INTRODUCTION

A. W. Graham

It is now evident that many plants of tropical rainforests are long-lived, particularly those regarded as "mature phase" species. In the absence of intense disturbances such as storms, floods or landslides, most significant changes in forest structure and composition take place at rates that often may be discernable only at decadal or longer timescales. This has been demonstrated in a 32-year record from North Queensland by Connell and Green (2000), and the value of such long-term studies is widely acknowledged (Rees *et al.* 2001). Despite all the conceptual and technological advances in biology, the use of permanent plots remains the most practicable way of observing and predicting the directions and rates of floristic and structural changes in natural systems, whether derived from incremental or catastrophic changes. To be truly useful, plots must have (a) an accurately known location, (b) a series of measures of various and appropriate kinds, and (c) a record of time (Hopkins and Johnson 1995). Standards for the establishment and enumeration of the plots must also be well documented and consistent (Condit 1998). As in most natural plant communities, plot-based studies of plant community dynamics in rainforest ecosystems require four essential sets of data – details of the physical forest structure, the floristic composition, the demographic patterns for each species, and some information on the environmental setting such as the local climate, geomorphology and soils.

For such plots, the costs of establishment and maintenance are typically high, particularly if the locations are in "natural" settings largely unaffected by human disturbance. The immediate return on the substantial investment comes in the form of the initial floristic and structural descriptions from characterised sites. In the longer term, the value of subsequent time-series data could be regarded as "periodic interest", with the accumulated understanding of the processes leading to forest changes being the "capital growth". Novel applications for either the plot or the datasets may lead to "windfall gains". Two North Queensland examples of the latter may be found in recognition of the role that long-term permanent plots may play in monitoring changes in World Heritage values in the Queensland Wet Tropics (Hopkins and Johnson 1995), and in provision of quality data for a multi-national project, coordinated by Professor Oliver Phillips of the Centre for Biodiversity and Conservation, University of Leeds, which is aimed at identifying world-wide trends in rainforest dynamics.

In 1971, about one hundred years after the first European commercial exploitation of rainforests in North Queensland, work commenced on the first, in a series of specifically planned, long-term research plots designed to examine natural processes in rainforests rather than responses to, or suitability for, timber extraction. This work was carried out by the Atherton-based staff of the Forest and Timber Bureau within the Commonwealth Department of National Development, under the leadership of a research forester, Geoff Stocker, whose motivation and dedication made initiation of this remarkable data set possible (see acknowledgements). While the plots were necessarily opportunistically located and had some explicit bias towards occurrences of commercially attractive timber species, the project nevertheless represented a major investment for basic plant ecology in Australian rainforests. Subsequently, CSIRO staff from a number of Divisions maintained this project and all available records are now held by CSIRO Sustainable Ecosystems in Atherton, North Queensland.

Several versions of descriptions of this series of plots exist, but none have been formally reviewed or published previously. The few publications based on the plot data suffer to some degree from incorrect interpretations or insufficient detail on the forest types and environmental settings. This report provides additional site description, forest dynamics and soil data (both chemical and physical), and also corrects a number of errors and misinterpretations given in earlier published and unpublished accounts, as well as in the file records. Examples include more accurate location references, important changes in descriptions of soil parent materials (rock types), new descriptions of geomorphology, and corrections to the allocations to rainforest physiognomic types based on the terminology of Webb (1959, 1968). Critical data on European disturbance regimes has also been included, including records of minor logging activities in a few of the plots and of intense human disturbance on Plot 1 (EP2) Downfall Creek. Previous published accounts have asserted that all data were derived from “unlogged sites” (West *et al.* 1988). In some previous documentation, data tabulations included sclerophyll forest plots that are not considered in this review.

PROJECT OBJECTIVES AND STRATEGY

A. W. Graham (from the archival records of G. C. Stocker) and G. L. Unwin

The aims and objectives of this project are given most succinctly in the earliest draft of the proposed technical memorandum on the permanent plots (file record, date ca. 1991): "To record and analyse patterns of tree growth and stand dynamics in a broad range of permanently reserved plots in rainforest and associated forest types of north Queensland."

That document continues, "The basic task of the long-term plot series is to build a comprehensive database of rainforest tree growth, extending over a useful range of sites and a biologically meaningful span of years. To provide for analysis and interpretation, the growth record needs to include descriptions of forest structure, floristic composition and stand changes in response to environmental disturbance. This requires a high standard of repeated mensuration and continuity, in a variety of rainforest sites whose location is definable in terms of major environmental gradients."

As many of the plots were expected to be representative samples of undisturbed rainforest surrounded by logged forest, the researchers anticipated that "The series of plots will therefore prove most useful in comparative studies of tree growth, regeneration and species diversity both among sites and between logged and unlogged rainforest communities" (Summary notes for EP3 and EP31, G. L. Unwin, 6 June 1977).

A more detailed project description (unpublished file record, dated prior to 1985) stated, "The main question confronting forest ecologists working in management research has changed from 'What kind of disturbance will promote wood growth on desirable species?' to 'What are the floristic and structural consequences of a given type of disturbance?'"

The strategy specified in that document was:

"(a) To establish a series of 0.5 ha reference plots where the growth, recruitment and mortality of component species could be monitored for long periods. Where possible, these plots have been located in generally representative, unlogged forest.
(b) To study the reproductive biology and early growth characteristics of the major (ecologically and numerically) species found in the permanent plot series.
(c) To use data from (a) and (b) to develop models which will predict floristic and structural change in different forest types subjected to disturbances varying in nature, frequency and degree.

The alternative approach, i.e. the direct study of disturbed areas, was not adopted for the following reasons:

(a) It was considered advantageous to first examine forest dynamics in situations where complex disturbance patterns due to logging were absent.
(b) The area of available unlogged forest was receding rapidly and it appeared desirable to commence studies in these areas as soon as possible. Logged areas would always be available and could be studied at some time in the future.
(c) The Queensland Department of Forestry already possessed a large volume of data on aspects of growth and regeneration in logged rainforest, but data for only one plot in an unlogged area."

In assessing this strategy of opportunistic location of plots it is essential to realise that, even "at the beginning of the study, it was apparent that at the then current logging rate, the whole of the accessible forest in State Forest Reserves would soon have been logged" (Stocker *et al.* 1977 cited in Stocker 1983). Plots were not established in National Parks "primarily because of the additional administrative problems associated with undertaking research in these areas" (unpublished file record, dated prior to 1985).

This document also records that "a few of the early plots were deliberately located in forest types containing *Flindersia* species in order to obtain autecological data on this commercially important group of species. However, this group of species is also numerically important in many north Queensland rainforest types, and our subsequent experience indicates that these early plots are representative of several widespread forest types."

METHODS

DATA SOURCES AND PLOT NUMBERING

A. W. Graham

The primary sources used in preparation of this report were a wide range of records and data that are held in the Permanent Plot Files at the CSIRO Tropical Forest Research Centre, Atherton. This information included project descriptions, plot establishment proposals, plot establishment reports, a series of duplicated plot descriptions typically with site, stem, basal area and species summary data, typed plot notes (headed *Notes on Species in Structural Groups*), file records (usually field observations made during plot remeasurements), floristic lists, Queensland Regional Station (QRS) Herbarium records, site maps, soil description summaries and previously untabulated data from several soils laboratory notebooks . Other material referred to included summary reports prepared for seminars, conferences or field trips, and preliminary report drafts prepared by Keith Sanderson (general plot descriptions and floristic lists) and Ron Knowlton (soil data). Geoff Stocker and Greg Unwin contributed greatly to the early phase of development of the long-term plots project. Their unpublished research theses (Stocker 1983, Unwin 1983) were two important sources of information. During this compilation, it was evident that some key data were not formally recorded, as in the case of patch death observations. Where possible, the appropriate researchers and past staff were contacted and all available documentation was obtained and placed on the file records. There have been relatively few publications dealing directly with the permanent plots, and to date none have provided full location or descriptive details for the complete series of twenty plots.

During 2000 and 2001, Andrew Graham, Matt Bradford and Bob Hewett visited thirteen of the twenty plot locations (Table 1) to check and augment the existing descriptions. These thirteen plots and the other seven remaining plots were revisited for enumeration during 2002, 2004 or 2005 (Table 2). Andrew Ford assisted by completing the supplementary species list at Plot 13 (EP35) Whyanbeel, as well as reviewing all of the floristic lists for misidentifications and to update nomenclature. J. G. Tracey assisted in a reassessment of the structural forest typing of the plots.

Throughout this report, both the sequential plot number and the corresponding EP (Experimental Plot) number are used consistently so that easy cross-reference may be made to existing documentation in CSIRO records and Queensland Government departmental files, as well as to herbarium voucher specimens. It should be noted that the numbering systems used in some publications referring to the plot series (e.g. Beadle 1981) do not correspond to the established sequential plot numbering system.

SITE ESTABLISHMENT AND REMEASUREMENT PROCEDURES

A. W. Graham, G. L. Unwin, K. D. Sanderson and M. G. Bradford

Site Selection Criteria and Forest Disturbance

The twenty plots are located in North and Far North Queensland, with the majority located within a two-hour drive from Cairns (Table 1, Table 1a, Figure 1, Figure 2). Most sites were selected opportunistically, usually without any prior classification of forest structure or typology. The general position for each plot was determined by the vehicular access available at the time, by the progress of logging activities, and in consultation with staff of the Queensland Department of Forestry (QDF). At each site, the 0.5 ha plot and its surrounding 20 m wide buffer zone were positioned intuitively to provide, as far as possible, a sample that was structurally and floristically similar to surrounding forest (prior to logging, if applicable). At establishment, few of the selected sites showed signs of any recent large-scale natural disturbance such as cyclone or storm damage, even where such disturbance was often evident in the general locality (e.g. Plot 9 (EP31) Woopen Creek).

In most cases, the enumerated 0.5 ha plot areas were not directly affected by logging activities, either prior to establishment or subsequently. However, at four sites, early versions of plot descriptions (in the plot file records) specify or suggest that the enumerated areas were logged prior to plot establishment (i.e. Plot 3 (EP4) Little Pine Creek, Plot 4 (EP9) Robson Logging Area (LA), Plot 14 (EP37) Eungella and Plot 15 (EP38) The Crater). At some locations, snig tracks or logging roads pass through a section of the 20 m wide buffer zone surrounding the enumerated plot area, as at Plot 1 (EP2) Downfall Creek and Plot 4 (EP9) Robson Logging Area.

At least the first four plot sites were selected with a particular regard for the occurrence of species of *Flindersia* spp. (Letter dated 27 April 1972, G. C. Stocker to Director, Forest Research Institute, Forestry and Timber Bureau; Plot 4 (EP9) file). During the 1970s, the autecology of this genus was a focus of research interest at Atherton.

Plot Establishment Procedure

Boundaries, Buffer Zones and Position

Plot boundaries were surveyed with prismatic compass, 50 m steel survey band and Abney level. All distance measurements were corrected for slope. The slope-corrected dimensions of all plots were 100 x 50 m, enclosing a projected plan area of 0.5 ha. *It is particularly important to note that, because the topographic settings of the plots are highly variable (from flat to steeply sloping), the actual land surface areas of the plots differ to varying extents*. The four plot corners were permanently marked with yellow painted, copper-chrome-arsenate treated wooden pegs, each 760 x 75 x 50 mm. Where logging activities were scheduled to occur in the future, a buffer zone (typically not less than 20 m wide) was established around the plot. Trees within the buffer were marked with painted yellow or orange rings at or a little above eye level, with an emphasis on commercial tree species. This area was to be protected from future logging or disturbance by agreement with the QDF.

All plots were subdivided into sixteen subplots (A to P), each 25 x 12.5 m (Figure 3). Each subplot corner was marked with a painted peg (760 x 35 x 25 mm). The orientation of the four rows of subplots varied between plots, although the sequence of subplots within the rows was consistent: A-D, E-H, I-L and M-P. For example, at Plot 1 (EP2) Downfall Creek, the commencement point (Subplot A) was at the left-hand end of the 100 m side of the plot. In contrast, the subplot layout at Plot 4 (EP9) is a mirror image of that at Plot 1, as the commencement point (Subplot A) was at the right-hand end of the 100 m plot edge. This inter-site variation in subplot layout should be considered in any computerised mapping or site-related analysis of the data.

When feasible, the plots were accurately located by tying in the site with QDF survey lines. Detailed maps of locations and access-routes have been filed in the project records.

Location and Enumeration of Trees ≥ 10 cm

The initial assessments of tree trunks ≥10 cm diameter at breast height (dbh) were made at breast height (1.3 m) where possible. On sloping sites, this measure was taken on the uphill side of the tree. Where trees had high buttresses or deformities, the position for measurement of the dbh was raised to the lowest suitable height. At the time of plot establishment, the dbh lines were painted on all trees ≥10 cm dbh. The lines were about 25 mm wide and perpendicular to the direction of the trunk. Each dbh measure was taken to the nearest millimetre on the centre of the painted line with the tape following the line around the trunk. Any changed or abnormal measurement positions were repainted on the trunks at the time of remeasurement and the alteration was coded (see below) and recorded on the subplot field sheet.

