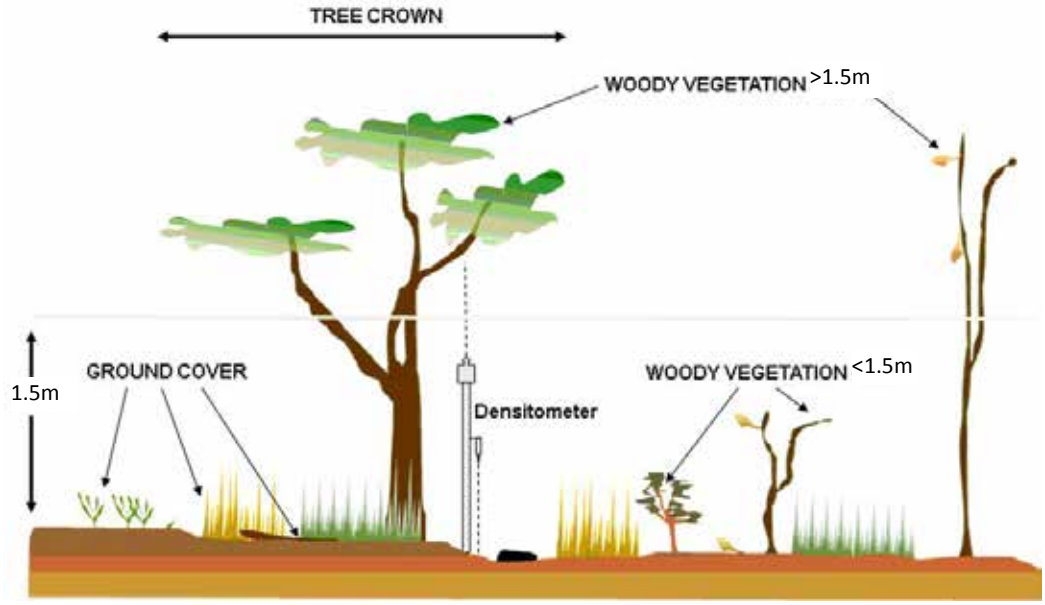


Figure 12: Vegetation categories measured (Adapted from AusCover SLATS STAR Transect protocol)

The PIM method is adapted from AusPlots Rangelands Survey Protocols Manual (White et al. 2012) and additional sources including http://www.webpages.uidaho.edu/veg_measure/Modules/Lessons/Module%207%28Biomass&Utilization%29/7_3_Direct%20Methods.htm).

The Point Intercept Method (PIM) is recommended in low sparse vegetation with hit/miss of crown cover. This method will be calibrated with direct measures from clip harvests. Point Intercepts and clip harvests will be collected every 6 months including the period of maximal leaf coverage for the initial 5 years to establish the basic relationships.

It is important to measure foliar cover at the same phenological or plant growth stage each year. Because plant growth stages are reached at slightly different times, due to variations in the weather each year, it is more accurate to monitor at the same plant growth stage each year than on the same date. It is expected that frequency and methods will be modified when clear relationships are derived from the direct (Clip Harvest) and indirect measures (Point Intercepts) of LAI.

The point intercept method is a rapid, repeatable and accurate method of quantifying canopy cover of individual plant species and total vegetation in sparse vegetation. With this method, cover is measured along linear transects and is based on the number of "hits" for each plant species from the total number of points measured along all transects.

Point Intercept Site Details

Three internal transects are located in the core 1 ha plot with records collected every 1 m giving a total of 303 points. These transects are permanently marked to allow recurrent monitoring every 6 months, including periods of greatest foliar coverage.

Attributes of point intercepts were based on the Australian Bureau of Agricultural and Resource Economics and Sciences 'Ground Cover monitoring for Australia' project 2010-2013 (Rickards et al, 2012) to quantify total vegetation canopy/crown cover and understory ground cover.

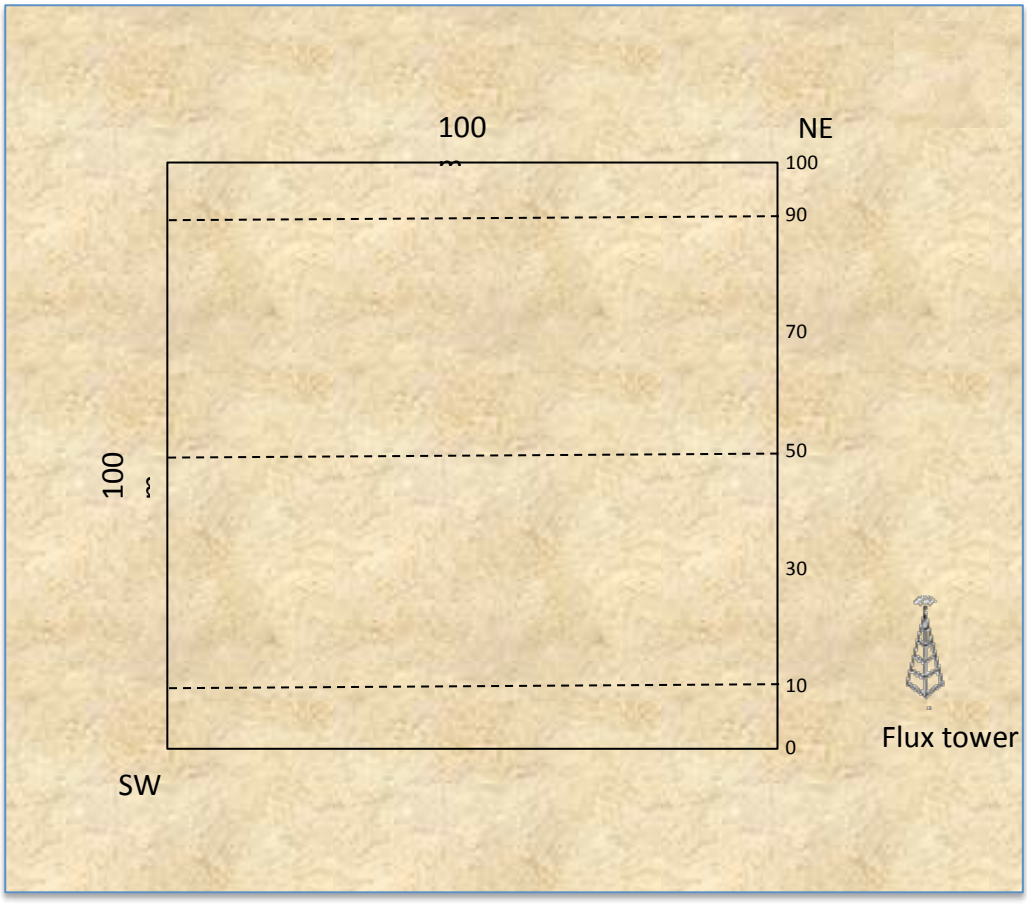


Figure 13: Layout of Point Intercept transects within core 1 ha plot.

9.1 Point Intercept Procedure

1. *For each transect lay out a 100 m tape or graduated cord between the start and end points/pegs.*

Ensure Tape is:

- *orientated to align with the grid,*
- *straight, and*
- *on the ground (where possible) and not draped over shrubs.*

2. *Using an extendable pole (preferably with a red or green laser pointer mounted at 1.5 m), start at the 0 m mark of the first transect. Place the bottom of the staff at the 0 m mark, ensure the staff is vertical.*

Collect intercept data for ground and woody understory strata as described below.

Continue recording the same information at each 1 m interval along each of the 3 transects, laying out the tape afresh for each new transect.

This will give a total of 303 points for each plot.

Measuring ground cover LAI and woody understory LAI will be done at each measurement point at the same time. The hits recorded will be allocated into ground cover or understory depending on the classification of the hit (does it hit woody vegetation or not - see Table 4 for details).

3. Measuring Ground Cover LAI

This category includes ***non-woody vegetation*** *(such as sparse grasses, forbs and herbs), litter, cryptogams, soil and rock.* ***There is no height restriction for the non-woody vegetation****.*

- *Position the pole (if it has a laser pointer point this down) vertically immediately adjacent to the metre mark on the measuring tape. Use a level to ensure the pole is vertical.*
- *Record the first intercept of the pole (or laser beam) with leaf branches etc when looking downwards, as you work your way down you may need to move the upper vegetation back. Place the intercepts (hits) in the appropriate category from the list below:*

Mineral Crust *- the hard surface layer of soil (field name cr, Table 4).*

Disturbed soil *- cracks in a soil crust, ant nests or other disturbances in the natural surface e.g. by animal hoof prints. In ploughed agricultural sites most soil recordings will be disturbed (field name ds, Table 4).*

Rock *- rock includes all stones and rock material greater than 2 cm (field name rk, Table 4).*

Cryptogam *- a biological crust composed of lichen, moss and algae (field name cy, Table 4).*

Green leaf *- a leaf with green pigmentation (one that is actively photosynthesising) attached to the plant. Sometimes the leaf in this state may appear more yellow than green. In this case a judgment call must be made as to whether it is placed in the green or dry category (field name gr, Table 4).*

Dry leaf *- a leaf with non-green pigmentation (one that is not actively photosynthesising). This can include senescent (alive) vegetation as well as dead vegetation. It must be attached to the ground or plant (field name dr, Table 4).*

Litter *- dead plant material that is not attached to the ground. Includes branches, leaves or fallen tree trunks (field name li, Table 4).*

4. Measuring Woody Understory LAI

*This category includes all **vegetation with a woody component** and a **height < 1.5 m**. These are generally shrubs and small trees.*

- *Maintain the pole in the same position as where the ground cover measurement was taken.*
- *Determine if there is an intercept of woody vegetation <1.5 m with the pole directly above the point recorded for the ground cover. Cover is determined by recording the number of "hits". To be counted as a "hit", a portion of the vegetation must cross the transect tape's interval number line e.g., 1m, 2m, 3m…. nth point. If a portion of the vegetation does not break the vertical plane at the interval number line, it is reported as a miss*
- *Record the intercept hit in the appropriate category—green leaf, dry leaf, branch.*

***Green leaf** - a green leaf attached to a plant (field name mg, Table 4).*

***Dry leaf** - a dead or dry leaf attached to a plant (field name md, Table 4).*

***Branch** - woody component of the plant (branch or trunk) (field name mb, Table 4).*

Equipment

- *100 m tape(s) or non-stretch cord marked with 1 m graduations*
- *Graduated staff (extendable pole that can be adjusted to eye height for different operators).*
  Ideally equipped with Laser pointer (taped to staff at approx. 1.5 m and pointing downwards)
- *Pegs to mark ends of transects*
- *Star droppers to mark plot corners*

Flagging tape (bright coloured to make sighting transect ends easier)

Data Collection

Raw point intercept data is collected on printed sheets or directly into a spread sheet with attributes and values as outlined in Table 4 (based on Rickards et al. 2012) with understory height set to 1.5 m.

Table 4: Attributes of point intercept data

Field name	Description	Data type	Values allowed	Strata
point	Transect observation	Integer	1–300	All
cr	Soil crust	Integer	0, 1	Ground
ds	Disturbed soil	Integer	0, 1	Ground
rk	Rock	Integer	0, 1	Ground
gr	Green leaf non-woody vegetation	Integer	0, 1	Ground
dr	Dry leaf non-woody vegetation	Integer	0, 1	Ground
li	Litter	Integer	0, 1	Ground
cy	Cryptogam	Integer	0, 1	Ground
mg	Green leaf woody vegetation <1.5 m	Integer	0, 1	Under
md	Dry leaf woody vegetation <1.5 m	Integer	0, 1	Under
mb	Branch <1.5 m	Integer	0, 1	Under
oic	In crown for live woody vegetation >1.5 m	Integer	0, 1	Over
og	Green leaf woody vegetation >1.5 m	Integer	0, 1	Over
od	Dry leaf woody vegetation >1.5 m	Integer	0, 1	Over
ob	Branch >1.5 m	Integer	0, 1	Over
unique_obs	Site identifier (longitude_latitude_date)	Text	00000000_0000000_yyyymmdd 32 characters	All
g_total	Only one observation for ground cover (cr+ds+rk+gr+dr+li+cy) is permitted at each point	Integer	1	Ground
m_total	Zero or one observations of woody vegetation <1.5 m (mg+md+mb) are permitted at each point	Integer	0, 1	Under
o_total	Zero, one or two observations of woody vegetation >1.5 m (oic+og+od+ob) are permitted at each point.	Integer	0, 1, 2	Over
all_total	Number of strata for each transect point (g_total+m_total+o_total)	Integer	1, 2, 3, 4	All

Note: Primary key = unique_obs, point. Non-woody vegetative cover, such as grasses, has no height restrictions; Dry leaf is senescent or dead vegetation attached to a plant or the ground; Litter is unattached dead vegetation; Cryptogam is a biological crust on the soil surface; In crown is the vertically projected perimeter of all foliage and branches of the plant and is recorded for live trees only. Latitude and longitude are given in decimal degrees. Each site visit is assigned a 'unique_obs' code of 'longitude_latitude_date' to join or relate all tables.

10 Understory LAI using the LAI-2000/2200

Note this method is to be used for ecosystems with dense grass understories, it is not a convenience method. It would be quite inappropriate for sparse understories - i.e. most ecosystems.

Step 1: you read the LAI-2000/2200 manual to make sure you understand basically what you are doing. Referring to Figure 8 (DCP layout) you will record LAI values at two heights at each position along each transect at 10 m intervals.

Step 2: attach a 10° view cap restrictor to the LAI-2000/2200.

Step 3: Place a 5 cm block of wood (level on the ground) adjacent to the Tape measurement position.

Place the LAI-2000/2200 sensor on the block and ensure that there is no vegetation within 5 cm of the sensor – duck down low. Take a measurement and calculate an LAI – store the value against the position. Raise the sensor above the grass to a set position ideally either 1.5 m or 2.0 m (note the value used and use for all locations along all transects), level take a measurement and store the value against the position.