The positions of all trees ≥10 cm dbh were located on the plot with an accuracy of ±0.5 m by using a six-digit coordinate system. In this system, the external corner peg of Subplot A was designated as “000 000”, with the first three digits representing distances along the 100 m axis (00.0 to 99.5 m), and the last three digits indicating distances along the 50 m axis (00.0 to 49.5 m). Using Figure 3 as an example, the coordinates for the internal corner of Subplot A are 250 125, and those of the external corner of Subplot P (diagonally opposite the origin) are 995 495. Because all locations were recorded with ±0.5 m accuracy, a tree on the plot boundary immediately adjacent to the peg marking the external corner of Subplot P would have location coordinates of 995 495. In a few cases, smaller trees growing close together may have identical coordinates. Calculations and interpretations based on the tree location coordinates must take account of both the accuracy limit as well as the variations in layout format.

In situations where trees were very close to the plot boundaries, particular attention was paid to determine if the stem fell within the plot, or if it was to be excluded. The criterion for these decisions was the relative location of the breast height section of the trunk. If the majority of this dbh section lay outside the boundary, the stem was excluded. Where the majority of the dbh section lay inside the boundary, the stem was included. In those rare cases where no discernible bias could be detected, such stems were alternately included and excluded as the initial survey proceeded along the plot boundary. It should be noted that the form and visual appearance of these stems near the boundary might have changed since establishment.

Individual tree trunks ≥10 cm dbh were numbered using an alphanumeric code that represented both the subplot (A to P) and the number of the trunk within that subplot, i.e. in Subplot A: A1, A2 ... … A35, A36, up to a potential maximum of A99; and similarly for Subplot B: B1, B2 … … B35, B36 up to B99. This code was painted on each enumerated tree.

Trees that were branched below the dbh measurement position, either as a branch or as a “twin” or “multi-stem” at ground-level, were identified and recorded using an additional numeral placed in the “hundreds” position in front of the number allocated to the “main” trunk. For example, at Plot 1 (EP2) Downfall Creek, the main trunk (≥10 cm dbh) of an *Acronychia laevis* J. R. Forst. and G. Forst. in Subplot P was numbered P5, the first branch ≥10 cm dbh arising below the dbh position was numbered P105, and the second branch ≥10 cm dbh was numbered P205. Similarly, at Plot 15 (EP38) The Crater, the main trunk of a *Pullea stutzeri*

(F.Muell.) Gibbs in Subplot F was numbered F10, while the branch arising below the dbh position was numbered F110.

This numbering system was also used in enumeration of *Ficus* spp. with multiple aerial roots ≥10 cm dbh. For example, at Plot 15 (EP38) The Crater, in Subplot B, the three stems (each ≥10 cm dbh) of a *Ficus pleurocarpa* F.Muell. were recorded as B4, B104 and B204. Similarly, at Plot 14 (EP37) Eungella, in Subplot B, the two stems (each ≥10 cm dbh) of a *Ficus destruens* F.Muell. ex C. T. White were recorded as B18 and B118.

This enumeration and reference number system has resulted in small discrepancies between the ≥10 cm dbh stem count and the actual number of ≥10 cm enumerated individuals on the plots.

Epiphytic Trees and Large Vines

Epiphytic trees, or the aerial roots of such trees, were not enumerated when <10 cm dbh, regardless of the size of the tree in the canopy. Where appropriate, these epiphytic tree species were recorded on the supplementary species list of the plot. For example, at Plot 12 (EP34) Russell River, in Subplot B, stem B12 (*Alstonia scholaris* (L.) R.Br.) was enveloped by a strangling fig but the numerous small root stems <10 cm dbh were not recorded. This feature was recorded in the plot field notes, but does not appear in the plot data records. It is likely that a number of similar situations involving epiphytic trees such as *Ficus* spp. or *Schefflera actinophylla* (Endl.) Harms will not be recorded in the data sets.

Vines were not enumerated, even if ≥10 cm dbh, but were noted on the plot supplementary species list. (In Plot 14 (EP37) Eungella, the record of an unidentified vine appears to be the single exception to this rule.)

Height Measurements

At the time of plot establishment, height estimates for all trees ≥10 cm dbh were recorded. These estimates were based on, and regularly validated by, actual measurements of canopy heights of the tallest tree and randomly selected subcanopy individuals in each subplot using the triangulation method (base distance and slope angle) with clinometer and measuring tape. No further height measures were taken until 1998 when the heights of all stems in the eighteen plots remeasured that year were accurately measured either by the triangulation method or by direct readings using a Bushnell Laser Rangefinder. Tree heights were also measured on Plot 14 (EP37) Eungella in 2001.

Other Data Records

At a number of plots, the positions, sizes and identities for stems <10 cm dbh but ≥2 m, or sometimes ≥3 m in height of all *Flindersia* species were recorded and, in some cases, every *Flindersia* stem so enumerated was marked with a small white peg. During 2000, some of these pegs were still evident at several plots. In at least one case, all *Flindersia* seedlings ≥500 mm high (or possibly ≥250 mm high) were identified and marked with a white peg and counted but not numbered, and all *Flindersia* seedlings < 500 mm high down to cotyledon stage were also enumerated. The eight available *Flindersia* sapling and seedling data sets are held both in the plot files and in the electronic project archive, representing Plot 2 (EP3) Mountt Haig, Plot 3 (EP4) Little Pine Creek, Plot 4 (EP9) Robson Logging Area, Plot 5 (EP18) Mount Lewis, Plot 6 (EP19) Garrawalt, Plot 7 (EP29) Mountt Fisher, Plot 8 (EP30) Agapetes Logging Area and Plot 13 (EP35) Whyanbeel.

Paint Types Used for Tree-marking and Pegs

From 1971 to 1990, trees and pegs were painted using the standard lead-based tree marking paint used by the QDF. From 1991 onwards, conventional acrylic lead-free paint was used.

Forest Structural Descriptions

In this report, the terminology for descriptions of forest structure (cf. forest structural typology, described below) follows Walker and Hopkins (1984). Soon after establishment of each plot, forest structural profiles were drawn to scale representing a 100 x 5 m transect based on the long axis of each plot commencing from the corner peg of Subplot A. The height and canopy form of all trees ≥10 cm dbh along the transect were recorded. Trees <6 m in height were not included.

Plot Remeasurements

Schedules and Procedures

The years of establishment and remeasurement, together with the number of years of records for each of the plots, are given in Table 2. Plots were remeasured every two years for a minimum of ten years, after which period the time frame for further assessments was reviewed. After 1990, remeasurements generally were carried out every five years. At the time of each remeasurement, general maintenance of painted tree markings was carried out, and records and maps were made of tree deaths, deformities and disturbances. If a tree became enmeshed in an immovable vine or strangling fig and the dbh could not be practically measured, the previous dbh was used and adjusted up slightly. Codes used on the field sheets were: *D* (dead); *BT* (broken top); *BND* (bloody near dead); *S* (sick); *DBHR* (dbh raised, with the measurements (usually) recorded from the old and new line); *L* (leaning); *DS* (dead side); and *DT* (dead top). These codes have not been incorporated into any database. Any discrepancies found in the database must be referenced back to the original field forms. For example, a tree with a decreased dbh may have *BND*, *S*, *DBHR* or *DS* written next to the measurement in the field sheet. All of the old field sheets are stored in the Permanent Plot Files.

Previously Recorded Stems ≥ 10 cm

The dbh of each existing individual stem was re-measured and, where new deformities or buttress growth occurred at the original diameter mark, the point of measure was adjusted by either raising or lowering it to suit future measurements. Diameter measurements were then recorded from both the original and new markings for tree growth calculations. Tree deaths and canopy disturbances were also noted.

New Recruits in the ≥ 10 cm dbh Size Class

All new recruits into the ≥10 cm diameter category were taxonomically identified, located in terms of plot coordinates, numbered and measured for both dbh and height. Voucher specimens were collected for any enumerated species not previously encountered on the plot.

PLOT DISTURBANCE HISTORY

General Physical Disturbances

K. D. Sanderson

Throughout the project, brief descriptions were made of both current and past disturbances (e.g. condition of the forest at plot establishment, management procedures, activities such as mining, or natural events including cyclones or major tree falls). Locations of large-gap tree falls or of multiple tree-falls caused by cyclones were mapped.

"Patch Death" Phenomena

B. N. Brown and K. D. Sanderson

The extent, development and recovery of "patch death" phenomena were also noted at affected sites. At some sites where this feature was encountered, soil samples were collected and forwarded to the QDF forest pathology laboratory in Brisbane. At the QDF laboratory, standard "baiting" techniques were used to detect the presence of the root-rot fungus *Phytophthora cinnamomi* Rands that is commonly associated with this forest dieback.

Historic and Pre-historic Fire

A. W. Graham, R. K. Hewett, E. Lawson, E. Bruce, U. Zoppi and Q. Hua

During field inspections in 2000 and 2001, soil samples were collected to refine estimates of forest biomass and carbon stocks at ten of the thirteen revisited plots listed in Table 1 (Plot 14 (EP37) Eungella, Plot 11 (EP33) Curtain Fig and Plot 12 (EP34) Russell River excluded). While these new biomass and carbon stock data will be published elsewhere, the associated observations of relict soil charcoal extracted from soil cores are relevant to the site histories of the plots and are presented in this report. At each site, six soil cores were taken in a stratified random sampling design that included each of the major landform elements present on the site. The corer was constructed of stainless steel tubing of 47 mm internal diameter. Cores were partitioned by depth intervals of 0-50, 50-100 and 100-200 mm, with the total volume of each core being 0.000347 m^3 (347 cm^3). For each depth interval, soil samples were washed over a 1 mm sieve and all charcoal fragments retained on the sieve were removed and bagged. The charcoal was oven dried at 70°C for 48 hrs and then weighed. Individual charcoal fragments were then sent for radiocarbon dating by Atomic Mass Spectrometry (AMS) from those sites that met the following criteria:

a) Charcoal at the site should be *in situ* (thus excluding Plot 17 (EP41) Oliver Creek);
b) The site had no known or suspected intensive disturbance of post-European age (thus excluding Plot 1 (EP2) Downfall Creek); and
c) There were no on-site or adjacent data relating to relict charcoal (thus excluding Plot 2 (EP3) Mount Haig, where abundant relict *Eucalyptus* charcoal was already known – see Hopkins *et al.* 1993).

Taxonomic determinations could not be undertaken due to the small size of the charcoal fragments.

In 1995, small charcoal samples were collected from soil pits at Plot 11 (EP33) Curtain Fig as part of a regional vegetation history project. In 2003, these samples were re-examined and two fragments of charcoal were selected for AMS dating. Again, no taxonomic determinations were possible.

The charcoal samples from these two sampling regimes were radiocarbon dated at the AMS facility of the Australian Nuclear Science Technology Organisation (Lawson *et al.* 2000). After physical removal of macroscopic contaminants such as roots and rootlets, samples were chemically pre-treated by using the AAA method (Mook and Streurman 1983). The chemical pre-treatment consisted of the following steps:

a) Washing in HCl 2M at 60°C for 2.5 hours to remove carbonate and infiltrated fulvic acids;
b) Washing in NaOH 2% at 60°C for 3-4 hours to remove humic acids; and
c) Washing in HCl 2M at room temperature for 2 hours to remove any atmospheric CO_2 absorbed during the alkali step.

Between steps, samples were washed with de-ionised water (DIW). Finally, all pre-treated samples were washed with DIW and oven-dried at 60°C for 2 days before being converted to CO_2 by combustion at 900°C for 5 hours in a sealed tube in the presence of pre-cleaned CuO and Ag wires. Graphite targets were prepared by reducing CO_2 using zinc (400°C) and iron (600°C) catalysts in the presence of a small amount of hydrogen. This reaction lasted for 6-10 hours. The technical details of these methods are described in Hua *et al.* (2001).

For all samples the $^{14}C/^{13}C$ isotopic ratio was measured relative to the internationally accepted HOxI standard material (Stuiver 1983). Corrections were then applied for the spectrometer background, for the contamination incorporated during the preparation of the graphite target and for the isotopic fractionation. Using the corrected radioisotopic ratio, the conventional radiocarbon age was calculated.

In conversion of the radiocarbon dates to calendar years, first an offset of 24±3 years was subtracted from the measured radiocarbon age to account for the incomplete atmospheric mixing between the two hemispheres (Stuiver *et al.* 1998a). The amended age was then calibrated using the CALIB 4.0 software (Stuiver and Reimer 1993) and the tree ring data set of Stuiver *et al.* (1998b).

GEOLOGY, LANDFORMS AND SOILS

I. S. Webb, R. W. Knowlton, K. D. Sanderson, A. Beech, S. Farr, M. G. Bradford, R. K. Hewett and A. W. Graham

Geology and Landform

At the time of plot establishment, descriptions of site geology were based on regional 1:250,000 map sheets (e.g. de Keyser *et al.* 1972). Where possible, those initial assessments now have been supplemented by or referred to more recent and more detailed descriptions (e.g. Willmott *et al.* 1988a,b). The terminology of the detailed geomorphological descriptions follows Speight (1984). The geological and geomorphic settings of a few sites are complex and some confusion is evident in past descriptions, both published and unpublished. Previous descriptions of the geology and geomorphology of the 13 sites visited during 2000 and 2001 (Table 1) were checked and updated. In 2005, the site and adjacent creek lines of Plot 6 (EP19) Garrawalt were inspected for rock outcrops during enumeration and rock samples were collected from Plot 9 (EP31) Woopen Creek.

Soil Sampling and Analysis

Because of changing research directions over time, the range of physical and chemical data collected varied between sites. The nature of the available data sets is summarised in Table 3. Three sets of soil analysis data have been collected from the CSIRO Permanent Plots.

Initial Soil Survey

The initial survey aimed to determine the general characteristics and broad-scale differences between the 19 sites established at that time. These analytical data were derived from bulked samples spanning the depth interval 0.0-0.3 m at the intersections of Subplots ABEF, CDGH, IJMN, KLOP and FGJK. All soil analyses were conducted at the analytical laboratory in Atherton and the details of the methods are reproduced directly from West *et al.* (1988).

"Soil pH was determined with a glass-calomel electrode using a 1:5 soil:water suspension. Organic carbon was determined by rapid titration (Walkley and Black 1934) and a correction factor of x1.32 applied (Teakle 1950). Total nitrogen was determined by the Honda (1962) modification of the semi-micro Kjeldahl digestion procedure and total phosphorus by the colorimetric method of Murphy and Riley (1962) using a perchloric-nitric acid digest (Baseden, Wooley and Moody 1974). Exchangeable basic cations (Ca, Mg, Na and K) were extracted with normal (pH 7) ammonium acetate and determined by atomic absorption spectroscopy. Cation exchange capacity was determined after cation extraction with ammonium acetate and replacement of the ammonium with 0.1M hydrochloric acid and titration (Chapman 1965). No values were determined for sodium in four plots. These missing values were estimated using the method of Beale and Little (1975)."

Second Soil Survey

Subsequently a second, more detailed and systematic soil survey was undertaken, though not all plots were re-sampled due to changing research priorities. In this second survey, within each plot, soil samples for chemical analyses were sub-sampled from bulked samples collected at five randomly located positions using four adjacent auger holes (i.e. a total of 20 holes per plot). The standard sampling intervals were 0-0.05, 0.05-0.1, 0.1-0.2, 0.2-0.3, 0.3-0.6, 0.6-0.90, and 0.9-1.20 m.

When possible, a soil pit site was selected adjacent to the plot boundary in an area representative of the aspect and slope of the plot. These pits were excavated to a depth of 2 m and the morphology of the profile was described. For the earliest plots, these descriptions were prepared in collaboration with Ray Isbell of the CSIRO Division of Soils, Townsville. Field texture classes were assigned according to Northcote (1979) and colour descriptions were made using the Munsell nomenclature following Soil Survey Staff (1951). For determinations of saturated hydraulic conductivity (K_S) and bulk density, soil samples were taken using a modified Ramset nail gun by firing a thin walled brass cylinder (50 mm long by 74 mm internal diameter, volume 0.215 l, internal cross sectional area 0.004301 m^{-2}) vertically into "steps" cut at various depths in the walls of the pits in the exposed profile. Soil bulk densities, moisture retention characteristics and hydraulic conductivities were determined in the Atherton analytical laboratory.

In the laboratory, the determination of Saturated Hydraulic Conductivity (K_S) was determined with an external, constant-head method using the soil "cores" in the brass cylinders. Detailed descriptions of the equipment and methods employed are given at the end of Appendix 2. Soil samples in the cylinders were saturated over a period of at least 24 hours prior to assessment by capillary action into the soil sample from the base of each cylinder. The determination of K_S was also carried out by upward infiltration from the base of the sample.

Following Loveday (1974, p 85, 10-15), for measurements made with constant head,

hydraulic conductivity $K = (Q*l) / (A*t*h)$,

where:

Q = volume of water passing in time t;
A = cross-sectional area of the sample;
l = the length of the test sample; and
h = mean hydraulic head difference (Ø2-Ø1, see Appendix 1 Figure 1).

After determination of the K_S values, the same soil samples were used for bulk density determinations, the values being recorded as the mean of four samples at each designated depth.

Soil moisture retention characteristics were determined using standard pressure plate techniques. Full procedural details are given at the end of Appendix 1.

All soil analyses from the second survey were also conducted at the analytical laboratory in Atherton. Soil pH was measured in 1:5 soil/water, 1:5 soil/1N KCl and 1:5 soil/0.01M $CaCl_2$ suspensions using a glass electrode with calomel electrode reference. Organic carbon was determined using Walkey and Black (1934) wet oxidation method. Total nitrogen was measured using a modification of the Kjeldahl method (Honda 1962). In the initial survey only, Total P was determined by a rapid perchloric acid digestion procedure (Sommers and Nelson 1972). The method of Gillman (1979) was used for an estimation of CEC and exchangeable cations. Cations of Ca, Mg, K and Na were extracted with 0.1M $BaCl_2$. Acidity and Al extracted by KCl were determined by the method of Yuan (1959).

Particle size analysis was carried out by the sieve and pipette method (Coventry and Fett 1979) with size limits based on the International System (silt 2 µm to 20 µm, fine sand 20 µm to 200 µm). Particle density analysis utilised the methods specified by Blake (date unknown, Paper No. 4949 of the Scientific Journal Series, Minnesota Agr. Exp. Sta., St. Paul following the procedures set out in Am. Soc. Testing Mater., 1958, p.80 and U.S. Dept. Agr., 1954, p.122). Full details of these methods are recorded in the soil records section of the Permanent Plot files.

Recent Soil Data Collection

The third set of soil chemical analytical data was obtained in 2000 from Plot 15 (EP38) The Crater. This site has a complex geomorphic setting and a stratified sampling was undertaken specifically to address possible confusion relating to the soil nutrient status, rock outcrops and the forest structural typology. The chemical analyses were conducted at the CSIRO Land and Water facilities at Townsville, North Queensland, and in Glen Osmund, South Australia using the standard techniques (the alpha-numeric code reference) of Rayment and Higginson (1992): pH by a 1:5 soil/water suspension [4A1]; electrical conductivity in a soil/water suspension [3A1]; exchange acidity (hydrogen and aluminium) by 1M potassium chloride [15G1], Yuan (1959); exchangeable bases and cation exchange capacity by compulsive exchange [15E1], 0.1M $BaCl_2$/0.1M NH_4Cl (Gillman and Sumpter 1986); bicarbonate-extractable phosphorus [9B2], 0.5M $NaHCO_3$ (Colwell, 1963), and colorimetric finish based on method of Murphy and Riley (1962). Total organic carbon was determined by a 1994 Leco CNS-2000 high temperature resistance furnace with infrared detection of total carbon only [cf. 6B3]. Total nitrogen was determined using a Leco CNS-2000 high temperature resistance furnace using thermal conductivity for the detection of nitrogen after the sample is combusted in the high temperature resistance furnace (see Etheridge *et al.* 1998, Matejovic 1997). More details of the CNS-2000 multi-functional analyser are given in Appendix 1.

In July 2002, soil bulk density was sampled at Plot 15 (EP38) The Crater from the walls of five small pits located just outside the four corners of the plot and at its centre. Samples were taken at depths of 0.0-0.05, 0.10-0.15, 0.25-0.30 and 0.50-0.55 m by driving thin walled stainless steel cylinders (50 mm long by 73 mm diameter, volume 0.209 l) into the exposed profile using a heavy hammer as lack of vehicle access precluded use of the sampling gun.

In August 2003, samples for soil particle size analysis were collected from Plot 19 (EP43) Mount Baldy to provide a more complete description of the rhyolitic soil profile that is typical of much of the highland area south of Atherton.

CLIMATIC RECORDS AND DATA

K. D. Sanderson and D. W. Hilbert

In the early stages of this project, annual rainfall values at the 20 plots were estimated intuitively from available long-term records and publications. These estimates were recorded in the site summaries in the plot files. For this review, climatic data for those plots located within the Wet Tropics region were derived from both the ANUCLIM climatic model (McMahon *et al.* 1995) and from a later refinement by Turton *et al.* (1999) based on an 80 m digital elevation model.

CSIRO staff obtained field records of rainfall for limited periods from sites adjacent to Plot 1 (EP2) Downfall Creek, Plot 2 (EP3) Mount Haig, Plot 4 (EP4) Little Pine Creek and Plot 11 (EP33) Curtain Fig. Some datasets were obtained on a fortnightly basis using recording pluviographs located in nearby clearings, while others were taken with automatic electronic weather stations. Thermohygrograph records of temperature and humidity were made at Plot 2 (EP3) Mount Haig between June 1974 and December 1978. All available data are from these sources are stored in the Permanent Plot Files. Other rainfall data were collected by staff of the QFS, as at the "Harvesting and Marketing Barracks" on the Windsor Tableland. Copies of rainfall data sheets from this location, spanning the period October 1978 to January 1987, are held in the scientific archive papers (Windsor Tableland section) of Francis Crome at the CSIRO Tropical Forest Research Centre, and a summary is held in the Permanent Plot electronic climate archives. Other notes and climatic summaries, including brief regional weather system summaries for the period 1974 to 1977, are also held in the Permanent Plot Files.

FOREST TYPOLOGY

J. G. Tracey and A. W. Graham

In February 2000, J. G. Tracey determined the rainforest structural type of each site in a desktop exercise using the updated and corrected locations, biophysical datasets and the forest structural descriptions and profiles for all 20 plots. The classification and terminology follow Webb (1959, 1968, 1978) and the typology within the humid tropics region follows the criteria of Tracey and Webb (1975) and Tracey (1982). The assessments then were validated, firstly by recognition of key species from the floristic list (Appendix 2) of each plot (an approach justified, for example, by Williams and Tracey (1984)), and subsequently by field inspection of the sites visited in 2000 and 2001 (Table 1).

FLORISTIC IDENTIFICATIONS, VOUCHERS AND LISTS

B. P. M. Hyland, K. D. Sanderson, R. K. Hewett and A. J. Ford

Enumerated Trees

All enumerated trees ≥10 cm dbh were identified. When necessary, leaf samples were collected and bark surface, bark blaze and stem features (such as buttresses or fluted stems) were recorded. For each recognised species within each plot, reference voucher specimens were prepared and formally determined. In addition, a field reference leaf collection was established for each plot.

Saplings, Shrubs and Other Life Forms

At all plots, the floristic composition of each subplot was recorded for all plants >0.25 m high but <10 cm dbh at establishment, recorded as presence or absence in two height classes, firstly for one or more individuals 0.5 to 3 m high, and secondly for one or more individuals >3 m high but <10 cm dbh. The qualitative version of this floristic data has been incorporated in the tables of Appendix 2. Some of the semi-quantitative data was used by Stocker (1983) as the basis of "regeneration stocking" assessments for "important species" as presented in his Tables 10 to 28, and for Plots 5 (EP18) Mount Lewis, Plot 11 (EP33) Curtain Fig and Plot 13 (EP35) Whyanbeel) in Tables 3 to 5 of West *et al.* (1988).

Species lists for these understorey plants were compiled by subplot at the time of establishment. Reference voucher specimens of those understorey species not already encountered as trees were collected and determined. Other life forms such as epiphytic trees, vines, herbs, ferns, and epiphytes present within the plot were recorded on a supplementary species list and reference voucher specimens collected when feasible.

Nomenclature and Voucher Specimens

A master reference list was prepared for tree and shrub species found within the 20 plots. Over time the nomenclature was updated (e.g. following Hyland and Whiffin 1993, Hyland *et al.* 1999). For this report all nomenclature follows Queensland Herbarium (2002).

All voucher specimens from the 20 plots are stored in the Queensland Regional Station (QRS) Herbarium at the CSIRO Tropical Forest Research Centre, Atherton. This research herbarium is a branch of the Australian National Herbarium in Canberra and is maintained by staff of CSIRO Plant Industry.

FLORISTIC RELATIONSHIPS BETWEEN THE PLOTS

A. W. Graham and J. Kanowski

Floristic relationships amongst the twenty rainforest plots were examined using the classification techniques in the PATN pattern analysis package (Belbin 1993a,b). Qualitative (presence/absence) and quantitative (abundance) datasets for the enumerated trees (i.e. of stems ≥10 cm dbh) were utilised for the analyses using the Czekanowski and Bray-Curtis association measures, respectively. Classifications were conducted using an agglomerative fusion algorithm (UPGMA). The quantitative data were log (x+1) transformed.