Step 4: Calculate the difference between measurements at a position to generate an LAI Undercover for that position.

e.g. LAI Understory $_{\text{(Transect 1Position 5.0m)}}$ = LAI[0.05m]$_{\text{(Transect 1Position 5.0m)}}$ - LAI[1.5m]$_{\text{(Transect 1Position 5.0m)}}$

Step 5: Average the LAI Understory values across all transects (k) and all positions (n) to generate a clumping-corrected LAI for the 1 ha. This is LAI Understory (LAI-2200)

$$\textbf{LAI Understory (LAI-2200)} = \sum_{k=1-9}^{n=1-9} \quad \textbf{LAI Understory}$$

This is the uncalibrated LAI understory which subsequently needs calibration against clip harvests.

11 Clip Plot Harvests for LAI Calibration

Clip plot harvests will provide direct measures of cover for low sparse vegetation that will be used to calibrate and validate the indirect Point Intercept Method and to calibrate the LAI-2200 measurements in productive grasslands. Clip plots will be established outside of the core 1 ha in comparable vegetation immediately adjacent to the plot.

Leaf area is measured on a sub-sample of leaves and related to dry mass (e.g. via specific leaf area, SLA, cm^2 g^{-1}). The total dry mass of leaves collected within a known ground-surface area is converted into LAI by multiplying by the SLA. Direct methods provide the reference for the calibration or evaluation of indirect methods (Bréda 2003).

Clip Harvest Plots

Individual SuperSite data managers must determine the most suitable area for clip harvests that take into account the size of the vegetation (e.g. tall stature vs short stature grasses, the former will require larger areas; sparse vegetation will require correspondingly larger areas to be sampled). As an indication of how to proceed for a short stature grass (procedures adapted from NEON and He et al. (2007). A 2 m × 3 m subplot should be designated for destructive clip harvest sampling, the location should be external but in close proximity to the core plot and in

representative vegetation. This subplot is divided into thirty 0.1 m × 2 m strips. A given strip will not be harvested more than once every 10 years, thus mitigating effects of harvest on the biomass estimate of any given year.

11.1 Clip Harvest Procedure

Two strips are harvested each period. When strips are harvested, the area should be temporarily delineated with tent stakes and nylon cord pre-marked in 10 cm increments, and all biomass rooted within the strip should be clipped as close to the ground as possible, taking care not to damage perennial crowns associated with certain graminoid species. With a pair of clippers, remove all vegetation in a three dimensional area above the area enclosed by the marked strip. Clip to ground level. Grass shears, powered shears, sickles etc. can be used to accomplish clipping. Clip harvest strips should be moved in a given year if atypical obstacles are encountered – e.g. ant mounds – and the location of each year's harvest should be recorded in order to prevent repeat sampling of a given area at less than a 10 year return interval.

Clip harvest from each strip is placed in a sealed bag, and stored in a cooled esky for transport to the laboratory. In the laboratory the leaves in each sealed bag are sorted into green and dead fractions for each species and the leaves of the green fraction are used to measure leaf area index. Ten percent of sampled leaves by weight are taken as a subsample. (the subsample is chosen to be representative across the size classes of leaves). The subsampled leaf area is measured using a commercial planimeter e.g. Li-3000 Portable Area Meter with transparent belt conveyor Li-3050. The rest of the green leaves are dried separately in an oven for 48 hours at 60 °C and weighed. The green leaves must be measured using the planimeter shortly after collection – **maximum 4 hours.**

Total leaf area (LA; m^2) per strip is calculated by multiplying the total weight (Wt; g) of all leaves from a strip by the Specific Leaf Area (SLA; m^2g^{-1}) of the subsample (10% by weight of green fraction).

$$LA = W_t \times SLA$$

SLA is calculated by dividing Leaf area of the subsample (LA_s; m^2) by the weight of the subsampled leaves (W_s; g)

$$SLA = LA_s / W_s$$

The site mean destructive LAI (DLAI) is calculated by dividing the total LA (m^2) for the 2 strips by 0.2 m^2 (He 2007)

$$DLAI = \frac{1}{4}\sum_{i=1}^{4}\frac{LA_{hi}}{0.2} = \frac{1}{4}\sum_{i=1}^{4}\frac{W_{ti}\times\left(LA_{si}/W_{si}\right)}{0.2}$$

As indicated the samples should also be weighed in concert with the leaf area measurements. The weight of freshly harvested plant material is highly variable and depends on recent weather, atmospheric conditions, and the water status of the plant. Plant biomass is typically expressed on an oven-dried basis. All samples are collected and brought back to the laboratory, weighed and then dried. Once a sample is dried the biomass is expressed as % dry matter = (Dry Mass/Fresh Mass) *100 where the "Dry Mass" is the mass of the sample after oven drying and "Fresh Mass." is the mass of the sample recorded in the field.

Recommended Drying Procedure:

(1) Dry sample within 24 hours of clipping.

(2) Place samples (in paper bags) in a forced-air oven 60 °C

(3) Dry to constant weight. Most samples will take 24-48 hours to dry.

To determine if a sample is dry, a few bags can be removed from the oven, weighed and then returned to the oven. A few hours later, (4-8 hours) the bags can be removed again and weighed. Samples are dry when no changes in weight occur between reweighing. Record these final stable values.

12 Calculating LAI from the Point Intercept Method

Leaf area index (expressed as units of **green** foliage surface area per unit of ground surface area) is determined by dividing the number of foliage hits by the total number of points in a given area.

LAI is calculated from point intercept data by summing the number of green hits per sample transect and dividing by the total number of sample points along the transect.

> e.g. there are 101 sample points per transect; if there were a total of 120 green hits along a transect the LAI would be 1.025 (i.e. 120/101 = 1.188). LAI (PIM) = 1.188

One then regresses a relationship between the direct (harvest) LAI value and the PIM LAI.

> e.g. LAI (harvest) = 0.011 + 1.1 LAI (PIM) $R^2 = 0.941$
>
> We next assume the LAI (harvest) is the true value for LAI and from this comes.
>
> LAI (PIM-corrected) = 0.011 + 1.1LAI (PIM)

LAI (PIM-corrected) is obtained from the regression and is used in subsequent calculations.

13 Calculating LAI from the LAI-2200/2000 Method

When using the LAI-2000/2200 instrument it is important to remember that the conversion from light transmission (or gap fraction) to LAI depends on crop/vegetation structure and leaf angle (and the relative contribution of wood to plant area index). The LAI-2000/2200 (used as specified in the manual) makes no attempt to correct for vegetation structure at all and guesses the leaf angle: the calculated LAI is a mathematical transformation of the gap fraction that requires calibration against reality. For example in blue gum plantations a few studies have come up with a rule of thumb that the correct answer is about 1.5 times the apparent answer from the instrument i.e. the error is not small.

One then establishes a relationship between the direct (harvest) LAI value and the LAI-2200 LAI.

> e.g.: LAI (harvest) = 0.011 + 1.1(LAI-2200 LAI) $R^2 = 0.941$
>
> We next assume the LAI (harvest) is the true value for LAI and from this comes.
>
> LAI (LAI-2200-corrected) = 0.011 + 1.1(LAI-2200 LAI)

LAI (LAI-2200-corrected) is obtained then from the regression and used in subsequent calculations.

Total LAI

The total LAI is calculated as the sum of canopy and understory LAI.

Total LAI = Canopy LAI + Woody Understory LAI (PIM-corrected) + Ground cover LAI (PIM-corrected)

or for ecosystems with a dense grass understory

Total LAI = Canopy LAI + LAI (LAI-2200-corrected)

The total LAI may be compared to the product MOD15A2 centred on the coordinates of a flux tower (8-Day Composite [Collection 5], 1 km Wide x 1 km High) from the MODIS Land Product Subsets project (http://daac.ornl.gov/MODIS/).

TERN Australian SuperSite Network
PHENOCAM MONITORING PROTOCOL

This is a preliminary set of Phenocam monitoring protocols, to be implemented during the NCRIS-2013 contract period.

Phenocam data collection is to be carried out on a continuous basis (allowing for hardware failures) during the NCRIS-2013 period.

Please send any comments, corrections and suggestions to the TERN Australian SuperSite Network Coordinator (*mirko.karan@jcu.edu.au*)

May 2014

14 AusCover Phenocams

Extracted from the AusCover Good Practice Guidelines (A technical handbook supporting calibration and validation activities of remotely sensed data products). Version 05, 25/03/2014. Natalia Restrepo-Coupe, Alfredo Huete and Kevin Davies. Plant Functional Biology and Climate Change Cluster, University of Technology, Sydney
http://data.auscover.org.au/xwiki/bin/view/Good+Practice+Handbook/PhenologyValidation

Introduction

Automated cameras have been installed across the SuperSite network with the aim of recording hourly and daily changes in vegetation. The cameras are permanently placed and will provide hourly daytime near-surface remote sensing data of the forest canopy (from the top of an eddy flux or fire observation tower) and/or understory phenology (3 cameras at each study site).

In addition several of the SuperSites have installed StarDot IP cameras that are providing live digital image data streams.

RGB and Spectral Cameras

In Australia, efforts to instrument flux tower sites with RGB cameras for phenology validation started in early 2000. Their value as a recording tool of the different phenological changes (visual or more complex analysis) has been proved in different applications (Crimmins and Crimmins 2008; Huemmrich et al. 1999). The selection between multispectral, hyperspectral and RGB cameras is generally made based on the cost and available technical resources. AusCover uses the WingScapes® RGB programmable camera which collects images to an SD card.

Camera Inclination and Azimuth

The positioning of the camera may have direct consequences on the data analysis. A combination of oblique and nadir cameras can therefore be used. The nadir looking (straight down) cameras capture an image where issues related to backscatter (sun behind observer) and forward-scatter (sun opposite observer) can be minimized. An oblique camera will capture a wider portion of the ecosystem and specifically focus on some key elements of the site. However, given that specular reflection of leaves can occur for camera inclination angles > 30° from the vertical, it is suggested to work at < 30° angles.

In the southern hemisphere, primarily in summer months (Figure 14), orienting the camera to face towards the south results in backscattering, and the image will show a bright region where all shadows are hidden (hotspot; see Figure 14). By contrast, forwardscattering (sun opposite to the observer) will result in mirror-like reflection from the leaves and bright object edges. Interesting, at many sites it is common to have both scenarios (forwardscattering / backscattering) as the solar azimuth will change during the year from N to S and vice versa.

It is preferred to seasonally maintain backscatter conditions, and limit the analysis to images collected when the sun is close to local noon (11:00 - 12:00 am), even if this configuration results in the greatest variation in the solar zenith angle (SZA). Having the sun facing into the camera is less desirable as it is difficult to separate the different vegetation components (wood, leaves, and shadows among others) (B Nelson personal communication). In summary, the camera azimuth

position is a compromise for each individual flux-tower site as it is necessary to balance the needs of the cameras with the EC, which usually has priority.

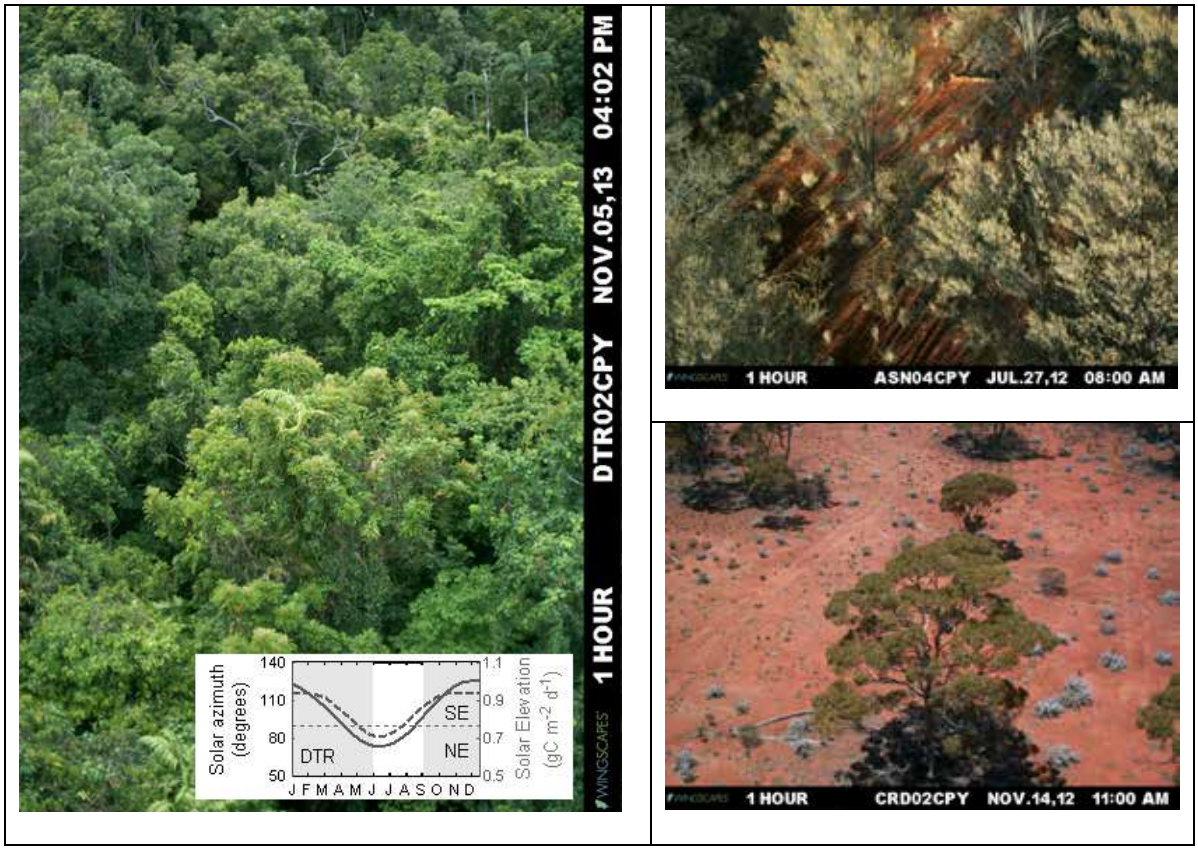


Figure 14: Camera azimuth and inclination.