DATA STORAGE AND ARCHIVE ARRANGEMENTS

D. W. Hilbert and M. G. Bradford

All available mensuration data are stored at the CSIRO Tropical Forest Research Centre, Atherton, in both hardcopy and electronic form. Field data sheets and descriptive records (including site maps) for each plot are filed on a plot-by-plot basis. All requests for access to, or use of, any data from the CSIRO Permanent Plot Files should be addressed to the Officer in Charge, CSIRO Tropical Forest Research Centre, PO Box 780, Atherton, Queensland 4883, Australia.

DESCRIPTIONS AND DATA SETS

A. W. Graham

DETERMINATION OF PLOT LOCATIONS

The locations of the plot sites were determined by two methods. The positions of the earlier plots (Plots 1 to 3 at least) were determined from surveys by K. Sanderson. The positions of the later plots were located using the most detailed available topographic maps (typically 1:50,000 scale in either the Commonwealth or Queensland Forest Service Series) and, in some cases, aerial photography. In the vicinities of the plots, the dense rainforest canopies generally inhibited the use of handheld global positioning system (GPS) in accurate determinations of plot locations. However, where possible, GPS readings were attempted at the plots or taken from nearby features to refine the position estimates for the unsurveyed locations. Overall, the accuracy of plot locations is considered to be ± 100 m.

For modelling purposes, it is suggested that particular attention should be paid to the location of the plots in relation to the relevant landform elements rather than to precise grid references, to ensure that the data are most appropriately related to their topographic setting.

The locations of the plot sites in terms of the current Geocentric Datum of Australia 1994 (GDA 1994) is given in Table 1. The data of Table 1 were calculated from the earlier Australian Geodetic Datum 1966 (AGD 1996) grid references as listed on Table 1a that also shows the sources of the maps that were used to determine the locations for the unsurveyed plots.

Within the detailed descriptions of some of the plots, grid references are provided for locations that are useful for navigation to the plot or of relevance to site descriptions. To allow easy use of the older maps held within the project files and to facilitate future GPS navigation, these grid references are given in both the original AGD 1966 and current GDA 1994 formats.

BIOPHYSICAL SETTINGS OF THE SITES

The plot sites were selected on an opportunistic basis that was determined largely by the history of logging and agricultural development, in the Wet Tropics region at least. It is therefore important to define, as fully as possible, the range of topographic, edaphic and climatic settings represented by the sites in order to maximise their usefulness in ecological studies. An outline of the geological and geomorphic settings of the 20 plots is given in Table 4 and the key climatic parameters for each of the plots are set out in Table 5.

Upland and highland settings characterise 14 of the sites, with 10 of these being on acidic igneous rocks. Model estimates of mean annual rainfalls at the sites span a range from 1266 mm (close to the lower limit for closed forests at this latitude) to more than 3400 mm. At many of the upland and highland sites, these rainfall totals will be augmented by cloud, as commonly observed at Plot 19 (EP43) Mount Baldy. In the Wet Tropics region, estimates of the mean annual temperatures represented vary from 18.3°C (Plot 7 (EP29) Mount Fisher, 1200 m asl) to 25.3°C (Plot 17 (EP41) Oliver Creek, 15 m asl) and, as is usual, this variation is strongly correlated with site altitude.

DISTURBANCE HISTORY

Any interpretation of the stand structure or of the floristic, growth or mortality data of rainforest plots must take account of disturbance history. Some of the historical factors that might be relevant include relatively recent geomorphologic changes (e.g. landslides, erosion) as well as various processes determining community composition and gap dynamics. Many of these changes are often driven by climatic events (e.g. storms, lightning strikes and fire, cyclonic winds, torrential rainfalls or droughts), sometimes in combination with pathogens (e.g. *Phytophthora cinnamomi*).

Direct and indirect human disturbances may also be superimposed on the broad scope of natural perturbations (e.g. mining excavations, walking tracks, cattle grazing, logging disturbances, anthropogenic fire). A summary of recent disturbances inferred or recorded at each of the plot sites up to the end of 2005 is presented in Table 6. The widespread disturbance effects on the plot series from Tropical Cyclone *Larry* (20 March 2006) and Cyclone *Monica* (19 April 2006) are not presented in this report.

It is most likely that Plot 1 (EP2) Downfall Creek was grossly disturbed during World War II, resulting in the anomalous successional or regrowth stand structure at this site. Logging at a very low relative intensity is recorded as occurring within the 0.5 ha enumeration area at two sites, Plot 4 (EP9) Robson Creek and Plot 15 (EP38) The Crater, and possibly at Plot 14 (EP37) Eungella and Plot 3 (EP4) Little Pine Creek. Cyclonic damage was observed on six plots prior to the 1998 enumerations, and at four plots subsequently up to the end of 2005. The development of an extensive canopy gap associated with a lightning strike was observed at Plot 5 (EP18) Mount Lewis after 1987. At Plot 6 (EP19) Garrawalt, the plot records span much of a development and recovery cycle for a patch death phenomenon associated with the confirmed presence of the root-rot fungus *Phytophthora cinnamomi*. At Plot 18 (EP42) Iron Range, meander migration has removed a substantial section of the original 0.5 ha area. More detailed accounts of these disturbances are given the detailed plot descriptions.

No systematic assessment was made of relict soil charcoal encountered in the plot soil pits, though field staff recalled charcoal fragments in soil pits at Plot 2 (EP3) Mount Haig, Plot 8 (EP30) Agapetes Logging Area, Plot16 (EP40) Agapetes Scientific Area, and Plot 11 (EP33) Curtain Fig (Ian Webb, personal observation). In the original surveys, no soil charcoal samples were collected. Without dated charcoal samples, no historical or ecological interpretations are possible due to the occurrence of relict Quaternary charcoal in the vicinity of at least some of these sites (Hopkins *et al.* 1993). The risks of uncalibrated interpretations are shown by the range in charcoal ages in the data from Plot 11 (EP33) Curtain Fig (Table 8).

Today, fire has no role in the on-going ecological processes and settings of any of the 20 CSIRO rainforest plots. Only for Plot 11 (EP33) Curtain Fig is there a possible historical record of fire that was probably associated with burning by European settlers in agricultural development context (West *et al.* 1988). However, as set out in the results below, radiocarbon dating has revealed that prehistoric fires occurred on, or immediately adjacent to, five of the plots during the last two thousand years (Table 8). Four of these sites include, or lie adjacent to, a ridgecrest (Table 4). Potential origins of the charcoal include aboriginal campfires, aboriginal ridgetop track maintenance activities (Ernie Grant of Tully, personal communication), more general aboriginal burning (or less likely natural fires) in cyclone or storm debris, and natural fire associated with lightning strikes in flammable ridgetop rainforest community debris (e.g. *Acacia* litter), or in now defunct *Eucalyptus* ridgetop vegetation. European origins for the charcoal fragments, such as campfires for forestry workers, are unlikely given the age of the wood burnt to produce the charcoal (mostly older than 1000 years BP), the broad distribution of the fragments within the sites, and the deliberate focus of the plot project on undisturbed forest settings.

The older charcoal date of 7790 BP from Plot 11 (EP33) Curtain Fig is most probably associated with the final phases of long-term Late Quaternary vegetation changes as described by Hopkins *et al.* (1993).

RAINFOREST STRUCTURAL TYPES AND REPRESENTATION

Table 9 sets out the rainforest structural type of each of the 20 plots, together with the generalised climatic and altitudinal zones in which the type occurs. Because of the bias towards nutrient-poor upland and highland settings, types 6, 8 and 9 are relatively well represented by 9 plots in total (Table 10). As noted previously, one of the type 6 representatives, Plot 1 (EP2) Downfall Creek, has an anomalous successional or regrowth stand structure.

Although Complex Mesophyll Vine Forest, type 1a, is represented nominally by three plots, two of these are floristic variants of the type. While these variants are locally extensive (e.g. the *Backhousia bancroftii* F.M.Bailey and F.Muell. ex F.M.Bailey dominated CMVF at Plot 9 (EP31) at Woopen Creek) or of outstanding conservation significance (e.g. *Idiospermum australiense* (Diels) S.T.Blake in Plot 17 (EP41) Oliver Creek), they are not representative of the physiognomy, stand structure or dynamics of the type at the regional scale. Complex Notophyll Vine Forest (CNVF), type 5a, is represented in Plot 15 (EP38) The Crater where the edaphic setting of the site (deep, carbon-rich soil developed from oligotrophic rhyolitic soil parent materials enriched with basaltic pyroclastics) is unusual for the type. The vast majority of this type is normally found on deep basaltic soils. Although Plot 11 (EP33) Curtain Fig satisfactorily represents Complex Notophyll Vine Forest (CNVF), type 5b, on a physiognomic basis, the site has a disturbance history that should be considered in any detailed interpretation of floristic composition and community dynamics.

STEM DENSITY AND BASAL AREA

The main aim of this report was to provide comprehensive biophysical site descriptions to allow subsequent detailed analysis of the stand, growth and floristic data. Accordingly, no detailed examination of these stem density and basal area data will be undertaken in this report. The summary of stem density and basal area data (Table 11) details mean, minima and maxima values to 2002 except for Plot 20 (EP44) Fantail Logging Area with data current to 2004, while data for Plot 6 (EP19) Garrawalt, Plot 9 (EP31) Woopen Creek and Plot 14 (EP37) Eungella are current to 2005.

No meaningful interpretations of these data are possible without considering the disturbance histories and topographic settings of the sites, as well as any pertinent forest characteristics such as local floristic variants. For conciseness, the data of Table 11 *do not* present the temporal relationships between stem density or basal area and various perturbations, or, just as importantly, the absence of perturbations. Such assessments must be done on a site-by-site basis.

For example, no reasonable explanation of the high stem density and low basal area of Plot 1 (EP2) Downfall Creek would be possible unless the high level of past disturbance on this site was known. Similarly, any attempt to generalise the characteristics of CNVF type 6 forest by considering both Plot 1 (EP2) Downfall Creek and Plot 16 (EP40) Agapetes Scientific Area would be unrewarding without that knowledge.

SOIL DESCRIPTIONS AND ANALYTICAL DATA

An incomplete version of the soil analysis data from the preliminary survey (unstratified sampling to 0.3 m depth) of the initial 19 plots has been published previously (Beadle 1981). These data, together with additional data from file records and Stocker (1983) are given in Table 12.

Despite the sampling limitations of this dataset (i.e. only 19 sites, and samples bulked over the depth 0 to 0.3 m), it allows some general interpretations of the relationships between soil conditions and forest physiognomic structure (in the sense of Webb 1959, 1968). Calcium and phosphorus are widely recognised as key macro-element indicators of soil fertility. The simplistic plot of total P against Ca (Figure 4) shows that the 19 sampled sites may be considered in two broad categories:

a) Five eutrophic sites (with either total P > 0.1% or Ca > 0.1 cmol(+) kg^{-1}); and
b) Fourteen oligotrophic to mesotrophic sites with low values for either P or Ca, or for both.

Most of this set of 14 oligotrophic to mesotrophic sites is located typically at higher altitudes on metasediments and acid igneous rocks (originating from burial of the metasediments at great depths, and hence of similar chemical composition). In general, these sites are structurally simple, predominantly being types 8 and 9 (Table 9).

Of the eutrophic sites, the most fertile is Plot 11 (EP33) Curtain Fig with high levels of both P and Ca. Both Plot 15 (EP38) The Crater and Plot 18 (EP42) Iron Range have moderately high values of P but low Ca, while Plot 14 (EP37) Eungella and Plot 12 (EP34) Russell River have moderately high Ca but low P levels. Of these five eutrophic sites, two are on basaltic soils, two on soils with basaltic influence, while the remaining site is on alluvial soil (Table 4). Most of these sites are structurally complex (types 1a or 5, CMVF or CNVF respectively). This general correlation of increasing structural complexity with more abundant soil nutrients is a keystone in the classification scheme of Webb (1968). The eutrophic Iron Range site (Plot 18 (EP42), is distinctive in its semi-deciduous nature, a feature facilitated by high nutrient availability (Webb 1968).

All available soil physical and chemical data from the subsequent more detailed stratified sampling programs are given in Appendix 1.

FLORISTIC COMPOSITION, SPECIES RICHNESS AND LIFE FORM ABUNDANCES

Detailed lists of the floristic composition of each of the plots at the time of establishment are given in Appendix 2. For plants >0.25 m high, the species richness varied from 84 to 189 variously representing between 6 and 11 of the 15 generalised life forms of higher plants that were represented in the plots (Table 13).

A number of key factors must be considered when attempting to identify relationships between the species richness or life form richness and the forest type or inferred nutrient status of the sites, including:

a) The limited replication in a restricted sampling of forest types;
b) The wide altitudinal, latitudinal and biogeographic ranges covered;
c) The great variation in climatic parameters;
d) The contrasting site disturbance histories; and
e) The differing landform elements encompassed.

In this dataset, no relationships appear to exist between either the total species richness or the tree species richness and either the altitude or rainfall (all four correlation coefficient values < 0.14). However, if the data are partitioned by forest structural type into "Simple" (Plots 2, 4, 5, 6, 7, 8, 19 and 20) and "non-Simple" types, significant differences between the groups are evident (2 tailed heteroscadistic t tests). The simple forests (types 8, 9 or 8/9) have significantly higher values for mean species richness (152 vs 124, p = 0.025), for mean tree-species richness (112 vs 84, p = 0.004), and for the mean percentage of tree species, i.e. tree species richness as a percentage of the total species richness (74 vs 68, p = 0.002). The lower values for tree species richness and for percentage of tree species in the more complex forests are still consistent with the principles of Webb's classification scheme (Webb 1968) as more life forms will occur in the more complex forests that typically have a relatively low tree stem density. (However, note that these data do not address the relationships for a total census including seedlings.) Even when the three plots that may be considered biogeographic outliers are not considered in the comparisons (i.e. Plot 10 (EP32) McIlwraith Ra., Plot 14 (EP37) Eungella, Plot 18 (EP42) Iron Range), the simple forests still have significantly higher values for mean tree-species richness (112 vs 89, p = 0.016) and for the mean percentage of tree species (74 vs 68, p = 0.0025).

Within the "non-simple" forests sampled, Plot 3 (EP4) Little Pine Creek has the highest species richness and tree species richness values, these values being respectively 5% and 15% greater than the next highest values in the group. The possible role of cyclonic disturbance in maintaining the species richness of this plot will, no doubt, be examined in subsequent publications.

Earlier interpretations of analyses of the life form, species richness, species diversity and floristic characteristics of the CSIRO plots may have been hindered by some incorrect descriptions of site and forest characteristics. Statistical methodologies for analysing multivariate data have also advanced in recent years. The quantitative and qualitative floristic analyses of Graham and Kanowski carried out for this review show very clear floristic groupings of the sites (Appendix 2 Figure 1, Appendix 2 Figure 2), and that these groups strongly reflect the forest physiognomic structural types (sensu Webb 1959, 1968, 1978). These classification results and interpretations contrast strongly with those of West *et al.* (1988).

PLOT DESCRIPTIONS

A. W. Graham, K. D. Sanderson and M. G. Bradford

Plot 1 (EP2) Downfall Creek

Location, Landform and Climate

The Downfall Creek plot is located on the eastern side of the Tinaroo Range, a little to the south of Downfall Creek that flows into Tinaroo Dam (Table 1, Figure 5) some 18 km north-northeast of Atherton. It lies on the margin of Danbulla Forest Drive and Danbulla National Park Recovery, and is close to both Danbulla National Park and Danbulla State Forest, (all previously Downfall Logging Area of State Forest 185 Danbulla) within the Wet Tropics World Heritage Area. Early maps show this site was originally in surveyed Portion 115 Parish of Danbulla, suggesting an intention to develop the land for agriculture. The site now is accessible only on foot along an abandoned logging track that commences from Danbulla Forest Drive at approximately 7.2 km past the northern carpark at the wall of Tinaroo Dam. The plot was established in July 1971, and the establishment report (J. L. O'Farrell, 21 March 1973) states that the object of this plot was to examine the structure and species composition of a typical *Flindersia schottiana* site (but see structural description below).

The plot straddles a low, gently to moderately sloping (2° to 9°) ridgecrest rising in a southwesterly direction on the lower footslopes of the Tinaroo Range at 720 m altitude. The 100 m axis of the plot lies at 300°, almost parallel to the ridge and the plot extends onto the upper slopes (5° to 8°) on either side of the crest. The commencement corner (Subplot A) is located in the eastern corner of the plot and the subplot layout is as represented in Figure 3. On the northeastern side of the plot, the pre-existing access track was included within the 20 m buffer zone. The southeastern corner of the plot was tied to QDF theodolite traverse peg TP73 on the Tinaroo to Danbulla road survey (Danbulla Forest Drive), and the boundaries of the plot are shown on the 1972 QFS Danbulla 1:25,000 map.

Along some sections of the ridge crest, soils are skeletal with abundant outcrops of coarse-grained biotite granite (Willmott *et al*. 1988a,b). On the upper slopes, the soil profile is at least 1.3 m deep. The rainfall pattern, as assessed by the rainfall Coefficient of Variation, is strongly seasonal (Table 5) and, in terms of the climatic zones of Tracey and Webb (1975), the site is dry (Table 9). From 1974 to 1978, rainfall data were collected by recording pluviograph from a nearby clearing immediately adjacent to Danbulla Forest Drive (c. Tinaroo 1:50,000 AGD 1966 349500 8103900, GDA 1994 349615 8104076) and these data are held in the Permanent Plot Files. The mean annual rainfall recorded at the site during this period was 1660 mm.

Forest Structure, Type and Floristics

Structurally, the rainforest on the plot is a tall, closed to mid-dense (but with local sparse patches) canopied forest with occasional emergents. The upper canopy ranges between 15 and 18 m with the more usually emergent *Agathis robusta* attaining only 22 m (Figure 6). Stocker (1983) described the upper canopy as relatively low and open, observing, "much light penetrated to within a few metres of the forest floor". In terms of both frequency and basal area contribution, *Cleistanthus semiopacus* clearly dominated the plot for stems ≥10 cm dbh (duplicated plot description, Table 2/3). Although not previously mentioned in any plot descriptions, numerous low branching trees were observed during the field inspection in 1999. These indicated that the canopy of the site was relatively open to clear in the recent past (see disturbance history below). The understorey is sparse and consists of overstorey tree species and shrubs while abundant ferns and sedges dominate the groundstorey, particularly in areas of more open canopy. The forest at this site is a successional stage of

Complex Notophyll Vine Forest (CNVF) with emergent *A. robusta*, i.e. type 6 of Tracey and Webb (1975) and Tracey (1982). A more typical example of the general appearance and forest structure of CNVF with *A. robusta* emergents to 30 m or more in height may be seen nearby, immediately adjacent to Danbulla Forest Drive from about 4.0 to 5.0 km north from the dam wall.

All species recorded from the plot at the time of establishment are listed in life form groups in Appendix 2 Table 1. Key species that confirm the structural/environmental classification through corresponding floristic relationships are *A. robusta*, *Argyrodendron polyandrum* and *Pseudoweinmannia lachnocarpa*. All the recorded species are typical of the type in this area.

The total species richness and tree species richness, 90 and 58 respectively, are the lowest values recorded from the 19 northern sites in the series of 20 plots. Life forms are moderately abundant (8) but the tree species constitute only 64% of the total species list, a low value in comparative terms (Table 13). These low values (cf. the other type 6 site, Plot 16 (EP40) Agapetes Scientific Area) may best be explained by considering the successional nature of the site where the open canopy has allowed the persistence of grass and sedge species with a relative abundance of shrubs, vines and herbs in a species poor community.

Disturbance History and Stand Structure

At plot establishment, records indicate there was no evidence of recent disturbance of the forest by natural events. Selective logging was conducted in the vicinity before 1971 and an old road passes within 10 m of Subplot A. On this road, a substantial retaining wall, constructed by the dry-stone pitching method, indicates a construction date well before establishment of this plot. Although snig tracks were evident throughout the area surrounding the plot at establishment, there was no direct evidence of recent logging operations within the 0.5 ha plot area (but see below). No significant disturbances have been recorded on the plot during the 14 measurements that span 31 years of observations (Table 6) though the site map records an area of pig rooting in Subplot C in 1989.

There are several possible reasons for the unusual characteristics of the Downfall Creek plot. During World War II, this ridgeline was used as a machine gun firing range (John Rudder, Queensland Forestry Department retired, personal communication July 2000). Alternatively, the site may have been in a natural state of long-term succession reflecting relatively recent rainforest colonisation of a Late Quaternary sclerophyll forest inlier, delayed perhaps by the shallow soils on much of the ridgetop. However, this is unlikely as no residual stumps or surface charcoal fragments are evident. Finally, as the plot lies only 1 km northeast of an old sawmill site drowned by Tinaroo Dam (see 1942 Gordonvale 1 Mile series map sheet; location at Tinaroo 1:50,000 AGD 1966 349000 8102800, GDA 1994 349115 8102976), early logging might have occurred on this land that originally was intended for farming use at the time of the portion survey.

As noted above, the structure of this plot is not typical of type 6, CNVF with emergent *Agathis robusta*. The low basal area (34.1 m^2 ha^{-1}) and high stem density (1062 stems ≥10 cm ha^{-1}) are respectively the second lowest and second highest recorded from the 20 CSIRO plots (Table 11, maximum values). In combination, these values are atypical of most undisturbed rainforests in north Queensland and reflect the unusual disturbance history of the site.

Soil Profile and Characteristics

Using selected chemical analysis data from the preliminary survey (Table 12) the granitic soil at this site was assessed as oligotrophic (Figure 4). The detailed soil profile description (Appendix 1 Table 1) is based on field records (Profile Number TL54, compiled by R. Isbell, CSIRO Division of Soils, Townsville) from a soil pit located near the plot, possibly adjacent to the access track. The profile was described as having a Principal Profile Form Um6.3 and affinities with the earthy sand Great Soil Group. Soil chemical analysis data (second series of analyses) are presented in Appendix 1 Table 2. Soil bulk density and moisture retention data are given in Appendix 1 Table 3 while soil hydraulic parameters are presented in Appendix 1 Table 4. Limited soil particle size data from the preliminary soil survey are given in Appendix 1 Table 5. Soil particle density data are given in Appendix 1 Table 6.

Plot 2 (EP3) Mount Haig

Location, Landform and Climate

The Mount Haig plot is located close to the crest of the highest and northernmost section of the Tinaroo Range (Table 1, Figure 7) in Dinden National Park (previously Emerald Logging Area of State Forest 607) within the Wet Tropics World Heritage Area. The site is about 24 km north-northeast of Atherton. Vehicular access to the plot currently terminates at the most northerly point on the Mount Haig road (at Tinaroo 1:50,000 AGD 1966 349500 8109500, GDA 1994 349615 8109676) with foot access over the next 1 km (approximately) of abandoned logging tracks. The plot was set out in October 1971 and the establishment report (J.L. O'Farrell, undated) states that the object of this plot was to examine the structure and species composition of a typical rainforest containing *Flindersia bourjotiana* and *F. pimenteliana* towards the upper altitudinal limit of their occurrence.

The plot lies on the eastern flank of a major north-south ridgeline of the Tinaroo Range at an altitude of 1120 m. The 100 m axis of the plot lies parallel to, and just below, the crest of a side-ridge on a bearing of 50°. The 50 m axis runs down slope at 140° (at right angles to the side ridge) and encompasses upper, mid and lower slope landform elements. Subplot A is located in the southwestern corner of the plot (Figure 8), and the subplot layout is a mirror image of that represented on Figure 3. Logging activities have not disturbed the buffer zone. The northwestern corner of the plot was tied to QDF theodolite traverse peg TE2 that was located near the junction with another abandoned logging track leading to the summit of Mount Haig.

The soils at this site have developed from deeply weathered coarse-grained biotite granite (Willmott *et al.* 1988a,b). Some granite boulders occur along the main ridgeline and on the plot. The site consists of two contrasting geomorphic settings (Figure 8). The southern half of the plot (Subplots A to H) lies on a typical ridge to footslope catena with moderately inclined to steep slopes. In this section, soil depths and characteristics vary along the catena from the ridgetop to gully. The northern section (Subplots I to P) lies across a substantial landslide, with the very steeply sloping headwall located in the buffer zone adjacent to Subplots I and M. The near-level to upthrust toe section occupies much of Subplots O and P. As many of the trees growing on the margins and toe of the slide are of moderate size, the landslide may be hundreds of years old. On this feature, on-going local small slope-failures and mass soil movements, as well as accelerated erosion, are causing tree mortality by root wrenching, root breakages and infections, and by toppling from precarious positions on the head and sidewalls. Soil characteristics in this section of the site will reflect the complexity of the landslide setting.

In terms of the climatic zones of Tracey and Webb (1975) the site is cloudy wet (Table 9). The rainfall pattern is amongst the least seasonal of the CSIRO plots (Table 5). The relatively low seasonality of precipitation, as represented by the rainfall Coefficient of Variation parameter (Table 5), is comparable with that of Plot 8 (EP30) Agapetes Logging Area. Only Plot 7 (EP29) Mount Fisher has a more equable rainfall seasonality. From 1974 to 1978, rainfall data were collected by recording pluviograph and temperature and humidity data from a screened thermohygrograph (calibrated against wet and dry bulb thermometers) from a nearby clearing located approximately 500 m southwest of the plot and 550 m northeast of the “B” Road turnoff, near Tinaroo 1:50,000 AGD 1966 349870 8109750, GDA 1994 349985 8109926, elevation 1150 m). During this period, the mean annual rainfall at the instrumentation clearing was 2226 mm while the maximum and minimum temperatures recorded at screen-height were 32°C and 5.5°C respectively. The original data and calibration values are held in the Permanent Plot Files.