Left panel: Daintree/Cape Tribulation flux tower phenocam, sun behind the observer (backscatter) and the presence of a hot spot at the center of the image (special thanks to M. Liddell and N. Weigand). Left side inset: seasonal cycle solar elevation at 11:00 am (right axis, grey), and azimuth (left axis, black), azimuth values >90 indicate sun at the southeast (SE) and <90 at the northeast (NE). Right top panel: Sun at low angle and mirror like effect on leaves. Sun behind the observer at the Alice Springs Mulga flux tower phenocam (special thanks to D. Eamus and J. Cleverly). Right low panel: Credo flux tower site phenocams images showing forwardscatter (Special thanks to C Macfarlane). Both right panels show issues posed by the shadows at arid and semi-arid environments. For all camera orientations, shadows from the vegetation and existing structures (e.g. from the flux tower) can increase the difficulty of processing the images. Using Green/Red band ratio and other ratios will decrease, but not completely remove, the influence of dark or bright areas across the image (see section on the computation of Red/Green (RGB) and NIR/Red ratios).

Over- and Understory orientations

For Australian multi-functional and multi-strata canopy types, two sets of cameras are needed to adequately characterise landscape phenologies, including an overstorey and understory camera (or herbaceous and woody layer camera). The tree layer needs an oblique view (30-60 from zenith) to capture sufficient number of trees and sampling of landscape cover while the understory should be nadir view or slightly oblique (0-30°). Azimuthal orientation should be as described in section above (camera inclination and azimuth). For the understory cameras, key

species or the location of the soil moisture/temperature array will dictate the location of the camera.

Diurnal, Daily, and Seasonal Settings (including frequency of observations)

Most phenocams record images every 30 – 60 minutes. Our experience in very wet environments (e.g. Amazon basin, see Figure 15) shows that a high frequency of images captures allows us to choose a time of day to be used when calculating the time series and to avoid using a "fixed" capture time where rain or fog may affect the quality of the images. Some researchers do select images captured during cloudy periods (under diffuse radiation) in order to avoid saturation, stray light or to correct for a seasonal changing SZA, in particular at those locations where the camera alternative captures images in forwardscatter and backscatter conditions (see the works of B. Nelson and previous section "Camera inclination and azimuth"). This approach, however, is known to introduce significant noise, thereby increasing the uncertainty of the observations, as the light environment is difficult to characterise. Arid and semi-arid sites (~75% of Australia) are cloudless for long periods of time (weeks to months), and this may translate into an incomplete time series if only images during diffuse radiation periods are used, although they will correspond to the dry/dormant season.

Some ecosystem components like the soil biological crusts respond after rain (greenup) at a faster rate (< 30 minutes). Even if the satellite will not capture these biological pulses, the phenocam can inform the flux tower measured C-fluxes about the length and spatial extent of the response - an interesting result by itself.

Camera Settings (integration times, F- stop, etc.)

Some hyperspectral cameras (e.g. SOC710 Surface Optics) allow the user to change the camera settings to obtain good quality images (spectral range, no saturation, etc.) under different light environments (e.g. outdoor or indoor locations). The f-stop regulates the aperture of the lens, a value of 2.8 or 5.6 means more light inside the camera compared to 11 or 22. Closing the lens (move the f-stop to higher values) translates in improving the depth of field and focus at the extremes of the spectrum and it can help in outdoor conditions by avoiding saturation. However, it is best to try to fix the f-stop and get more or less light into the camera via changing other parameters. Similar results can be obtained by modifying the integration time. In general, radiance and spectral factory calibrations are done using a fixed f-stop (e.g. 5.6) as it provides a good trade-off between speed and quality. If we assume that each increment in the f-stop (e.g. 5.6 to 8), cuts the illumination in half, the integration time can be doubled in order to obtain similar results (e.g. 10 milliseconds integration time at f5.6 *vs* 20 milliseconds at f-stop 8). It is always good practice to obtain the highest number of digital counts as possible.

Some cameras offer the possibility to modify the electronic gain as an alternative to integration times, as increasing integration times in windy conditions can be problematic. However, since the gain is electronic, noise in the image will also increase correspondingly. It is suggested to use a gain value of '1' or unity (no gain).

Very simple cameras (e.g. WingScapes®) do not offer any of the above- mentioned settings. However, light settings can be set to auto, sunshine, fluorescent and other light environments. As we want to capture each object reflective properties rather than changes to the camera settings, we fixed the light setting to sunshine (outdoor conditions). Moreover, if the camera allows the user to obtain RAW files rather than JPEG, it is recommended the use of RAW as Gamma

correction and other image enhancement filters are usually applied to the RAW data in order to generate JPG extension files.

Use of White/Grey References

In order to calculate reflectance, measures of incoming light are necessary. For this purpose, a reference plate (TEFLON or Spectralon) is installed in front of the camera so the image captures all or part of the plate. If the plate is going to be used as a reference it needs to be installed horizontally (see Figure 15b). Our experience has shown us that the plate can be under a different light environment than the rest of the canopy (e.g. patchy clouds) and not represent the light environment of the canopy (see Figure 15a). The area immediately around the plate should not be included on the analysis. Moreover, the spectral range of the camera is generally stretched. For example, vegetation is "dark" on the red region of the spectra (0.63 - 0.69 nm) and the plate will be highly reflective. Thus to avoid saturation, the aperture will need to be closed. However, this would not be able to capture subtle changes in the canopy due to the strong absorption in the red region by vegetation (see Figure 15c). Grey standards have been suggested to bypass issues related to spectral range and saturation but they can easily degrade (e.g. due to dirt) in outdoor conditions. References therefore seem impractical and not required if working with ratios.

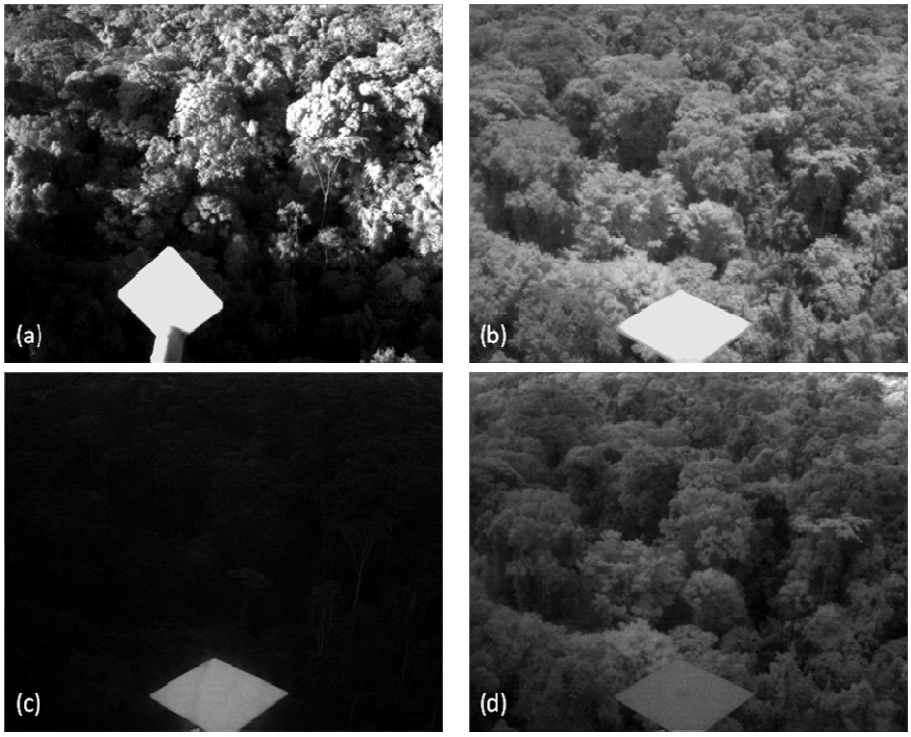


Figure 15: TETRACAM 3-band camera (NIR, Red, and Green) installed at the Amazon basin K67 eddy flux tower.

With (a) NIR band showing the TEFLON panel set vertically (check camera consistency, no use as reference); (b) NIR band showing the TEFLON plate set horizontally to be used as reference standard (note observable glare around the plate); (c) Red band; and (d) Green band. All images as Digital Counts 0-255. Acknowledgments to S. Saleska and A. Huete

14.1 WingScapes RGB Digital Camera (AusCover) Set Up

1. Three cameras per site
2. The cameras and solar panels are small (12.5 x 17 cm and 15 x 15 cm, respectively). However, we need to minimize any light obstruction.
3. Camera ecosystem 1 and 2: install one oblique, one nadir at the top of the tower
4. Camera understory 3: Install at 3 m oblique looking oblique towards the south towards the South with the sun behind the "observer" (less shadows and glare).

Materials

WS camera (3)

Solar panel (3)

Straps and Velcro

Camera mounting bracket (3)

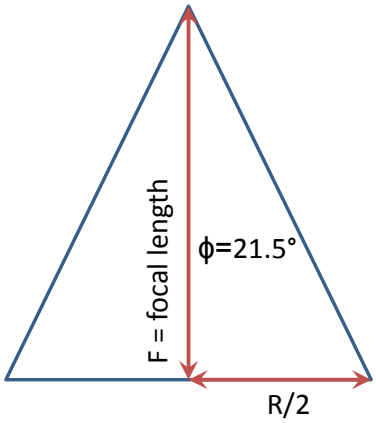
Batteries (3x6 C-batteries)

SD card (6). Therefore you are able to swap the cards.

Compass + clinometer

14.1.1 Camera properties

Lens Field of View Low, High, Max: 43 Degrees



R = image dimension

$R = 2\,F\,\tan(\varphi)$

Total Image Dimension (m)	Focal length (m)
1	1.27
2	2.54
3	3.8
4	5.0-8
5	6.35
6.54	8.3
8	10.15
10	12.69
12	15.23
15	19.04
20	25.38
25	31.73
30	38.08

Camera “program”

Time lapse interval:	1 hour
Photo or video:	Photo
Photo Quality:	High 2592x1944
Multi-program:	1-program
Program 1	Wakeup: 6 am; Sleep: 6 pm
Imprint Info:	Yes
Date/Time:	Local time Alice Springs UTC/GMT + 9:30 hours
	Local time Sydney UTC/GMT + 10 hours (no savings time)
Camera Name:	ASP-01UNDERSTORY (ASP = Alice Springs; 01: Camera 1; US: understory)
	ASP-02UNDERSTORY (ASP = Alice Springs; 01: Camera 1; US: understory)
	ROB-01UNDERSTORY (ROB = Robson Creek; 01: Camera 1; NADIR: top of the canopy nadir camera)
White Balance:	Sunlight

Radiation Footprint

Understory camera should be placed outside the footprint of the radiation sensor. LWup fov 180 deg and SWup 150 deg. Instrument installed 20 m at height.

R = 2*20*tan(75) = 149 m

R = 2*20*tand(88) = 1145.5 m

R = 2*20*tand(89) = 2291.6 m

15 StarDot IP Digital Camera Set Up

In a future iteration of funding there will be a roll out of StarDot 5 megapixel (MP) IP cameras across the SuperSite network as these have been chosen by both the US PhenoCam network and NEON networks due to its resilience to extreme environments (this will be tested by the conditions in the Daintree rainforest. The SuperSites will standardise on the IR enabled version of this camera with a 4.5-10 mm IR lens for improved image quality compared to the stock 4 mm lens. Currently two SuperSites have deployed these cameras and the installation details are as below:

Camera Details

Tropical Sites (wet):

- DOM-SEC5IR NetCam Dome 5MP IR. 4-12mm Lens, Day/Night

- Non-tropical sites:
  - CAM-SEC5IR-B – StarDot NetCam SC5 IR [1,2] (standard IP camera)
  - 4.5-10mm IR/megapixel lens [3]
  - Heavy Duty Outdoor enclosure (ENC-OUTD)

Installation of the camera needs to ensure that an appropriate water proof enclosure and water proof cabling is supplied with the camera. For dome cameras, we recommend adding significant quantities of waterproof silicon sealant between the dome mount and the camera, both above and below the waterproof mounting gasket as well as covering the mounting screws on the top of the camera mount with sealant. The back of the mount where it attaches to the pole is closed as per normal mounting instructions and the cable pass-through holes are not sealed. Fill the cavity at the top of the camera mount and the space between the cable pass-through panel and the inside of the camera mount with 2 pieces of foam from the camera packaging to provide an additional barrier to water entry into the camera. This provides a solid waterproof seal for the main part of the camera while permitting moisture to escape the housing and reducing water ingress points from the back of the camera where the wires come out.

For non-tropical installations a standard box camera can be used with the StarDot heavy duty housing. Note that this housing is not environmentally sealed but has been widely tested in extreme (non-tropical) environments. For locations that require a locking housing an alternative housing must be used.

The camera orientation is as for the WingScapes set up – canopy mount.

The timelapse images are collected as follows:

Capture rate	15-min interval*
Start Time (AM)	06:00
Stop Time (PM)	18:30
Image resolution	2592x1944 (5MP)
Avg. image size	850KB (avg of 29,000 files captured from the Daintree camera)

Camera is configured to auto-ftp an image over an Ethernet connection to a central server through modem connectivity.

Camera requires 12v nominal input (~0.5A/4w power usage)

- Capture interval can be lengthened or image size can be reduced if cellular data requirements limit amount of data that can be transferred.

TERN Australian SuperSite Network
SOIL/WATER MONITORING PROTOCOL

This is a cut back set of the complete soil/water monitoring protocols, to be implemented during the NCRIS-2013 contract period.

Soil/water sampling is to be carried out as follows. If a SuperSite has not fully characterized the soil (as per the protocol) in the core 1Ha plot then this needs to be carried out during the NCRIS-2013 period. Beyond this if a SuperSite is able to continue water monitoring then they should aim to adhere to the protocols.