Forest Structure, Type and Floristics

This rainforest is a very tall closed forest with occasional emergents. The upper canopy height ranges between 25 and 32 m with emergent *Agathis atropurpurea* to 40 m (Figure 9). For stems ≥10 cm dbh, *Brackenridgea australiana*, typically a small tree to about 12 m high has the highest stem frequency, while the emergent *A. atropurpurea* contributes over 12% of the basal area (plot description). The treefern *Cyathea rebeccae* is a conspicuous component of the understorey. Interpretations of species importance of the plot should take account of the differences in crown form amongst the canopy trees (plot notes). This forest is Simple Microphyll Vine-Fern Forest (SMiVFF), i.e. type 9 of Tracey and Webb (1975) and Tracey (1982). All species recorded from the plot at the time of establishment are listed in life form groups in Appendix 2 Table 2. *A. atropurpurea* is the key species that confirms the structural/environmental classification. The recorded species are typical of the type in this area and the floristic composition shows similarities to a section of a long-term plot monitored by Prof. Joseph Connell at Davies Creek (Connell *et al.* 1984).

The total species richness (144), tree species richness (110) and life form abundance (8) fall in the moderate range amongst the values recorded from the 20 plots (Table 13). The percentage of tree species (76%) falls in the highest range (75% to 76%) that appears characteristic of structurally simple forests from cloudy sites in upland and highland settings.

Limited *Flindersia* sapling and seedling data are held in the plot files and electronic archive.

Disturbance History and Stand Structure

At the time of plot establishment, the site was described as “relatively free from recent disturbance”, although “tree falls across Subplots A, B and P have opened the canopy and increased the amount of seedling regeneration in these areas” (J. L. O’Farrell, undated plot establishment report). Selective logging of areas adjacent to the site commenced in 1971 after plot establishment but these activities caused no structural damage to the buffer zone or the plot.

From the limited quantitative data available (CSIRO plots 2, 5, 8 and 19) and the transect drawing of Tracey (1982), the combination of high stem density values (1014 stems ≥10 cm ha^{-1}) and a high basal area (67 m^2 ha^{-1}) appears typical of type 9 rainforest (Table 11, maximum values). This basal area is the second highest recorded from the 20 CSIRO plots, while the stem density value is the fourth highest in the series.

Although no significant disturbances have been recorded on the plot during the 14 measurements that span 31 years of observations (Table 6), patterns of large tree mortality appear concentrated around the ancient landslide, particularly on the steeply sloping sidewalls.

Soil Profile and Characteristics

Using selected chemical analysis data from the preliminary survey (Table 12) the granitic soil at this site was assessed as oligotrophic (Figure 4). The soil pit for the detailed soil profile description (Appendix 1 Table 7) was located near the northeastern corner of the plot in colluvial gully infill. This pit location is not typical of the *in situ* soils of the mid- and upper slope sections of the soil catena and extrapolation of the soil data across the plot should be undertaken with caution. The pit profile was described as having a Principal Profile Form Gn3.14 and affinities with the red podzolic Great Soil Group. Relict Quaternary charcoal fragments are abundant in the profile of the pit (Hopkins *et al.* 1993) but, because of their substantial age, they reflect past regional vegetation changes that have no immediate bearing on interpretation of the structure and dynamics of the plot. Soil chemical analyses data (second series of analyses) are presented in Appendix 1 Table 8. Soil bulk density and moisture retention data are given in Appendix 1 Table 9 while soil hydraulic parameters are presented in Appendix 1 Table 10. Soil particle size data are shown in Appendix 1 Table 11.

Plot 3 (EP4) Little Pine Creek

Location, Landform and Climate

The Little Pine Creek plot is located about 12 km north northeast of Gordonvale on the western lower slopes of the Malbon Thompson Range (Table 1, Figure 10) in Malbon Thompson Forest Reserve, designated by the Queensland Government as a future National Park (previously Little Pine Logging Area of State Forest 933 Malbon-Thompson) within the Wet Tropics World Heritage Area. An early forestry map shows this site originally lay in surveyed Portion 248 Parish of Trinity, suggesting an intention to develop the land for agriculture. The current access road to the site crosses privately owned land and prior permission for access by this route must be obtained from the landowner. The old forestry map clearly indicates that the surveyed access road extended across to the eastern flank of the range, suggesting that originally it may have been an old aboriginal foot track. Within the State Forest, present access to the plot is by foot for about 1.0 km along an abandoned logging track. This plot was established in July and August 1972. The plot establishment proposal (G. C. Stocker, 3 September 1971) and report (J. L. O'Farrell, undated) state that the object of this plot was to examine the structure and species composition of a lowland rainforest site containing *Flindersia pimenteliana* and *F. bourjotiana*.

The plot lies on a gently sloping area at 110 m on the western side of a north-westerly spur of the Malbon Thompson Range and includes hill crest, upper and midslope landform elements, close to the site of a now-demolished CSIRO canopy research tower. From the commencement corner (Subplot A), the 100 m axis of the plot runs southwest bearing 211° 45' and the 50 m axis bears 301° 45'. Subplot A is located in the northeastern corner of the plot and the subplot layout is a mirror image of that represented on Figure 3. The buffer zone is undisturbed by logging. The northwestern corner of the plot was tied into a 75 mm square survey peg for R247 on Little Pine Creek.

Extensive outcrops of coarse-grained biotite granite (Willmott *et al.* 1988a,b) occur along the access track to the plot. While the relatively gentle slopes at the site suggest that soil depths and characteristics are probably relatively uniform across the plot, the patchy distribution of the fan palms suggests that some variability may occur in internal drainage characteristics. In terms of the climatic zones of Tracey and Webb (1975) the site is wet (Table 9) while the rainfall Coefficient of Variation value (Table 5) indicates the rainfall distribution is moderately seasonal. From May 1985 to December 1987, rainfall data were collected by an electronic weather station from a nearby clearing (probably at Gordonvale 1:50,000 AGD 1966 375000 8120000 or 374650 8120300, GDA 1994 375115 8120176 or 374765 8120476). Less extensive records of air and soil temperatures are also available. A printout of data is held in the Permanent Plot Files.

Forest Structure, Type and Floristics

At the time of plot establishment, the structure of the rainforest on the plot was a tall to very tall closed forest with an irregular canopy (Stocker 1983), occasional emergents and a conspicuous subcanopy of fan palms, *Licuala ramsayi*, at a density of 268 stems ha^{-1}. The upper canopy height varied between 15 and 23 m with emergent *Acacia celsa* and *Xanthostemon whitei* to 29 m (Figure 11), these emergents being disturbance artefacts rather than characteristic of the undisturbed physiognomic type. Stocker (1983) reported the vegetation of the site at establishment to be "characterised by a more or less continual mid canopy layer of the palm, *Licuala ramsayi".* The plot description shows that, on a species basis, this palm dominates both the stem frequency and basal area contributions (28% and 10% respectively). The next most frequent species were *Macaranga subdentata* (8%) and *Acacia celsa* (6%), while the next most important species by basal area were *Acacia celsa* (9%) and *Elaeocarpus bancroftii* (8%). In addition, *Pandanus monticola* and *Calamus* spp. were abundant in the understorey.

The plot establishment report (O'Farrell, undated) records "The most striking feature of the vegetation in this plot is the small tree/understorey growth in which *Licuala muelleri* (sic, *L. ramsayi)*, *Calamus* spp. and *Pandanus* sp. form an almost impenetrable mass in places where the upper canopy is slightly open." This description suggests that both the structure and floristics of the plot were already influenced by cyclonic disturbance prior to the time of plot establishment.

At establishment, and prior to extensive removal of the upper canopy by Tropical Cyclone *Joy* (described below), it is probable that much of this plot had the structure typical of the variant of Mesophyll Vine Forest (MVF) in which fan palms may be an important feature of the subcanopy, i.e. type 2a of Tracey and Webb (1975) and Tracey (1982). In terms of the palm forest classification developed subsequently by Hopkins *et al.* (1998), this structure probably resembled a "Class 3" fan palm forest, i.e. "a fan palm forest with a *Licuala* canopy or subcanopy stratum (palm crown cover of 50-100%) overtopped by a tree canopy stratum (60-100% crown cover)".

All species recorded from the plot at establishment are listed in life form groups in Appendix 2 Table 3. The recorded species are typical of the type in this coastal area that is intermittently disturbed by cyclones. The total species richness (160) is the third highest recorded in the plot series (Table 13), but lies well below the 189 recorded at Plot 4 (EP9) Robson or 183 at Plot 5 (EP18) Mount Lewis. Tree species richness (115) is moderate to high being comparable with values recorded from Plot 19 (EP43) Mount Baldy (118), Plot 6 (EP19) Garrawalt (112), Plot 2 (EP3) Mount Haig and Plot 8 (EP30) Agapetes Logging Area (110). The percentage of tree species is 72%, and the plot ranks as moderate, being in the fourth recognised class (72% to 73%), comparable to Plot 16 (EP14) Agapetes Scientific Area (73%), Plot 7 (EP29) or Mount Fisher (72%). These characteristics may reflect the relative abundance at this site of trees favoured by gross disturbance such as *Acacia* spp., *Alstonia* spp., *Commersonia bartramia* or *Grevillea baileyana*. The high life form abundance (11) reflects the importance of the palm, cycad and pandan forms at this site, and this value is shared with another cyclone disturbed MVF site, Plot 13 (EP35) Whyanbeel**.**

Flindersia sapling and seedling data are held in the plot files and electronic archive.

Disturbance History and Stand Structure

Cyclones, Logging and Plot Establishment

This plot has a history of periodic disturbance, as noted in the 12 measurements that span 30 years of observations (Table 6). According to the plot notes (at establishment), "This plot shows evidence of having been disturbed periodically by cyclones and some logging damage approximately 20 years ago, due to the presence of what are considered to be light responsive species such as *Acacia aulacocarpa, Commersonia bartramia, Alstonia muellerana, Alphitonia whitei* and, to a certain extent, *Flindersia bourjotiana* and *F. pimenteliana,* generally growing on old logging tracks." The plot notes also state "One representative of *Endiandra palmerstonii* at a dbh of 0.7 m (largest in the plot) and only attaining the height of 17 m further reinforces the opinion that the canopy is subject to a general compression due to cyclones." At plot establishment, however, O'Farrell (undated establishment report) recorded that "The site appears to be relatively free from recent disturbance". Stocker (1983) noted, "Although there was no evidence of recent logging, the site was close to an old logging road and it may have been selectively logged in the past. Damage from recent cyclones (perhaps from the one in 1958) was, however, strongly suspected for the canopy was rather irregular and "large gap" tree species, especially *Acacia aulacocarpa*, were relatively abundant."

O'Farrell's description of the dense understorey (noted above) is supported by his further comment "The plot has large areas of *Calamus* sp. and *Pandanus* sp., some of which had to be lightly brushed to give access to the trees. More trampling and clearing of understorey occurred than is desirable but in this instance could not be avoided."

Selective logging operations commenced nearby soon after plot establishment in 1972 but caused no structural damage to the area within the bounds of the buffer zone.

On 28 December 1990, Tropical Cyclone *Joy* caused considerable damage to the plot and surrounding areas. More than 30 large trees on the plot were uprooted, creating large canopy gaps and transforming the understorey considerably. The positions and extents of the fallen trunks and canopies were mapped on 31 July 1991.

By the 1998 remeasurement, the understorey was nearly impossible to walk through, being dominated by dense *P. monticola* and *Calamus* spp. Patches of recent seedling regeneration of shade tolerant species of Lauraceae had established below the dense understorey.

At this plot, the low basal area of 43.4 m^2 ha^{-1} (Table 11, maximum value) probably reflects a history of repeated disturbance by cyclones. This basal area value is at the lower end of the range recorded from the 20 CSIRO plots. Plot 13 (EP35) Whyanbeel, with only 2 stems ha^{-1} of *Licuala ramsayi*, is a somewhat more typical but disturbed MVF site in the series of CSIRO plots. Both the Little Pine Creek and Whyanbeel basal area values are much lower than the 63.6 m^2 ha^{-1} value determined for a typical MVF site at El Arish by Webb and Tracey, as reported by Hopkins *et al.* (1998). The basal area of Plot 3 (EP4) Little Pine Creek lies towards the lower end of the range of values recorded from Class 1 and Class 2 fan palm forests values by Hopkins *et al.* (1998) and the establishment basal area contribution of 3.6 m^2 ha^{-1} by the 268 stems ha^{-1} of *Licuala ramsayi* is very much lower (10% vs 37 to 56%). The history of repeated disturbances probably accounts for the high all-species stem density (1022 stems ≥10 cm ha^{-1}) recorded on the Little Pine Creek plot.