Please send any comments, corrections and suggestions to the TERN Australian SuperSite Network Coordinator (*mirko.karan@jcu.edu.au*)

May 2014

16 Background

The soil/hydrology monitoring protocol for the Australian SuperSite Network aims to provide generalised data for each SuperSite describing soil types within each land use type within the ecosystem(s) being studied and baseline time series hydrological data to aid in detecting future changes in soils and water (surface and ground) in response to environmental, management or land use changes. The data will also contribute to cross-SuperSite comparisons e.g. hydrological and soil nutrient dynamics in response to the current and/or changing environment and their relationship to primary productivity.

The protocol is basically structured into four time dependent activities:

- Initial site and soil characterisation
- Annual (or event based) soil sampling
- Frequent (and/or event based) water sampling
- Repeat soil sampling (typical interval 10 years)

Regular soil and water monitoring activities will, where feasible, be coordinated with vegetation monitoring at each SuperSite. Because of the wide variation in the temporal dynamics of soil chemical and physical properties and the unique ecological questions being addressed at each site, the soil sampling protocol is not intended to be entirely prescriptive in terms of detail and frequency, but some "***essential***" analyses and procedures potentially exist.

It is ***essential*** that any land use changes, including changes in plant species, or soil management interventions within the SuperSite be fully documented and quantified if possible e.g. mineral or organic C and N additions, fire, tillage, grazing changes.

Soil measurements to be taken from:

A) Soil pit at flux tower – proximity to core 1 ha in flux footprint.
Provides physico-chemical and soil characterisation. Provides high frequency data (T, TDR, heat flux)

B) Core 1 ha Plot: 8 x perimeter cores + 1 x central core (0-10 cm & 10-30 cm)
Provides physico-chemical soil characterisation in the core 1 ha plot. Low frequency data (10 year).

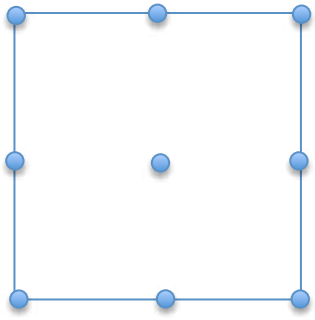
17 Summary of Soil/Water Protocols (Post 2014)

Table 5: Summary table of essential measurements for Soil / Water Protocol

Measure	Priority & frequency of sampling
Initial site and soil characterisation core 1Ha	- Essential initial assessment, soil pit within tower footprint.
OzFlux soil instrumentation: measuring volumetric water content, soil temperature and soil heat flux – soil pit	- Essential - Continuous
Hydrogeological description	- Essential - Once only
Digital Elevation Model	- Essential - Once only - Repeat only if higher resolution
Soil physico-chemical analyses **A)** Soil pit **B)** 8 x perimeter cores + 1 x central core (0-10 cm & 10-30 cm)	**A)** - Essential **B)** - Essential - Repeated in 10 years
Soil Metagenomics	- Highly desirable - sampled seasonally (wet/dry) - Repeated every year / every 5 years
Streams	- Essential where surface water exists. - Continuous water quality (telemetric level/flow, EC, temp, pH and turbidity) - Major ions and nutrients 2 x / yr - Major streams gauged for flow and surveyed. - Event based sampling where possible.

Table 6: Summary of suggested protocols and / or references relevant to NCRIS-2013

Measure	Protocol / Reference
Initial site and soil characterisation	- Digital soil map should be expressed on the basis of the Australian Soil Classification (Isbell 1996). - Local soils to be described using standard terminology (McDonald *et al*. 1990). - Standard pedological description for the profile should be made using the field survey guide from The National Committee on Soil and Terrain (2009). The soil profile pit may be the same as the OzFlux soil pit - Soil profile pits to 1.5m with depth distribution of roots recorded. - Samples for analysis to be collected as described below. If there are marked soil horizons, the horizons should also be sampled and the depth of samples noted. - Determine dry bulk density by constant volume rings or Brasher method. Four replicates per depth at each horizon or at least 10, 20, 30 cm (and at 20cm intervals below 30cm). Digital photographs taken of the soil profile and of the landscape features.
OzFlux soil pit	Standard instrumentation measuring volumetric water content (TDR 3 depths), soil temperature (surface TCAV array) and soil heat flux in OzFlux soil pit.
Digital Elevation Model	The development of a high quality DEM of the entire SuperSite and surrounding catchment contributing to the SuperSite is desirable to aid in interpretation of surface and sub-surface water flows. The DEM should extend beyond the boundaries of the SuperSite and beyond the catchment boundaries sufficiently that DEM analysis routines would be able to automatically determine the catchment boundary from the data. This should be the highest possible resolution. For most sites this will be derived from LiDAR data. If this is not available then a lower resolution product (1 m vertical resolution) may be obtained from Geoscience Australia, CSIRO. The DEM and preferably also a Digital Terrain Model (DTM) should be produced in at least BIL and TIFF formats, AusCover would also prefer a NetCDF format file if possible. Appropriate metadata must be provided with the files, this should meet AusCover requirements.

Soil physico-chemical analyses - Soil pit A - Soil cores B	- **Sample preparation**: samples air-dried to constant mass, sieved to 2 mm, roots and rocks removed and weighed. Homogenised. This must occur prior to splitting into analyses and archive samples - **Physical properties** to be determined: **Volumetric water content** - Additional soil samples should be dried at 60°C for 48 hrs to determine field water content for soil volumetric water probe calibration. - **Soil Bulk Density** - using constant volume rings at three depth increments: 10 cm; 20 cm; 50 cm and 100cm (or the Brasher method). - 500 g sub-sample of dried soil should be sent to a NATA accredited laboratory for **chemical/physical characterisation** of the soil. **Physical properties (**laboratory): Particle size/ texture (2 sand fractions 2000-200μm; 200-20μm; silt 20-2μm; clay <2μm), Volumetric water content (suction plate method). **Chemical properties (**laboratory): - Total organic C, Total C, Total N, Total P, EC, exchangeable cations (Ca, Mg, K, Na, Al), pH ($CaCl_2$), pH(H_2O), Colwell-P, trace elements (copper, iron, manganese, zinc), conductivity. *Potentially add: Mineralisable N, Olsen P, anion EC.* - Non-essential analyses on soil extracts: DOC, DON, DIC, DIN. **Samples:** **A)** Soil pit sampling Depth sampling combination method: layers with horizons. For profiles that are generally gradational samples (approx 1500g) of soil should be taken in the increments 0-0.05, 0.1-0.15, 0.25-0.30, 0.45-0.50, 0.70-0.75, 1.0-1.05, 1.45-1.5m. In addition soil samples from each horizon are to be collected. In particular where there are texture contrast and crete soils the break should be handled in a sensitive fashion to avoid mixing vastly different materials. **B)** Nine cores (50mm diameter; 0-10 cm and 10-30 cm depth) in core plot: from geo-referenced locations on the corners (4) of the vegetation plot, equidistant from corners (4) and a single geo-referenced core from the centre of the plot (1). These 9 cores will be bulked according to depth. Ideally, the individual depths should not be disturbed as these will be analysed separately to the bulked depth samples. Soils should be stored in a refrigerator prior to analysis in the laboratory. Core samples, rather than auger samples are preferred because the subsampling for depth and bulking will be more accurate. Where core samples cannot be taken (e.g. in stony soils) auger samples taken with care to keep the depths separate will be needed. 
Bores	- At least one bore (with associated depth logger) should be located at each SuperSite in the first instance to a depth that ensures the water table is accessed throughout the dry season, through droughts and accounting for likely long-term trends, whether rising or falling. - Location and depth of existing bores and new piezometers should be geo-referenced and included as a GIS theme. - If additional bores are to be established, no less than three bores should be established along any hydraulic gradients.

	- Shallow wells are to 2.5 m or a perched horizon, whichever is the shallower. Shallow bores must be established to at least 1 m below the (dry season) water table unless there is an impeding layer preventing this. - If there are multiple aquitards (water impeding layers) then piezometers should be established to just above each impeding layer. This means if there were 3 aquitards there may be three (nested) side by side to different depths. Any piezometer penetrating an aquitard must be sealed with bentonite or equivalent at and above the aquitard. - Detailed bore installation procedures are available from Richard Silberstein (CSIRO). - Root depth to be assessed on cores during bore drilling where feasible. - It is ESSENTIAL that at least one measurement be conducted of complete analyses in all bores early in proceedings. All the named analytes below should be included. Water samples should thereafter be collected on a six monthly basis at minimum (dry season, wet season). Water samples collected and stored in polyethylene bottles and refrigerated. If possible, the bottles should be filled and closed with little or no air and filtered (GF/C filter) as soon as possible after collection, and the proportion of sediment determined. - Essential analyses should include *pH, EC, ammonium---N, nitrate---N, DON, DOC, total---N, total---P and major ions, (Al^{3+},* Mn^{2+}, Fe_{tot}, Mg^{2+}, Na^{+}, K^{+}, Ca^{2+}, Cl^{-}, SO_4^{2-}, HCO^{3-}). - Groundwater sampling requires special equipment and may require precautions to prevent changes in water quality due to reduced pressure when brought to the surface that cause release of gases and exposure of water to air which may cause changes such as oxidation. - The bore should be pumped for three bore volumes, preferably start near the top and lower the pump down to the screen to ensure a complete turnover of bore water. Once the water turnover has been achieved sample from the centre of the screen. This can be done using the pump. It is best to monitor the EC (and pH) as the water is pumped to check for stability of water condition as sometimes three volumes is not enough to ensure a uniform sample. However, also sometimes this may not be reached and a decision is required whether enough pumping has been done. Pump at a rate slow enough not to cavitate or introduce air into the water. This is especially important if sampling for dissolved gases. A bore bailer can be used for most dissolved ion sampling and dissolved organics. Fill the sample bottle to the top to remove air and ensure well sealed. It can be useful to store the bottles upside down to ensure a water seal. Samples for dissolved organics may require refrigeration or freezing on sampling. In all cases analysis should be undertaken as soon as possible after sampling. - For special analytes advice may be needed about possible corruption due to PVC glue or other bore construction materials or pump hose and fittings. - For sample collection refer to AS/NZS 5667 11 1998 (Water Sampling Guidelines—Part 11 Guidance on sampling ground waters).
Soil Metagenomics	- BioPlatforms Australia BASE Soil and contextual data collection protocols to be followed. - Sub-samples (approx 50 ml) of the pooled mixed samples (0-10cm and 10-30cm depths) used in soil physico-chemical analysis (Eight + central core) will be frozen as soon as possible and sent to the Australian Genomics Research Facility in Adelaide for analysis.
Streams	- Water samples collected on a six monthly basis at minimum (dry season, wet season), stored in polyethylene bottles and refrigerated. The bottles should be filled and closed with little or no air and filtered (0.45µm) as soon as possible after collection, proportion of sediment determined. - Further guidance for environmental sampling can be found in the Monitoring and Sampling Manual 2009 Environmental Protection (Water), (http://www.ehp.qld.gov.au/water/monitoring/monitoring_and_sampling_manual.html) - **Essential analyses** should include pH, EC, ammonium-N, nitrate-N, DON, DOC, total-N, total-P and major ions (Al^{3+}, Mn^{2+}, Fe_{tot}, Mg^{2+}, Na^{+}, K^{+}, Ca^{2+}, Cl^{-}, SO_4^{2-}, HCO_3^{-}). - Additional **non-essential analyses** should include total particulate N, orthophosphate (PO_4^{3}),

	dissolved organic P, total dissolved P, total particulate P. - At some SuperSites, **automated sensors** are deployed, which consist of a physico-chemical sensor (e.g. Sonde 6600 V2, YSI incorporated, Ohio, USA) to measure temperature, pH, Eh, conductivity, turbidity, DO and a velocity Doppler (e.g. Argonaut-SL, Sontek/YSI, San Diego, USA) to measure water flow and stream height.
Archiving soil samples	- Specimens must be stored in long-lasting, air-tight containers with permanent, unambiguous labels that record site number, location, depth, date of sampling, fineness of the specimen (e.g. < 2 mm) and other relevant identifiers. Labels should be on both the container and lid – a copy of the label on plastic or similar material should be placed inside the container with the specimen. The soil archive inventory and database from the monitoring program should be integrated. Specimens must be matched to database records (e.g. using bar coding) - Data entry: all data pertaining to the soil specimens needs to have been entered into the SuperSites data base. It should also include ancillary data that capture details of land management practices, anomalies of particular years, observations of pests and diseases and any other factors considered relevant to future interpretation.

TERN Australian SuperSite Network
ANT MONITORING PROTOCOL

This is a draft ant monitoring protocol to be implemented during the NCRIS-2013 contract period.

Samples are to be collected twice during the NCRIS-2013 period according to the milestone table.

Please send any comments, corrections and suggestions to the TERN Australian SuperSite Network Coordinator (*mirko.karan@jcu.edu.au*)

May 2014

Rationale

Ants are Australia's dominant faunal group in terms of biomass and energy flow. They occupy all trophic levels, act as ecosystem engineers, feature in many mutualistic interactions with plants, and are a key food resource for many vertebrates. Ants are also Australia's best studied insect group in terms of biogeography and community dynamics. They are the most widely used invertebrate bio-indicators in environmental assessment and monitoring. Ants are a focal faunal taxon for the Australian Transect Network (ATN) component of TERN, and have also been sampled at many GWW sites.

18 Ant Sampling Procedure

Ants are readily sampled for monitoring purposes using pitfall traps. Pitfall traps are especially effective in open habitats, where the great majority of ant species are trappable. Pitfall traps capture less of the fauna in tropical rainforests (which support a high diversity of specialist arboreal taxa), but have still proven effective for environmental assessment and monitoring in these habitats. Pitfall traps have been used to sample ants at thousands of sites from throughout Australia over the past 30 years.