Pre-European Fire History

Charcoal fragments were found at a depth of 0.1 to 0.2 m in three of six soil cores taken from this site during 2000 (Table 7). A single charcoal fragment from hole 2 provided a radiocarbon date of 1740 ± 40 years BP (CSIRO sample L49 H2.3, ANSTO code OZF174), (Table 8). The corresponding calendar year ages, together with the interval probabilities, are 260 AD - 297 AD (40.2%) and 322AD - 384 AD (59.8%). Due to the small fragment sizes, no taxonomic determination was possible.

From the distribution of the charcoal across the site (Table 7), it is evident that the occurrence of fire was widespread across the site. It is not possible to distinguish between the more probable sources of the charcoal, i.e. burning of a possibly pre-existing *Eucalyptus* open forest now replaced by rainforest, burning of rainforest debris following a major storm or cyclone, or aboriginal activities along the probably important ridgetop track leading to the east coast.

Soil Profile and Characteristics

Using selected chemical analysis data from the preliminary survey (Table 12) the granitic soil at this site was assessed as oligotrophic (Figure 4). The detailed soil profile description (Appendix 1 Table 12) is based on field records from a soil pit located adjacent to the plot but the exact location is not known. The profile was described as having a Principal Profile Form Uf4.2 and affinities with the red earth Great Soil Group. Soil chemical analysis data (second series) are presented in Appendix 1 Table 13. Soil bulk density and moisture retention data are given in Appendix 1 Table 14 while soil hydraulic parameters are presented in Appendix 1 Table 15. Soil particle size data from four unrecorded positions are given in Appendix 1 Table 16 and some corresponding soil particle density data in Appendix 1 Table 17.

Plot 4 (EP9) Robson Logging Area

Location, Landform and Climate

The Robson Logging Area plot is located about 24 km northeast of Atherton on the western slopes of the Lamb Range (Table 1, Figure 12) in Danbulla National Park (previously Robson Logging Area of State Forest 185 Danbulla) within the Wet Tropics World Heritage Area. Current access to the plot is by foot along an abandoned logging track that leaves the Mount Edith Presentation Road at the southern end of an old sand quarry (Tinaroo 1:50,000 AGD 1966 354100 8106700, GDA 1994 354215 8106876). The plot was set out in March 1972 (Stocker 1983). The plot establishment proposal (G. C. Stocker, 17 April 1972) and report (J. L. O'Farrell, undated) state that the object of this plot was to examine the structure and species composition of a typical rainforest containing *Flindersia laevicarpa* var. *laevicarpa*.

The plot is located on the side of a major winding spur of the Lamb Range at 800 m. From the commencement corner (Subplot A), the 100 m axis of the plot runs at a bearing of 5°, parallel to, and just below, the crest of the ridge, which runs north to south in this vicinity. This axis rises at a 5° slope from the commencement corner. The 50 m axis lies on a bearing of 95° giving the plot an eastern aspect. This axis runs down-slope at an angle of 27°, from ridge crest to lower slope landform elements just above a creek flat. Subplot A is located in the southwestern corner of the plot, and the subplot layout is the mirror image of that represented on Figure 3. The western side of the plot is immediately adjacent to the ridgetop logging track, and as a result, there is virtually no marked buffer zone to the plot along that upper margin. (See disturbance history below.) The southwestern corner of the plot was tied in to QDF theodolite traverse peg TP24 on the main access road.

Mid-Palaeozoic metasediments of the Hodgkinson Formation outcrop along the ridgetop and metamorphic rock fragments are common across the plot. However, this exposure is not marked on the most recent detailed geological map for this area (Willmott *et al.* 1988a,b). Soil depths and characteristics will vary along the ridge-crest to lower slope catena. In terms of the rainfall Coefficient of Variation (Table 5) the rainfall seasonality pattern lies near the seasonal end of the range represented in the CSIRO plots. In terms of the climatic zones of Tracey and Webb (1975) the site is wet (Table 9).

Forest Structure, Type and Floristics

In structure, the rainforest on the plot is a very tall to extremely tall closed forest. The upper canopy ranges between 26 and around 40 m (Figure 13). The tallest trees on the plot are *Beilschmiedia bancroftii* (42 m), *Flindersia pimenteliana* (40 m), *Ceratopetalum succirubrum* (40 m), with *F. laevicarpa* var. *laevicarpa* and *F. bourjotiana* at 39 m. The plot description indicates that the small tree *Medicosma fareana* dominates the stem frequencies list (21%), while *Flindersia laevicarpa* and *Ceratopetalum succirubrum* lead the species contributions to basal area (11% and 9% respectively). This forest is Simple Notophyll Vine Forest (SNVF), i.e. type 8 of Tracey and Webb (1975) and Tracey (1982).

All species recorded from the plot at the time of establishment are listed in life form groups in Appendix 2 Table 4. *Agathis microstachya* and *Elaeocarpus sericopetalus* are key species that confirm the structural/ environmental classification. The recorded species are typical of the type in this area and the floristic composition shows similarities to a section of a long-term plot monitored by Prof. Joseph Connell at Davies Creek (Connell *et al.* 1984).

Both the total species richness (189) and the tree species richness (142) are very high, being the maximum values recorded in the series of 20 plots, with only Plot 5 (EP18) Mount Lewis having near comparable values (183 and 127 respectively). The ecological reasons for this are not clear. One possible explanation may be a floristic composition reflecting an "overlap" zone between highland and upland communities. Life forms are of moderate abundance (9). At 75%, the proportion of tree species falls in the highest range (75 to 76), typical of structurally simple forests from cloudy sites in upland and highland settings.

Flindersia sapling and seedling data are held in the plot files and electronic archive.

Disturbance History and Stand Structure

Gaps, Logging and Plot Establishment

The plot establishment report (O'Farrell, undated) describes the site as "relatively free from recent disturbance" but also noted, "An old snig track is located below the eastern boundary of the plot adjacent to a creek." This report concludes "Subplots A, E, I and M have a high number of small trees which could be due to disturbance when the logging road on this side of the plot was first constructed. A tree fall on the southern ends of Subplots G and H has opened the canopy in this area. A considerable amount of trampling of the shrub layer has occurred during identification and measuring."

The plot notes record "The stand has been subjected to natural disturbance and the presence of a few stumps suggest(s) that stems have been selectively harvested at some stage approximately 30 years ago. Where the canopy has been opened by this activity the niche has been utilised by *Polyscias murrayi* and *Alphitonia whitei* in considerable numbers filling the lower to mid-canopy category in these disturbed sections of the plot." Areas of abundant seedlings and movement-restricting *Calamus* tangles were mentioned in the plot notes and Stocker (1983) suggested these were located in "Several small recent gaps due to natural tree deaths (perhaps lightning strike)".

On this plot, values for both basal area (59.9 m^2 ha^{-1}) and stem density (926 stems ≥10 cm ha^{-1}) fall towards the higher end of the ranges recorded from the 20 CSIRO plots (Table 11, maximum value) and appear typical of well developed undisturbed rainforests in north Queensland.

No major disturbances have been recorded at this site during the 13 measurements spanning 30 years of observations (Table 6).

Pre-European Fire History

Charcoal fragments were found at a depth of 0.1-0.2 m in one of six soil cores taken from this site during 2000 (Table 7). A single charcoal fragment from hole 1 provided a conventional radiocarbon date of 780 ± 50 years BP (CSIRO sample L50 H1.3, ANSTO code OZF175), (Table 8). The corresponding calendar year ages, together with the interval probabilities, are 1228 AD - 1229 AD (14%); 1240 AD - 1288 AD (86.0%). Due to the small fragment sizes, no taxonomic determination was possible.

Because of the restricted knowledge of the distribution of the charcoal across the site (Table 7), it is not possible to distinguish between the more probable sources of the charcoal, i.e. burning of a pre-existing ridgetop *Eucalyptus* open forest now replaced by rainforest, burning of rainforest debris following a major storm or cyclone, or aboriginal activities along a ridgetop track. A European origin for this charcoal is highly unlikely (though not impossible) given the age of the wood that was burnt and the relatively undisturbed nature of the site.

Soil Profile and Characteristics

Using selected chemical analysis data from the preliminary survey (Table 12) the metamorphic soil at this site was assessed as oligotrophic (Figure 4). The detailed soil profile description (Appendix 1 Table 18) is based on records from a soil pit, the location of which is not known. The profile was described as having a Principal Profile Form Gn3.71 and affinities with the xanthozem Great Soil Group. The slope along the 50 m axis of this plot suggests that variation within the soil catena may be an important environmental factor, and extrapolation of soil pit data sets across the whole plot may not be appropriate. Soil chemical analyses, based on multiple bulked samples taken at various depths from random locations, are presented in Appendix 1 Table 19. Soil bulk density and moisture retention data are given in Appendix 1 Table 20 while soil hydraulic parameters are presented in Appendix 1 Table 21. Limited soil particle size data from the preliminary soil survey are given in Appendix 1 Table 22.

Plot 5 (EP18) Mount Lewis

Location, Landform and Climate

The Mount Lewis plot is located on the Carbine Tableland on the southwestern side of the Main Coast Range (Table 1, Figure 14) in the Mount Lewis Forest Reserve, designated by the Queensland Government as a future National Park, (previously North Mary Logging Area of State Forest Reserve 143 Mount Lewis) inside the Wet Tropics World Heritage Area. The site is 12.5 km northwest of Julatten Township. The plot is accessed by a short walk from the Mount Lewis Forestry Road at a northwest to northeast corner 26.0 km from the Julatten-Mossman Road, or 22.7 km from the eastern State Forest and World Heritage Area boundary, or 3 km back from the old shed that is at the end of the accessible road (in 2000). The plot was established in September 1973 to examine the structure and species composition of a typical rainforest containing *Flindersia brayleyana* along with *F. bourjotiana, F. pimenteliana* and *F. acuminata* (establishment report, J. L. O'Farrell, undated).

The plot lies on the western side of a north-south ridge at 1100 m. The 100 m axis of the plot is parallel to the broad and relatively flat ridge crest on a bearing of 190°. The 50 m axis runs at 280° and encompasses ridge crest and upper slope landform elements. The commencement corner (Subplot A) is located in the northeast corner of the plot, and the subplot layout (Figure 15) is a mirror image of the layout represented on Figure 3. Although the buffer zone was not affected by logging activities, there has been significant natural disturbance along the eastern margin (Figure 15) in a "patch death" caused by a lightning strike (described below).

Along the main ridgeline, minor outcrops of coarse-grained biotite granite occur, being of Late Carboniferous to Early Permian (Bain and Haipola 1997). Soil depths and characteristics possibly vary slightly along the catena from the ridgetop to upper-mid slope positions. The rainfall pattern is amongst the least seasonal of the CSIRO plots (Table 5) and, in terms of the climatic zones of Tracey and Webb (1975), the site is cloudy wet (Table 9).

Forest Structure, Type and Floristics

This rainforest is a very tall closed forest with an uneven upper canopy, ranging from between 23 and 28 m with the highest trees (e.g. *Ceratopetalum succirubrum*, *F. brayleyana* or *Syzygium wesa*) up to 34 m (Figure 16). This plot is of particular botanical interest because two of the charismatic tree species have very limited distributions. *Stenocarpus davallioides* is recorded only from the Mount Lewis, Thornton Peak and in the northern section of the Alexandra Creek valley (north of Thornton Peak) while *Prumnopitys ladei* occurs only in the Mount Lewis and Mount Spurgeon areas (Hyland *et al.* 1999). The limited distributions of *Elaeocarpus largiflorens* spp. *retinervis* and *Endiandra phaeocarpa* are of comparable botanical interest. This plot has the second highest values for species richness for all life forms as well as for tree life forms (Table 13) ranking as very high, although the percentage of tree species (69%) ranks only as moderate to low due to the importance of epiphytes (11%, second highest value in series) and vines (10%). The plot description indicates that *Niemeyera* (Mount Lewis AKI 1402) dominates the stem frequencies list (12%), while *Flindersia bourjotiana* leads the species contributions to basal area (9%). This forest is Simple Microphyll Vine-Fern Forest (SMiVFF), i.e. type 9 of Webb and Tracey (1975) and Tracey (1982). All species recorded from the plot at the time of establishment are listed in life form groups in Appendix 2 Table 5. Key species that confirm the structural/environmental classification include *Sphalmium racemosum*, *Elaeocarpus elliffii*, *Balanops autraliana*, *Argyrodendron* sp. (Mount Haig LSS 14307), *Garcinia* sp. (Davies Creek JGT 14745), and a range of Lauraceae such as *Cryptocarya densiflora*. The recorded species are typical of the type in this area.

Limited *Flindersia* sapling and seedling data are held in the plot files and electronic archive.