Pitfall traps are standard 4 cm plastic medical specimen containers with ethylene glycol or propylene glycol (to a depth of 1 cm) placed in the bottom to preserve the samples.

Twenty pitfall traps are placed in a standard grid (4 x 5) with 10 m spacings within the core 1 ha in permanent positions marked with PVC tubes (or inverted traps). If the position on the grid is occupied by a tree or rock then the trap is placed adjacent to it. Trapping is conducted over 3 days with traps sealed with screw cap at the end of the period. Remove any dirt, plant material or other debris. Contaminating material can stain the ants if left with them for extended periods. It is especially important that the tubes be stored in the dark as light will cause colours to fade and the cuticle or integument will deteriorate over time, greatly reducing the usefulness of the material for taxonomic studies and making identifications difficult or impossible.

Ensure traps are buried with lips completely flush with the soil surface. Light rain does not interfere with trapping, however heavy rain may wash out traps through surface flow. If this happens it is best to repeat the sampling.

Sampling is conducted twice each year, in March/April and October/November.

Management of Samples

The sealed traps will be sent for processing, identification and curation of samples at CSIRO's Tropical Ecosystems Research Centre in Darwin (Alan Andersen), This laboratory holds the most comprehensive collection of Australian ants (currently 5,900 species), and has Australia's leading capability in ant biogeography, community ecology and the use of ants as bio-indicators in land management. This laboratory is managing the TERN ATN ant sampling program. Non-ant bycatch will be stored for future reference.

When taxonomic identification is complete a reference collection will be sent back to each SuperSite.

Send samples to:

Alan Andersen

CSIRO Darwin,
564 Vanderlin Drive,
Berrimah, NT 0828

Human Resource Requirements

Two samples from each of ten sites would take approximately ten weeks of processing time in the laboratory, including the curation of a voucher collection of species.

TERN Australian SuperSite Network
ACOUSTIC MONITORING PROTOCOL

This is the acoustic monitoring protocols to be implemented during the NCRIS-2013 contract period.

Acoustic data collection is to be carried out on a continuous basis (allowing for hardware failures) during the NCRIS-2013 period.

Please send any comments, corrections and suggestions to the TERN Australian SuperSite Network Coordinator (*mirko.karan@jcu.edu.au*)

May 2014

19 The Song Meter SM2+

Overview

The Song Meter SM2+ is an environmental acoustic sensor, designed to remain deployed in the field recording continuously for extended periods of time. The Sensor cover, when properly closed, is weather-tight and vented to protect against condensation and stress on seals caused by pressure changes. While it is designed to survive temporary immersion in water, it is not designed or recommended for underwater use.

All of the sensors electronics, batteries, data storage flash cards, and controls are mounted inside the enclosure to protect them from the elements, and are therefore inaccessible without removing the enclosure's cover. Figures 16 and 17 illustrate the inside of the sensor.

For comprehensive instructions please consult the Song Meter User Manual at: http://www.wildlifeacoustics.com/images/documentation/SM2plus1.pdf

Removing and Replacing the Cover

There are four plastic cover screws in the corners. These screws have clips to prevent them from falling out and getting lost. When closing the cover make sure the indicator LED window is correctly oriented over the LED on the circuit board and tighten the screws by turning them clockwise. The foam insert on the inner side of the lid is to prevent battery movement.

Figure 16: Song Meter SM2+

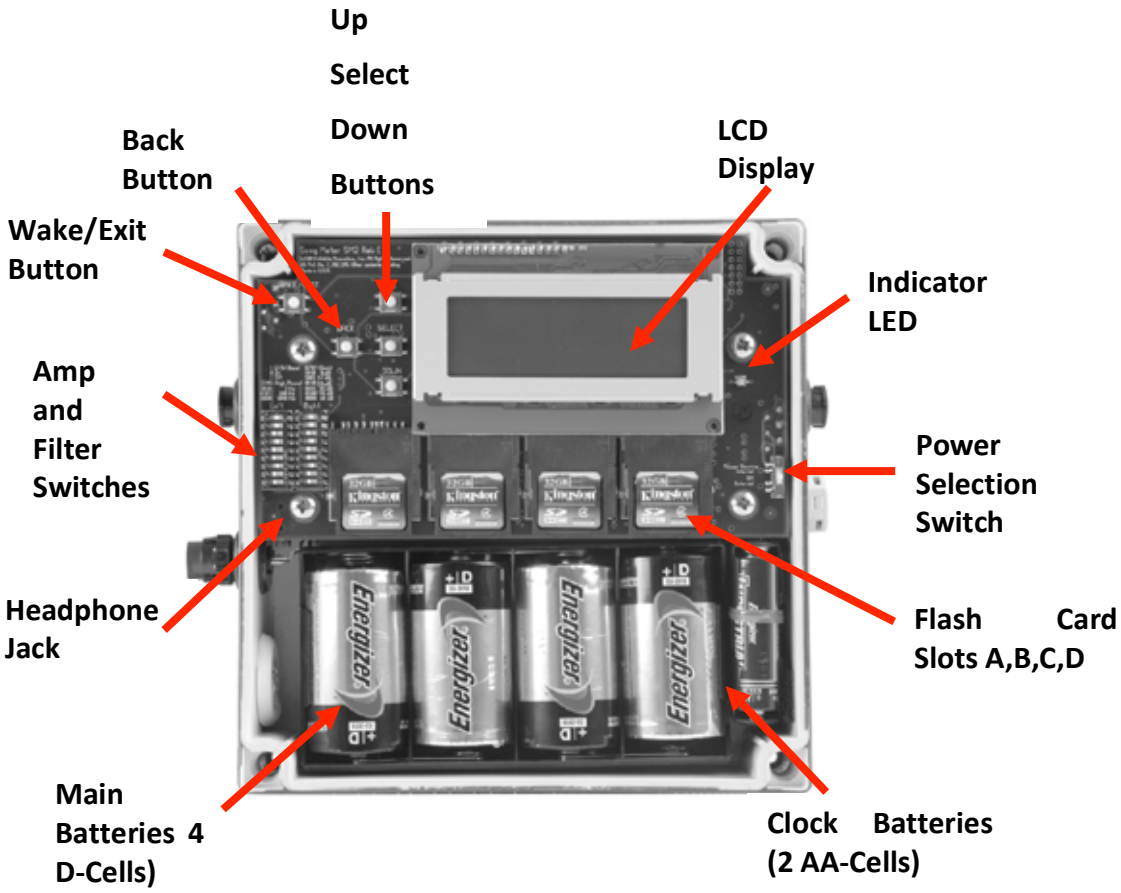


Figure 17: Inside of sensor

Power Resources

Each unit requires 4D cell batteries. Batteries last for approximately 14 days. Rechargeable batteries have very high failure rates, so use good quality alkaline batteries (i.e. Duracell Procell).

The Power Selection Switch can be used to select between “internal” and “external” power sources and to turn the unit “off”.

If an external power source is used (and memory cards swapped out at longer than 14 day periods) ensure that files are stored in the compressed .WAC4 format.

Clock Batteries

Song Meter uses two AA alkaline batteries to power the clock. These batteries should last between two and three years, but it is recommend that these are replaced every year as the Song Meter will not operate when these batteries are depleted.

Installing Memory Cards

Standard SD memory cards can be used. The four card slots can be populated with one to four flash cards of assorted capacities.

You must install at least one flash card in order for the Song Meter to make and store recordings. Up to 0.5 Tb of memory can be loaded, but it is recommended that data is downloaded at no more than 3 monthly intervals so that recording quality can be checked.

Installing Microphones

The SMX-II weather-proof microphones can attach directly to the left and right microphone input connectors on the Song Meter. Alternatively, they can be extended on cables. **Note that the microphones are fragile - they should be removed from the Song Meter during transport.**

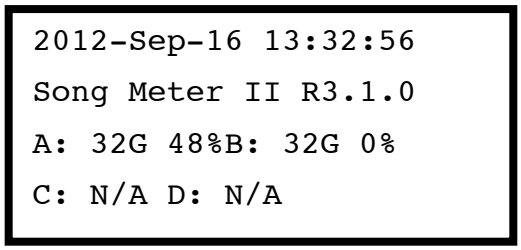
Mounting the Sensor

Where practical, the sensors should be deployed at roughly chest height on a star picket in the centre of the core 1ha plot.

Please also refer to the pre-deployment checklist further below before deploying.

Switching the Sensor ON and OFF

To switch the Sensor On/Off press the "Wake/Exit" button (see Figure 2). When the Sensor is switched on, the display will look something like this:



The top row displays the current date and time and is updated every second. The bottom two rows display the status of the four SD card slots labelled "A" through "D". If no SD card is plugged into a slot, "N/A" is displayed to indicate that the slot is not available.

Sensor Configuration

The sensors sent from QUT have been pre-configured to record for 12 hours per day (6 hours around dawn and 6 hours around dusk). They will adjust themselves to record at the correct time (relative to sunset and sunrise) throughout the year using the GPS coordinates of the individual sites. If Sensors require configuration contact Jason Wimmer (QUT) to get appropriate configuration files and instructions.

Configured to record 12 hours per day, the units will run for approximately 14 days before running out of battery power. At this point, the batteries will need to be replaced and the data should be transferred from the SD cards.

Sensors are configured to record at 44100 Hz in stereo at 16 bits and store files in .WAV format if using internal batteries or compressed to .WAC4 files if using an external power source. While the 44100 Hz sampling frequency exceeds what is required for Australian bird songs, it was selected to future proof the analysis of the dataset for other purposes.

For more details on configuration see:
http://www.wildlifeacoustics.com/images/documentation/SM2plus1.pdf pp 15-25

Menu Navigation

Press the “Wake/Exit” button, then press the “Select” button to enter the main menu. The display will look like this:

```
Song Meter Main Menu
= Schedule (daily)
- Settings
- Utilities
```

The double underline indicates the blinking cursor position. Each menu screen can only display three lines at a time, scroll down using the “Down” button.

The “Up” and “Down” buttons can be used to scroll through the menu choices. To select a menu choice, press the “Select” button. To return to the previous menu, press the “Back” button. From the Main Menu, you can press the “Back” button to return to the start-up screen.

The “Wake/Exit” button will start or resume the recording schedule.

Start Recording Schedule

Press the “Wake/Exit” button. If the next scheduled recording is more than 45 seconds away, the following message is displayed:

```
2012-Sep-16 13:34:12

Going to sleep until
2011-Sep-17 05:30:00
```

The top row indicates the current time and date. The bottom shows the next scheduled recording start time. After 5 seconds, the Song Meter will go into a deep sleep and the display will go blank. You should now replace the protective cover.

If the next scheduled recording event is in progress or within 45 seconds away, the Song Meter will begin preparing to record and begin recording at the correct start time (or as soon as possible if a scheduled recording is already in progress).

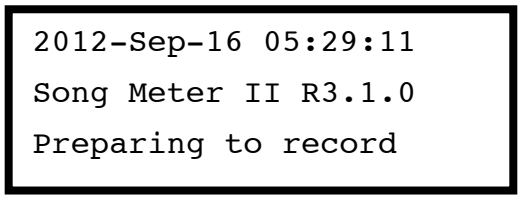
Making Recordings

Once configured, pressing the “Wake/Exit” button will cause the Sensor to put itself to sleep until the next scheduled recording event.

The Sensor will automatically wake up about 30 seconds before the scheduled event.

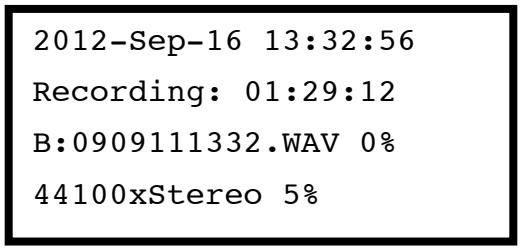
```
2012-Sep-16 13:32:56
Song Meter II R3.1.0
A: 32G 48%B: 32G 0%
C: N/A D: N/A
```

After scanning the four SD flash card slots, the message “Preparing to record” will appear:



Note that if a scheduled recording time is already in progress, the Sensor will begin recording as soon as it is ready to do so and end the recording on schedule. You can abort the next recording and return to the main menu by pressing the “Wake/Exit” button.

When the Sensor begins recording, the display will indicate progress as shown below:



The top line of the display shows the current date and time as before.

The second line indicates the time remaining in the current recording.

The third line shows the flash card slot and short file name of the recording file (MMDDhhmm.WAV) and the percent complete.

The last line shows the sample rate and number of channels (x2 for stereo, x1 for mono), and the percentage indicates how full the SD flash card slot is on which the recording is being made.

You can press the “Select” button to toggle between the displays.

Aborting a Recording in Progress

While the Sensor is recording, you can press the “Back” or “Wake/Exit” to abort the recording in progress.

Manual Recording Feature

In addition to recording on a schedule, the Sensor can also start a recording when the start-up screen is displayed by pushing the “Up” and “Down” buttons simultaneously. This will start a one-hour recording on the lowest lettered slot on which the recording will fit.

Pressing the “Select” button toggles between display modes and headphone.

19.1 SM2+ Configuration Instructions

The SM2 acoustic sensors can be configured using a PC-based configuration utility (the Songmeter Configuration Utility), which generates configuration files for uploading to the units. If required, you can get a copy of individual SuperSite configuration files from the SuperSites Data Officer (Shiela.lloyd@jcu.edu.au) or Jason Wimmer at QUT. Configuration files are uploaded by copying the configuration file to an SD card, inserting the SD into slot A in the SM2, and following the configuration upload steps below.

1. Turn the SM2 on, using either internal or external batteries.

2. Insert an SD card with the configuration file copied to the root directory (ie not in a subdirectory on the SD card) into Slot A in the SM2 (see Figure 18)

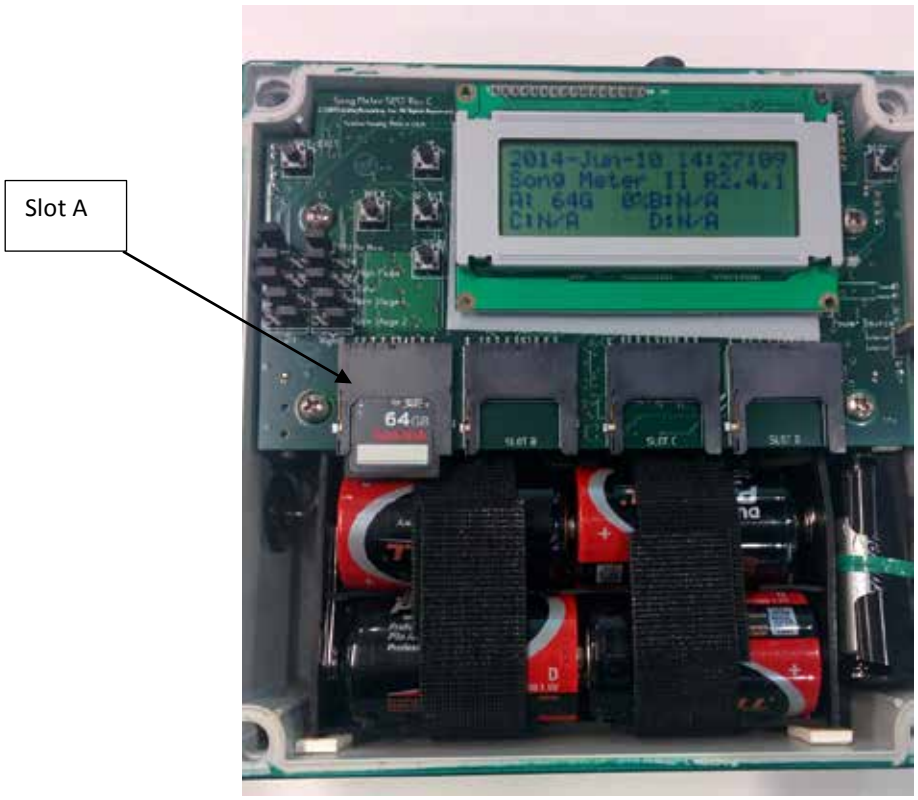


Figure 18: Position of Slot A

3. Navigate to the SM2 main menu using the select button (see Figure 19).

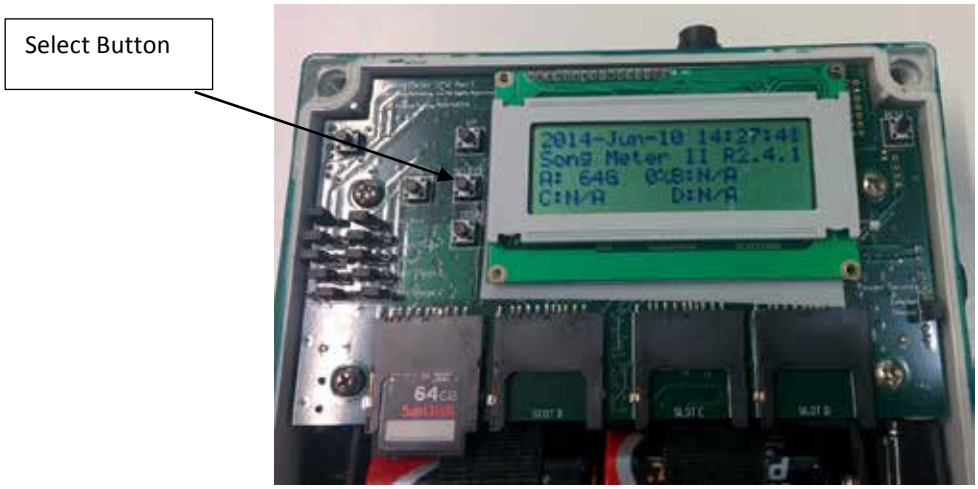


Figure 19: Location of Select Button

4. Navigate to the Utilities menu using the Down button (see Figure 20).

Figure 20: Down Button and Utilities Menu

5. Press the Select button to enter the Utilities menu, and navigate to the *Load config from A:* menu item using the Down button (see Figure 21).

Figure 21: Utilities Menu and Load config from A:

6. Configuration files have the .SET extension and may be named SONGMETER.SET or SITENAME.SET e.g. ALICE1.SET. Select the appropriate .SET file using the select button (see Figure 22).

Figure 22: Select configuration .SET file.

7. When configuration file has loaded successfully a CONFIGURATION LOADED message will display briefly (see Figure 23). When loaded, press the back button to return to the main menu or home screen.

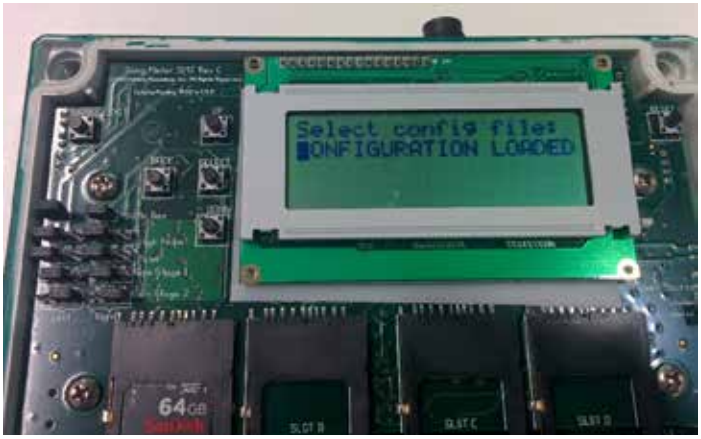


Figure 23: Configuration Loaded Message

Detailed instructions on using the Songmeter Configuration Utility and loading configuration files are also available in the SM2 User Manual (http://www.wildlifeacoustics.com/images/documentation/Song-Meter-Users-Manual.pdf).

Acoustic Recording Metadata

Ensure that a metadata file is supplied to the SuperSites Data librarian for each site where a sensor has been deployed. Ensure sensor site names and exact GPS coordinates for each are recorded (these can be made less accurate for publication if security is an issue). Specify a start date for when recording started at each site. Acoustic monitor details (eg. Song Meter SM2+).

QA/QC of Acoustic Data

Before transferring data listen to the beginning and end of each recording for sound quality. The microphones are prone to degrade over time in the field. They may require replacement every 6 months to a year.

19.2 SuperSite FTP Instructions

1. Download and install FileZilla (http://filezilla-project.org/download.php)
2. Open FileZilla and select 'File', 'Site Manager…'
3. Select 'New Site' and give the site a name (e.g. TERN Upload)
4. In the General tab, fill out the following details:

   Hostname: bush.fm

   Port: 22

   Protocol: SFTP (SSH)

   Logon Type: Normal

   Enter the **Username** you have been provided

   Enter the **Password** you have been provided
5. We don't need to worry about any of the other tabs, so select 'Connect' to connect to the upload site. **Note**: you will need to have internet access enabled to connect.

6. Once you have connected successfully you will be taken to your home directory on the server which appears on the right side of the screen. The left side of the screen is your local computer.

7. Double click on your home directory (same as your username, e.g.: fnqr) to make it your current location. This directory is owned by you and you have full access to create, modify, or delete all files and directories inside it. To create a directory, right click on the file list area and select 'Create directory'.

8. To have consistencies between Supersite and to allow data ingestion, please follow the guidelines to organise the files under directories structure. The structure should follow `site/sensor/year` format.

    a. The `site` is the first level directory that represents a specific region that has one or more sensors. The name of the `site` directory can be anything, for example, `site_1`. However, something more descriptive is preferred. For example, under seqp, we have `karawatha` and `samford` sites. If you only have one site then just create one site with the name of the Supersite.

    b. Within each `site` directory, please create `sensor` directory that represent each of the sensor deployed at the site. You can use any name that can be user to easily identify the actual sensor at particular location. For example, `sensor_1`, `sensor_2`, `sensor_a`, `sensor_b`, `plot_a`, `plot_b`, etc. If you only have one sensor deployed then just create one directory.

    c. Within each `sensor` directory, please create a `year` directory for each year that any recording was made, for example: `2013`, `2014`. This is to avoid a single directory having too many files which may slow down read access of the directory. Please upload the respective file within the right `year` directory.

    d. For example, the structure should look like this:

```
seqp
├── karawatha
│   ├── plot_e1
│   │   ├── 2012
│   │   └── 2013
│   └── plot_e2
│       └── 2012
└── samford
    ├── sensor_a
    │   └── 2014
    ├── sensor_b
    │   ├── 2013
    │   └── 2014
    └── sensor_c
        ├── 2013
        └── 2014
```

9. All data from each sensor should then be dumped straight into the respective sensor directory. All you need to do is select all the files from the correct sensor and drag and drop them into the corresponding `site/sensor/year` directory on the server. The "sensor_a", "sensor_b" etc folders relate to the location of the acoustic monitor within the SuperSite. If an acoustic sensor is

moved to a new location within the SuperSite then create a new folder. If you wish to name the sites to something more descriptive, please feel free to do so.

Original Data Transfer Method

This may be useful if the FTP method is problematic.

Data should be transferred from the SD cards to the 1TB external USB drive. Once the data has been successfully transferred from the SD cards to the external drive, please delete the data from the SD card, re-insert it in the sensor and redeploy. Please return the external USB drives to the address below every three months to have the data uploaded to the central repository. Ensure you send an email to miro.karan@jcu.edu.au before posting the drives. Please also keep a copy of all the data stored on the external drive in case it fails or is lost in the post. Once the data has been uploaded, the external USB hard drives will be returned.

Mirko Karan
TERN SuperSite Coordinator
James Cook University
Cairns Campus
Building E1, Room 102B
14 – 88 McGregor Road
Smithfield
Cairns
Queensland 4878

The external drives are USB 3.0 compatible, so if possible use a computer with a USB 3.0 port to save time transferring the data. Otherwise, downloading takes approximately 1 minute per GB.

19.3 TERN Acoustic Sensor Solar Configuration

The solar power setup comprises a deep cycle 12 volt battery, charge controller, solar panel, pole mount and SM2 external power adapter cable.

- Battery: http://www.apolloenergy.com.au/Renewable-Energy-Components/Batteries/N50-GEL
- Charge Controller: http://www.apolloenergy.com.au/Renewable-Energy-Components/Charge-Controllers/SS-10L-12V
- Solar Panel: http://www.apolloenergy.com.au/Renewable-Energy-Components/Browse-by-Manufacturer-Suntech/STP020S-12-Cb
- Solar Panel Pole Mount: http://www.greensystems.com.au/products/product.php?prod_code=GS-MNT-02
- SM2 (acoustic sensor) external power adapter cable: http://www.wildlifeacoustics.com/wa-php/order.php#power

You need:

- 2 x star pickets (preferably 240 cm)
- Battery box similar to this http://www.jpwmarine.com.au/products/electrical/battery-boxes/battery-box-standard-size.aspx
- Multimeter (http://www.jaycar.com.au/productView.asp?ID=QM1500)

Installation:

1. The entire setup is not particularly bulky, but the battery weighs about 24kg, so vehicular access to the site would be an advantage.
2. The solar panel pole mount can be mounted on a star picket. The mount has been designed to accept the Suntech 20W solar panel without any modification, but please test both mounting of the solar panel and attaching to a star picket beforehand http://www.greensystems.com.au/files/pdf/products/GS-MNT-02_pdf.pdf. There may be some slight modifications required.
3. Some wiring will be required when deploying the solar setup to connect the solar panel to the charge controller, charge controller to the battery and sensor. This will require a screw driver, pliers and wire strippers. If possible bring a multimeter with you as well, for fault finding (http://www.jaycar.com.au/productView.asp?ID=QM1500). Instructions for the charge controller are included here: http://www.apolloenergy.com.au/core/media/media.nl/id.245333/c.851604/.f?h=9667c223a94e62fe2322
4. The solar panel should be mounted on a star picket and oriented to the north at an angle of approximately 30 degrees (Figure 18). The solar panel should be mounted on another star picket next to this, with the battery and charge controller in between.

Figure 24: Star Picket

5. The battery and charge controller are fairly robust, but should be kept off the ground and out of direct sunlight. Try using plastic marine battery enclosures like this: http://www.jpwmarine.com.au/products/electrical/battery-boxes/battery-box-standard-size.aspx Use a couple of house bricks to keep them off the ground. Also sprinkle ant granules in the bottom to keep the ants away.
6. If you have any cattle or other curious animals, you may need to consider a little electric fence setup, such as: http://www.sureguard.com.au/products/Farm-Electric-Fencing/Portable-Budget-Electric-Fence-12-Volt The solar configuration selected should support this, but you may need to increase the solar panel size to 40W.
7. In terms of maintenance, give the solar panel a wipe and check the cables for damage when you change the SD cards.

Sensor Setup:

1. Attach the SM2 external power adapter to the SM2 external power input (below the left-hand microphone input). See Figure 16.
2. Switch the SM2 from internal to external power using the power selection switch. See page 4 and page 10 **http://www.wildlifeacoustics.com/images/documentation/SM2plus1.pdf**
3. When connected to the battery, the unit should power up as normal.

19.4 Pre-Deployment Checklist

1. Inspect the Sensor for damage inside and out. Verify that the three input connector nuts (left and right microphone inputs and external power input) are finger tight and that the weatherproof vent is also finger tight by turning clockwise. Never turn the nuts or vent counter-clockwise. Also verify that the cable gland is well seated and not punctured.
2. Install four fresh high-quality alkaline batteries in the main battery tray. Always remove flash cards prior to inserting or removing batteries to avoid damage to the card connectors.
3. Test and replace the 2 AA clock batteries annually.
4. Check to make sure that the date and time are set correctly and the clock is running.
5. Check to make sure you have the latest version of firmware (http://www.wildlifeacoustics.com/).
6. Check the Zorb-It® packet installed on the inside cover. If it is noticeably swollen, it may have been exposed to liquid water and should be replaced. For more information, visit www.zorb-it.com.
7. After installing flash cards and microphones, use the instant record feature to make a test recording, and listen to the test recording to verify your audio settings are set as intended. See “Manual Recording Feature” above.
8. In hot environments, avoid exposing the Sensor to direct sunlight to ensure that the inside temperature does not exceed the rated limits of the Sensor or batteries.
9. When you put the Sensor to sleep with the Wake/Exit button, make sure it indicates the expected wake-up time.
10. Make sure the indicator LED is flashing once per minute when sleeping or once per second while recording before walking away.

TERN Australian SuperSite Network

ISOTOPE AND PLANT GENETIC SAMPLING PROTOCOL

This is a leaf stable isotope / DNA plant bar-coding monitoring protocol to be implemented during the NCRIS-2013 contract period.

Sampling is to be completed during the NCRIS-2013 period as per the milestone table.

Please send any comments, corrections and suggestions to the TERN Australian SuperSite Network Coordinator (*mirko.karan@jcu.edu.au*)

May 2014

20 Sampling Procedure for Stable Isotope and Plant Genetic Analysis

20.1 Plant Isotope Sampling - Leaves/Needles

Leaf samples will be collected from at least 20 plant species (trees, shrubs, grasses, forbes) at each core 1 ha plot and processed as follows to facilitate ^{13}C analyses.

1. Leaf/needles samples should be collected from significant functional types and dominant species based on basal area. Five trees (ideally) of each species to be sampled, where possible. If not five, then three or four, where possible.
2. Sampling the crown:
    a. For short (< 2 m tall) trees/shrubs: Leaves/needles should be sampled from branches that are of similar length from the upper third of the crown.
    b. Sample from the north facing aspect of the crown.
    c. For taller trees (> 2 m) samples should include bottom, middle and the top thirds of the crown, where possible. If this isn't possible, the upper third of the crown is requested. Within each third of the crown, (i.e. upper, middle, lower) try to sample branches of (approximately) the same length. Sample from the outer third of each branch.
    d. Keep samples from each tree and from each part of the crown separate from each other, and labelled (**Species, Date, Time, Location** (geographic), **Tree Number, Leaf Number** (e.g. Tree 1 Leaf 1, Tree 1 Leaf 2 etc). **Part of Tree** (crown position) the sample was taken from.
    e. Sample mature fully expanded leaves, preferably not diseased.
    f. Collect two leaves from each of the five replicate trees, leaves should **not** be collected from the same branch, if you can avoid it.
3. Samples should be collected once, in March/April or October/November, to coincide with ant monitoring (however, further sampling in an opposing season would be scientifically very useful, but not a milestone requirement for this funding period).
4. Individual sample weight should be *around* 1 g (fresh weight).
5. Collected leaves can be stored in plastic zip-locked bags. Alternatively 50 mL centrifuge tubes (capped) may be used.
6. Samples can be dried at 80º C for at least 48 h. If you can't get to an oven in the field you can air dry the samples in the sun. It is important to minimise respiration during storage, so either dry them quickly in the field in direct sunlight, and then store in a fridge, or if the weather doesn't allow quick drying in the field, then frozen in the field until drying in the lab is a good alternative, as freezing them will stop the respiratory losses during storage in the field. To keep leaf samples useful for DNA extraction leaves can be dried in paper bags with sachets of silica gel for drying, or use a teabag in a sealable lunch box with 1 cm of silica granules (10% self-indicating mixed with 90% standard non-indicating granules) and seal.
7. Once samples are dried, they can be kept dried, double plastic bagged in a freezer until posting.

8. Dry samples can be sent to University of Technology Sydney (address below), or you can grind them to a fine powder in a ball mill grinder prior to sending in microcentrifuge tubes. A minimum of 150 mg dry weight is required per sample.
9. Each sample should be labelled. The label should include: **Species, Date, Time, Location** (geographic), **Tree Number, Leaf Number** (e.g. Tree 1 Leaf 1, Tree 1 Leaf 2 etc). **Part of Tree** (crown position) the sample was taken from.
10. Record tree dimension (**DBH** and **Height**). Tree height can be estimated or categorized in height class 0 – 2 m; 2 – 5 m; 5 – 10 m; etc.

Post samples to:

James Cleverly

University of Technology Sydney,

UTS Science Store,

Building 1, Level 2, Room 40C,

Thomas St,

Ultimo 2007 NSW

and send an advisory email James Cleverly <James.Cleverly@uts.edu.au>

20.2 Wood Sampling for Isotope Analysis (OPTIONAL)

Take cores (at least five or six centimeters long) from the trunk at 1 m height above the ground. UTS can assist with lending people / core samplers if required.

It is important to keep the spatial relationship along the core intact, even if the core itself breaks into 2 or more pieces, so that we know that as we sample the core along its length, we are moving backwards in time. Wrapping the core in cling-film and binding with tape along its entire length can assist in this. Packing several (labelled) cores into lengths of small diameter (1 cm) plastic water pipe inside a jiffy bag can be used for posting.

Storing in the cold before sending is preferred as this minimizes fungal/bacterial growth during storage.

Sample one core from 3 – 5 replicate trees per species. Label cores with:

1. *Species ID*
2. *Tree size (DBH, H)*
3. *Date of Sampling.*

20.3 Plant Genetic Sampling

Protocol abstracted from the AusPlots Rangelands Survey Protocols Manual (White *et al*. 2012).

Leaf samples will be collected from at least 20 plant species (preferably more) at each core 1 ha plot and dried to enable subsequent genetic analyses. By collecting these samples in synthetic tea

bags and gathering a sufficiently large volume of material, one field sample can be sub-sampled to enable both genetic and isotope analyses to be undertaken.

1. Collections may be made during voucher specimen collection or specifically for genetic/isotope studies. If collecting a voucher specimen for identification and lodging in state herbaria (as per the vouchering protocol), take a small sub- sample (equivalent to around 10 cm^2 or five eucalypt leaves) of green leaves and ensure labelling of sub-sample indicates the link to the vouchered specimen.
2. The collected material (around 10 cm^2) should be young and free from disease, insect or fungal contamination wherever possible.

   Handle the sample to minimise skin contact and hence contact with other sources of organic carbon (important for the isotope analysis). For broad-leaf plants, hold the leaves by the petiole (leaf stem) or by the base of the leaves for grasses where possible. This sample should then be carefully placed into a synthetic teabag and sealed.
3. Label the teabag with an adhesive voucher label.
4. Place the teabag in a sealable lunch box with 1 cm of silica granules (10% self-indicating mixed with 90% standard non-indicating granules) and seal. If possible a single lunchbox, clearly labelled with the plot identifier should be used for each plot.
5. Over the duration of a sampling trip replace the silica granules when necessary. When the self-indicating granules change colour from blue to pink their moisture absorbing capacity has been reached and the granule mix should be replaced with fresh silica mix. Do not discard the used silica, as it can be oven dried and re-used.
6. Store the container in a cool location out of direct light and then send all samples in a batch to the SuperSite Central:

M. Liddell
James Cook University,
Building E1 Room 102B,
McGregor Rd.
Smithfield Qld 4878

Plant genetic samples will be collated and barcode identified to allow integration into the University of Adelaide / AusPlots Rangelands database and repository.

TERN Australian SuperSite Network

AVIFAUNA MONITORING PROTOCOL

Provided are two field monitoring approaches for bird surveys that are currently being used in the SuperSite network that may aid the adoption of particular methods during the NCRIS-2013 contract period.

Avifauna sampling is to be carried out twice a year at a minimum during the NCRIS-2013 period.

Please send any comments, corrections and suggestions to the TERN Australian SuperSite Network Coordinator (*mirko.karan@jcu.edu.au*)

May 2014

21 Avifauna surveys

Background

The fauna monitoring protocol aims to provide generalised data (biodiversity and abundance) that will be useful for describing each ecosystem and for detecting future change, and to contribute towards addressing cross-SuperSite level questions including:

1. What are the current patterns and dynamics of terrestrial (and aquatic) fauna?

2. Are there general patterns in changing abundance and/or biodiversity across the network?

3. Can we determine the drivers of faunistic change?

21.1 BirdLife Australia Avifauna Survey Method at the Great Western Woodlands SuperSite

BirdLife Australia uses a mix of 2 ha searches, area searches and incidental sightings to survey GWW.

- **2 ha Search**: a search of a two hectare area for 20 minutes.
- **Area Search**: more flexible than the 2-ha Search. Search of any area, listing the birds seen around a central point. These searches can cover a small area within 500 m of the central point, or a large area out to 5 km. The search area can be any shape and the search time can be anywhere between 20 minutes and one month.
- **Incidental Sighting**: records of rare, uncommon or unusual species, seen as once-off sightings; or surveys of a specific group of birds, such as wetland birds, waders, or waterfowl.

Description of columns in GWW bird survey data files

Column Header	Descriptor
LocationName	Location name
Latitude	Latitude in decimal degrees
Longitude	Longitude in decimal degrees
StartDate	Date bird survey started
FinishDate	Date bird survey finished
StartTime	Time bird survey started
FinishTime	Time bird survey finished
SurveyType	Type of survey conducted (2ha search, Area search, or Incidental record)
Habitat	Broad habitat type of the survey area, based on volunteer description
BirdID	Species recorded

Count	Number of individuals recorded (Blank – not recorded)
Breeding	Any evidence of breeding recorded
GWW.ID	BirdLife GWW project internal reference number

LocationName	Latitude	Longitude	StartDate	FinishDate	StartTime	FinishTime	SurveyType	Habitat	BirdID	Count	Breeding	GWW.ID
Credo 13	-30.37583	120.7467	10/10/13	10/10/13	6:50	7:10	2haSearch		Australian Ringneck	3		5136380
Credo 13	-30.37583	120.7467	10/10/13	10/10/13	6:50	7:10	2haSearch		Weebill	2		5136380
Credo 13	-30.37583	120.7467	10/10/13	10/10/13	6:50	7:10	2haSearch		Striated Pardalote	5		5136380
Credo 13	-30.37583	120.7467	10/10/13	10/10/13	6:50	7:10	2haSearch		Yellow-throated Miner	4		5136380
Credo 13	-30.37583	120.7467	10/10/13	10/10/13	6:50	7:10	2haSearch		Red Wattlebird	2		5136380
Credo 13	-30.37583	120.7467	10/10/13	10/10/13	6:50	7:10	2haSearch		Black-faced Cuckoo-Shrike	2		5136380
Credo 13	-30.37583	120.7467	10/10/13	10/10/13	6:50	7:10	2haSearch		Crested Bellbird	1		5136380
Credo 13	-30.37583	120.7467	10/10/13	10/10/13	6:50	7:10	2haSearch		Pied Butcherbird	1		5136380
Credo 13	-30.37583	120.7467	10/10/13	10/10/13	6:50	7:10	2haSearch		Grey Currawong	2		5136380
Credo 15	-30.34917	120.7119	9/10/13	9/10/13	12:00	12:20	2haSearch		Australian Ringneck	5		5136379
Credo 15	-30.34917	120.7119	9/10/13	9/10/13	12:00	12:20	2haSearch		Rainbow Bee-eater	1		5136379
Credo 15	-30.34917	120.7119	9/10/13	9/10/13	12:00	12:20	2haSearch		Yellow-plumed Honeyeater	2		5136379
Credo 15	-30.34917	120.7119	9/10/13	9/10/13	12:00	12:20	2haSearch		Little Crow	1		5136379
Credo 17	-30.25528	120.6606	9/10/13	9/10/13	11:20	11:40	2haSearch		Splendid Fairy-wren	4		5136325
Credo 17	-30.25528	120.6606	9/10/13	9/10/13	11:20	11:40	2haSearch		Weebill	4		5136325
Credo 17	-30.25528	120.6606	9/10/13	9/10/13	11:20	11:40	2haSearch		Chestnut-rumped Thornbill	6		5136325
Credo 17	-30.25528	120.6606	9/10/13	9/10/13	11:20	11:40	2haSearch		Striated Pardalote	2		5136325
Credo 17	-30.25528	120.6606	9/10/13	9/10/13	11:20	11:40	2haSearch		Grey Shrike-thrush	2		5136325
Credo 17	-30.25528	120.6606	9/10/13	9/10/13	11:20	11:40	2haSearch		Grey Butcherbird	1		5136325
Creedo ADHOC 1	-29.99417	120.5572	18/06/13	18/06/13	15:40	16:00	2haSearch		Singing Honeyeater	2		793546
Creedo ADHOC 1	-29.99417	120.5572	18/06/13	18/06/13	15:40	16:00	2haSearch		Red Wattlebird	1		793546
Creedo ADHOC 1	-29.99417	120.5572	18/06/13	18/06/13	15:40	16:00	2haSearch		Crested Bellbird	1		793546
Creedo ADHOC 1	-29.99417	120.5572	18/06/13	18/06/13	15:40	16:00	2haSearch		Willie Wagtail	1		793546
Creedo ADHOC2	-30.42972	120.7133	19/06/13	19/06/13	10:02	10:22	2haSearch		Singing Honeyeater	1		793547
Creedo ADHOC2	-30.42972	120.7133	19/06/13	19/06/13	10:02	10:22	2haSearch		White-fronted Honeyeater	6		793547
Creedo ADHOC2	-30.42972	120.7133	19/06/13	19/06/13	10:02	10:22	2haSearch		Spiny-cheeked Honeyeater	6		793547
Creedo ADHOC 3	-30.43056	120.6381	19/06/13	19/06/13	10:45	11:05	2haSearch		Crested Pigeon	3		793548
Creedo ADHOC 3	-30.43056	120.6381	19/06/13	19/06/13	10:45	11:05	2haSearch		White-necked Heron	1		793548
Creedo ADHOC 3	-30.43056	120.6381	19/06/13	19/06/13	10:45	11:05	2haSearch		Weebill	4		793548
Creedo ADHOC 3	-30.43056	120.6381	19/06/13	19/06/13	10:45	11:05	2haSearch		Yellow-rumped Thornbill	4		793548
Creedo ADHOC 3	-30.43056	120.6381	19/06/13	19/06/13	10:45	11:05	2haSearch		Striated Pardalote	1		793548
Creedo ADHOC 3	-30.43056	120.6381	19/06/13	19/06/13	10:45	11:05	2haSearch		Singing Honeyeater	2		793548
Creedo ADHOC 3	-30.43056	120.6381	19/06/13	19/06/13	10:45	11:05	2haSearch		White-fronted Honeyeater	2		793548
Creedo ADHOC 3	-30.43056	120.6381	19/06/13	19/06/13	10:45	11:05	2haSearch		Spiny-cheeked Honeyeater	2		793548
Creedo ADHOC 3	-30.43056	120.6381	19/06/13	19/06/13	10:45	11:05	2haSearch		Red Wattlebird	1		793548
Creedo ADHOC4	-30.41055	120.7933	19/06/13	19/06/13	14:30	14:50	2haSearch		Weebill	3		793549
Creedo ADHOC4	-30.41055	120.7933	19/06/13	19/06/13	14:30	14:50	2haSearch		Singing Honeyeater	2		793549
Creedo ADHOC4	-30.41055	120.7933	19/06/13	19/06/13	14:30	14:50	2haSearch		Yellow-plumed Honeyeater	1		793549
Creedo ADHOC5	-30.29139	120.6719	20/06/13	20/06/13	8:50	9:10	2haSearch		Weebill	4		793550
Creedo ADHOC5	-30.29139	120.6719	20/06/13	20/06/13	8:50	9:10	2haSearch		White-eared Honeyeater	1		793550
Creedo ADHOC5	-30.29139	120.6719	20/06/13	20/06/13	8:50	9:10	2haSearch		Yellow-plumed Honeyeater	5		793550
Creedo ADHOC5	-30.29139	120.6719	20/06/13	20/06/13	8:50	9:10	2haSearch		Grey Currawong	1		793550
Creedo ADHOC6	-30.29	120.675	20/06/13	20/06/13	9:20	9:40	2haSearch		Singing Honeyeater	1		793551
Creedo ADHOC6	-30.29	120.675	20/06/13	20/06/13	9:20	9:40	2haSearch		Yellow-plumed Honeyeater	4		793551

Figure 19: Example of GWW bird survey data

21.2 Warra Tall Eucalypt SuperSite Avifauna Survey

The annual spring - summer "Bird Track" survey consists of five-minute counts of birds (seen or heard) observed during >5 separate visits made each year to each of 20 points located at 50-metre intervals along “Bird Track”.

On each occasion a sample point is visited, a five-minute observation period to record birds present follows a two-minute “settling” period that commences on arrival to the sample point. Each sample point is visited on at least five separate days during each annual campaign. Those visits are spread evenly across three time periods: morning – “am” (6-9 am); mid-morning – “mid” (9-12 am); afternoon – “pm” (12-3 pm). Visits were confined to fine days (no more than slight drizzle and winds less than Beaufort force 2).

Table 7: Description of variables in data worksheets for the Warra "Bird Track" survey

Variable	Description
Recno	Record Number. A unique number representing each bird observation. This includes an observation of “no birds” when no birds were seen or heard at a sample point visit. The

	numbers are assigned sequentially to each observation as they are added to the Birds database (Access)
Samplecode	A unique number assigned to each visit to a sample point. Multiple records (Recno) with the same Samplecode occur when more than one bird species are detected in a visit. Each Samplecode is prefixed with the respective alphanumeric code of the treatment within the Silvicultural Systems Trial: All sample points along Bird Track are assigned the prefix "EX".
Pointcode	A code assigned to each unique sample point. The twenty sample points monitored annually along Bird Track are assigned Pointcodes in the range EX01 – EX021 (sample point EX019 is excluded).
Year	Year in which the survey was done. Most year records will span the months October – December
Date	The actual date the survey visit was made (notation dd/mm/yyyy)
Time of Day	The time of day the survey visit was made. One of three values: am (morning: 6- 9 am); mid (mid-morning – 9-12 am); pm (afternoon: 12-3 pm).
Acronym	An alphanumeric code unique to each bird species and derived as a compression of the accepted common name of that species. A lookup table of the full species binomial and common name assigned to each Acronym is given in the workbook "Names" in the file "Bird_Track_Birds_1998_2010".
Incidence	A value of 1 / 0 denoting presence (1) of a bird species within 25 m of a sample point during a visit. An Incidence value of 0 is assigned if a species was observed from a sample point visit but at a distance of > 25m from the sample point.
Number Recorded	Number of individuals of a bird species observed together within 25 m of a sample point during a visit. Note: records of species observed at separate times during a five minute sample period are each assigned separate values of number recorded
Distance	Estimated distance from the sample point to the bird observed
Height	Numeric code between 1-6 that represents the approximate height of the vertical stratum of the forest in which the observed bird occurred.
Direction	Approximate bearing from the sample point to the bird record observed. Represented by a number between 1-8 representing successive 45 quadrants where 1 = N-NE.

Table 8: Locations of the twenty sample points along "Bird Track" are recorded in a separate file.

Pointcode	MGA Easting	MGA Northing	GPS grid ref quality
EX01	0471674	5229069	Good
EX02	0471649	5229104	Good
EX04	0471608	5229109	Deduced
EX05 etc	0471527	5229111	Deduced

21.3 FNQ Rainforest SuperSite - Robson Creek Avifauna Survey

Background

The aim of the bird surveys at Robson Ck are to provide a description of the bird community, including its richness and composition, and having established a baseline description to monitor the dynamics and phenology of the community over time. The aim is to be able to link this data to environmental drivers of dynamics. Ideally, the monitoring could also be used as means of estimating and monitoring abundance of individual species. Unfortunately, most if not all species at the site can move rapidly between transects and within transects. This means that the survey transects are not independent of each other and it cannot be assumed that the observations of individual birds or groups of birds encountered are independent of each other on a transect or

even at a point on a transect. Given that that most detections are by ear and not by eye means there is no guarantee that new detections at a point are not simply a bird moving.

This project is documenting the distribution of bird species and the structure of bird communities at the TERN 25 ha Plot at Robson Creek. The advantage of using the Plot as a point of focus is that the mapping and plant community data provide a phenological and ecological context for interpreting drivers of the bird community at that site. The Robson Creek plot site was chosen because being situated at c. 700m it represents a 'tension' zone between different tropical forest communities that are likely to show shifts under climate change. Bird communities below 600-800 m can be characterised as current lowland, warm climate communities while those above 600-800 m take on species with upland distributions, e.g. golden bowerbirds. grey-headed robins and fernwrens. Robson Creek being situated at the current altitudinal boundaries of the distribution of the upland and lowland specialist species consequently represents an ideal site for monitoring the species and community responses to climate change over time. In this project we are interested in species and community responses to climate change in three contexts. First, at the species level we are interested in how individual species respond in abundance and seasonality. Second, at the community level we are interested in i) describing changes in species distribution, ii) the effects of this on community composition and structure and iii) how this varies through the year.

Robson Ck Survey Method

Bird surveys at Robson Creek are conducted using walked transects and are largely in line with the Transect Method used in the Birdlife Australia Atlas Project. When a bird was detected the time since the start of the survey, species and number of individuals was recorded. Surveys are conducted monthly at a minimum but usually fortnightly. They are conducted in all weather conditions except those which would seriously impact detection ability, i.e. during very heavy rain or wind. Should heavy rain or wind occur after the commencement of a survey the survey is paused until those conditions end. If this seems unlikely the survey is abandoned until a later date. Where ever possible surveys are conducted by the same two observer, though over time this, inevitably, cannot always be achieved. Surveys are begun between 0600 and 0800with later start times occurring in the cooler months when days are shorter. Survey duration is two and a half to three hours Observers walk five set sections of trail on and around the Robson Ck plot. They move at such a pace that they spend a minimum of, and as close as possible, to 30 minutes on each section. With each survey bout the observer records: Date, Time, Weather, Observer. Encounters with birds can be visual or aural. At each encounter the following data is collected: species, number of individuals, whether the bird was seen or heard, sex (if possible), age (if possible), time since start of the survey.

21.4 Calperum Mallee SuperSite avifauna protocol

Australian Landscape Trust Bird Survey Plots

There are 20 circular (80m radius) plots within the Mallee in a 4 x 5 km area around the flux tower, and a further 16 plots in floodplain woodlands covering a similar extent. A single bird survey plot is associated with each of the AusPlots SASMDD0001, SASMDD0002, SASMDD0003, SASMDD0012 and SASMDD0013.

Table 9: Data table for Robson Creek Bird Survey

Session ID	Date	Time	Animal Name	Detection (heard/seen)	Number
1	Aug	0	Catbird; Spotted	h	1
1	Aug	0	Fruit-Dove; Superb	h	2
1	Aug	0	Honeyeater; Lewin's	h	2
1	Aug	1	Scrubwren; Yellow-throated	h	1
1	Aug	1	Scrubwren; Large-billed	h	1
1	Aug	2	Spinebill; Eastern	h	1
1	Aug	2	Gerygone; Brown	h	1
1	Aug	3	Whistler; Golden	h	1
1	Aug	3	Honeyeater; Lewin's	h	1
1	Aug	3	Honeyeater; Macleay's	h	1
1	Aug	4	Scrubfowl; Orange-footed	h	1
1	Aug	4	Mistletoebird	h	1
1	Aug	7	Honeyeater; Macleay's	h	1
1	Aug	7	Scrubwren; Large-billed	h	2
1	Aug	7	Riflebird; Victoria's	h	1
1	Aug	7	Fig-Parrot; Double-eyed	h	1
1	Aug	7	Chowchilla	s	3
1	Aug	8	Whipbird; Eastern	s	1
1	Aug	9	Robin; Grey-headed	s	1
1	Aug	10	Fantail; Grey	s	1
1	Aug	11	Thornbill; Mountain	h	2
1	Aug	11	Scrubwren; Large-billed	s	2
1	Aug	11	Fruit-Dove; Superb	h	1

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24 Appendix

24.1 AusPlots Rangelands Survey Protocols Manual

A number of protocols have been derived or abstracted from the AusPlots Rangelands Survey Protocols Manual (White *et al*. 2012) that can be downloaded from the TERN website at http://www.tern.org.au/AusPlots-Rangelands-Survey-Protocols-Manual-pg23944.html with updates periodically available at www.tern.org.au/ausplots-pg17871.html

24.2 Dataset and File Naming Guidelines

SuperSites DATASET naming protocol

(Short description of data), (SuperSite Name), (Location), (Year)

SuperSites FILE naming protocol

If there are files for a given year then:

asn_(SuperSite code)_(data type)_(optional location)_(YYYYMMDD)

or if by month then:

asn_(SuperSite code)_(data type)_(optional location)_(YYYYMM)

if there is a range of years then:

asn_(SuperSite code)_(data type)_(optional location)_(YYYY(start)-YYYY(end))

or a range within years then:

asn_(SuperSite code)_(data type)_(optional location)_(YYYYMMDD(start)-YYYYMMDD(end)) or (YYYYMM(start)-YYYYMM(end))

(SuperSite code)	File name code
Alice Mulga SuperSite	ALIC
Calperum Mallee SuperSite	CLPM
Cumberland Plain SuperSite	CBLP
FNQ Rainforest SuperSite	FNQR
Great Western Woodlands SuperSite	GWW
Litchfield Savanna SuperSite	LFLD
SEQ Peri-urban SuperSite	SEQP
Tumbarumba Wet Eucalypt SuperSite	TUMB
Victorian Dry Eucalypt SuperSite	VICD
Warra Tall Eucalypt SuperSite	WRRA

(optional location)	File name code
Robson Creek	robson
Robson Creek 25 ha plot	robson_25ha
Samford	samford
Karawatha Forest	karfor
Core 1 ha	core_1ha
Logan River	loganr
Albert River	albertr
Flux Tower plot	tower_plot
Cape Tribulation	capetrib
Daintree Discovery Centre	ddc
CTBCC LU11A	ctbcc-lu11a
CTBCC LU7A	ctbcc-lu7a (etc)
Wombat	wombat
Whroo	whroo
Riggs Creek	riggsck
GWW TC	redwood
GWW BB	blackbutt
GWW Gim200W	gimlet
GWW SG100E	salmon_core_1ha
WRRA Bird Track	external_control
CBLP Eucface control plot	eucface_control

(data type)	File name code
vegetation DBH and H	veg_dbh-h
vegetation species list	veg_species
Coarse Woody Debris	veg_cwd
Leaf Area Index	veg_lai
Gentry data-Mid Stratum (trees)	veg_gentry_mid-stratum
Gentry data-Subordinate Stratum (herbs/shrubs)	veg_gentry_sub-stratum
Point Intercept Method	veg_pim_cover
intercept cover survey	veg_pim_cover
vegetation floristics	veg_floristics
stem/tree map	veg_map
vegetation structural summary	veg_struct
net primary production	veg_npp
Leaf structural traits	veg_leaf_traits
Leaf level physiology	veg_leaf_phys
leaf chemistry	veg_leaf_chem
leaf isotope	veg_leaf_isotope
seedling survey	veg_seedling
leaf litter	veg_litter
fruit phenology	veg_fruit_phen
stream physico-chemical	stream_phys-chem
stream chemistry	stream_chem(_std methods/anal)
estuarine productivity	estuarine_prod
soil description	soil_charact
soil bulk density	soil_charact
soil pit temp/moisture/potential	soil_pit
soil chemistry	soil_chem
soil moisture (COSMOS)	soil_cosmos
Lizards	fauna_lizards
Mammals	fauna_mammals
Moths	fauna_moths
Beetles	fauna_beetles

Invertebrates-not to species	fauna_invert
Bird survey	fauna_birds
bird capture	fauna_birds_capture
vertebrate fauna biodiversity monitoring	fauna_biodiversity
Weather station data	weather
Digital Elevation Model	dem_surface
base geographical data	geo_tracks
fire history	fire