Disturbance History and Stand Structure

The plot establishment report (O'Farrell, undated) described the site as unlogged and free of recent wind damage. It noted that the western side of the plot has a rather dense shrub and small tree layer and the presence of several old logs on the ground, suggesting past wind damage. The plot notes suggest, "cyclonic disturbance … … could explain the relatively large amount of very old fallen stems. These specimens are in a similar stage of decay and probably 'came down' about 50 years ago." These notes specified "Subplots C, D, G, H, K, L, O and P have high numbers of small trees and shrubs which could be due to disturbance at some time. A considerable amount of trampling of the shrub layer in these subplots has occurred during identification and measuring. A dense shrub layer in Subplots C and G is composed mainly of *Ardisia brevipedata*" (now referred to *Ardisia* sp. (Mountain Ardisia BH 8778).

Selective logging of areas adjacent to the site commenced in 1973 during plot establishment but these activities caused no structural damage to the buffer zone or the plot.

Two distinct styles of disturbance have been recorded on the plot during the 13 measurements that span 29 years of observations (Table 6). Firstly, major tree fall gaps were recorded in 1985 (Subplots G and K) and in 1991 (Subplots D and H). Secondly, an extensive "patch death" phenomenon was first noted within the buffer zone adjacent to Subplots E and I in 1987 (Figure 15). This was due to a lightning strike (Bruce Gray, personal communication September 2000). The initial observation recorded the extent of the "patch death" as being roughly circular and 30 m in diameter. Subsequently, the patch had extended northwards into Subplots E and I and westwards in the buffer zone at the 1988 measure. By 1991, more than half of Subplot I was affected. The area had not extended by 1996 and the understorey was recovering. In 1998, there was no evidence of any further recent mortality and the understorey in Subplots E and I had completely recovered, being noticeably denser than in the unaffected plot area. The understorey species within this recovery area consist of tree and shrub species typically found within the plot.

Detailed notes dated 3 August 1989, from the plot records reveal some uncertainty about the timing and nature of this disturbance, possibly due to different staff making sequential observations. These notes read:

> "Dieback (death) affects most if not all canopy species. Patch death first recorded July 1989 – approx. 30 m diam. roughly circular patch adjoining upper shallow ridge (EI side of plot) – recent dieback in most canopy trees and some (approx. ½) understorey crowns. Dead leaves and branchlets still in place, (no sign of lightning damage). Upper crowns of canopy trees dead first (as in drought stress – exposure), lower crowns of some species still green. Understorey regeneration already commencing with shade intolerant species , e.g. *Omalanthus*. Plot trees still dying in EI as dieback creeps into the plot area. Dead patch now simply a passing canopy gap. Estimated age of patch death 3 – 6 months."

From the limited comparable quantitative data available (CSIRO plots 2, 5, 7, 8 and 19) and the transect drawing of Tracey (1982), the combination of moderate to high stem density values (908 stems ≥10 cm ha^{-1}) and a high basal area (62.1 m^2 ha^{-1}) appears typical of type 9 rainforest (Table 11, maximum values).

Soil Profile and Characteristics

Using selected chemical analysis data from the preliminary survey (Table 12) the granitic soil at this site was assessed as oligotrophic (Figure 4). The detailed soil profile description (Appendix 1 Table 23) is based on records from a soil pit, the location of which is not known. The profile was described as having affinities with the xanthozem Great Soil Group. The flat nature of this plot suggests that variation in soil parameters may be relatively small although the soils of the western section of the plot may be somewhat deeper. No soil charcoal was found in near-surface soil samples from the plot (Table 7). Fragments of relict soil charcoal of Late Quaternary age are relatively abundant nearby (Hopkins *et al.* 1993) but, because of their age, reflect past regional vegetation changes that have no immediate bearing on interpretation of the structure and dynamics of the plot. Soil chemical analyses, based on multiple bulked samples taken at various depths from random locations, are presented in Appendix 1 Table 24. Soil bulk density and moisture retention data are given in Appendix 1 Table 25 while soil hydraulic parameters are presented in Appendix 1 Table 26.

Plot 6 (EP19) Garrawalt

Location, Landform and Climate

The Garrawalt plot is located on the eastern side of the Seaview Range (Table 1, Figure 17) in Girringun National Park (previously Burgoo Logging Area, State Forest 750) inside the Wet Tropics World Heritage Area. The site is 46 km west northwest of Ingham. Originally, the plot was accessed from the old road to Princess Hills Station from Wallaman Falls (about 16 km to the south). As the plot now lies adjacent to one of the Great Walks of Queensland, vehicle access to the plot must now be negotiated with the Queensland Parks and Wildlife Service. The plot was set out in June 1975 "to examine the structure and species composition of a typical rainforest containing *Flindersia bourjotiana*" (plot establishment report, K. D. Sanderson, undated).

The plot lies at 620 m on the southeastern side of a ridge running northeast to southwest above White Adder Creek (previously named as Burgoo Creek), a tributary of Garrawalt Creek. The 100 m axis of the plot is parallel to the ridge crest on a bearing of 47°. The 50 m axis runs at 137° and encompasses upper and mid-slope landform elements. The commencement corner (Subplot A) is located in the northwest corner of the plot, the subplot layout (Figure 18) is a mirror image of the layout represented on Figure 3, and the buffer zone is complete and intact. The northwest corner of the plot was tied to QDF theodolite traverse peg TF79 on the main access road.

Although the archived plot descriptions consistently refer to the soil parent material as granite, geological maps (de Keyser *et al.* 1972; Bain and Haipola 1997) indicate that most of the locality in the vicinity of the plot is acidic volcanics, typically rhyolitic lavas and pyroclastics. Although there are no rock outcrops within the plot, nearby outcrops in creek gullies appear to be acid volcanics (2005 plot enumeration). Never the less, it is highly likely that local occurrences of granite could occur within the general area, as occurs along the Herberton Range.

In his discussion of the general area, Brown (1999) notes that "most of Garrawalt …. is on the Glen Gordon Volcanics, massive rhyolites to dacites" and that the "dominant soils in the area are red podzolics and xanthozems (GM3.14 and GM3.75 of Northcote 1965) (G. G. Murtha personal communication [to B. Brown])".

The Garrawalt soil particle size data (Appendix 1 Table 30) show some similarities to those of the granitic soil of Plot 2 (EP3) Mount Haig (Appendix 1 Table 11) with the coarse sand fraction being greater than that of the fine sand. The Garrawalt soil particle size data differ strongly from rhyolitic profiles described by Laffan (1988) in which the fine sand fraction usually exceeds the coarse sand, and from those of the rhyolitic Plot 19 (EP43) Mount Baldy (Appendix 1 Table 82) that are characterised by lower percentages of coarse sand compared with either the Mount Haig or Garrawalt data with the fine and coarse sand fractions being of roughly equal proportions.

The plot is divided fairly evenly between the upper slope (inclination 5°) and midslope landform elements. A small gully forms just above the western side of the plot and runs from Subplot I to Subplot L. The rainfall pattern is highly seasonal with this plot having the second highest rainfall Coefficient of Variation of the CSIRO plot series (Table 5). In terms of the climatic zonation scheme of Tracey and Webb (1975), the site is dry (Table 9) although cloud combing may augment the direct precipitation.

Forest Structure, Type and Floristics

This rainforest is a tall to very tall closed forest with emergents (but see disturbance description below). The height of the continuous upper canopy is quite variable and ranges between 15 and 30 m (Figure 19). At establishment, the tallest trees were *Cryptocarya corrugata* (38 m), *F. bourjotiana* (38 m) and *Canarium muelleri* (36 m). The treefern *Cyathea robertsiana* and the ground fern *Blechnum cartilagineum* are conspicuous and fairly abundant. The plot description indicates that the small tree *Brombya platynema* dominates the stem frequencies list (13%), while *F. bourjotiana* clearly dominates the contributions to basal area (22%).

This plot has moderate values for total species richness (150) and for life forms (8), and these values are comparable to those of other high altitude cloudy sites on infertile soils such as Plot 19 (EP43) Mount Baldy and Plot 8 (EP30) Agapetes Logging Area (Table 13). The plot ranks fifth in tree species richness with a moderate to high value of 112, while the proportion of tree species (75%) falls in the highest range (75% to 76%), both characteristics being typical of structurally simple forests from cloudy sites in upland and highland settings.

This forest was mapped as Simple Notophyll Vine Forest, i.e. type 8 of Tracey and Webb (1975) and Tracey (1982). All species recorded from the plot at the time of establishment are listed in life form groups in Appendix 2 Table 6. Key species that confirm the structural/environmental classification include *Cryptocarya angulata*, *C. putida*, *F. bourjotiana* and *Halfordia kendack*. The recorded species are typical of the type in this area. It should be noted that this location lies outside the range of *Agathis microstachya* that characterises this physiognomic type in areas to the north.

Limited *Flindersia* sapling and seedling data are held in the plot files and electronic archive.

Disturbance History and Stand Structure

Rainforest Development, Stand Form and Human Disturbance

Stocker (1983) suggested that, as large areas of eucalypt forest that had been recently invaded by rainforest were seen in the general area, "the rainforest species on this plot may not have been there for much longer than the age of the oldest tree." This idea is also found in the plot report, "One of the more interesting features of the species reaching the upper canopy is their comparatively small crown development, which together with their fairly early successional nature tends to suggest that this stand of rainforest is quite young and of a transient nature."

However, the possible aggregation of early successional species, together with the very variable canopy height (which in turn may have led to the technical definition of some emergent trees) alternatively may be viewed as responses to one or more of a series of relatively intense and/or localised disturbances ranging from droughts to cyclones and possibly including earlier patch death phenomena similar to that described below.

The plot lies about 40 m from the old Princess Hill Station access road and there is no structural damage from road construction within the buffer zone. Logging activities do not appear to have affected the plot or buffer zone.

Patch Death Phenomenon

This plot is of particular ecological interest because the 11 enumeration records over 30 years span most of a period of development of, and subsequent recovery from, a "patch death" mortality phenomenon that was associated with a positive record of *Phytophthora cinnamomi* (Table 6). Although patch deaths were present in the general Garrawalt area since at least 1968 (Brown 1976, 1999), the plot establishment report described the site as "relatively free from recent disturbance". On 6 October 1976, Dr Bruce Brown, the forest pathologist of the Queensland Forest Service, collected soil samples from the site for pathogen assessment. The most common species of *Phytophthora* recorded was *P. cinnamomi* accounting for 85.8% of all isolates, while *P. heveae* A. W. Thomps. was the second most common species detected (9% of all isolates). There was no indication that P. heveae was specifically associated with diseased forest. The distribution of these species was as follows:

- Northwest corner – *P. cinnamomi*;
- Northeast corner – *P. cinnamomi and P. heveae;*
- Southeast corner – *P. cinnamomi and P. heveae*;
- Southwest corner – *P. heveae*; and
- Centre – *P. cinnamomi and P. heveae.*

In a discussion of the occurrence and role of *P. cinnamomi*, Stocker (1983, p. 229) noted "At the time of (plot) establishment there was a small dead patch containing a large dead tree on a ridge a few metres to the south of the plot and it was assumed then that the death of those trees had been caused by lightning." File notes dated 22 July 1977 record widespread deterioration in the condition of the plot. Further more detailed files notes, dated 22 February 1978, report a "complete open gap" in the area of the three Subplots H5, G14 and K2 and "evidence of past patch death in gully". In Subplot K, dead stems were observed, the mortality of which was considered by the observer(s) to precede plot establishment. Further the canopy was described as "open, disturbed" with the "understorey in gully recovering – vigorous – extra light". The first patch death mortality to occur during the enumeration period was also recorded in this vicinity at the joint corner of Subplots G, H, K and L. The general development of this patch death phenomenon until 1989 is presented in Figure 18.

K. D. Sanderson (file note 25 June 1991) recorded that (by 1991) no additional mortality was attributed to the patch death phenomenon, the understorey was in the process of recovery, the 'Pc' phase was past, and "one would never know 'Pc' had occurred in (the) plot". In 1998 there still was no further patch death mortality and the understorey had recovered, being noticeably denser than the original understorey cover and restricting passage through the plot.

Cyclone Disturbance

During Tropical Cyclone *Winifred* (1 February 1986), about ten tree falls occurred in the strong northeast to easterly winds, and the positions of the stems and crowns were mapped during the 1987 remeasurement (Table 6).

The (post-recovery) stem density value (1014 stems ≥10 cm ha^{-1}) ranks with higher values for the plot series, (Table 11, maximum values). The basal area of 44.9 m^2 ha^{-1} lies towards the lower end of values for the plot series, and, within the Wet Tropics biogeographic region, is comparable only to forests with known histories of heavy human or natural disturbance (i.e. Plot 1 (EP2) Downfall Creek, Plot 3 (EP4) Little Pine Creek, Plot 13 (EP35) Whyanbeel, and the floristically unusual Plot 9 (EP31) Woopen Creek).

Soil Profile and Characteristics

Using selected chemical analysis data from the preliminary survey (Table 12) the soil at this site was assessed as oligotrophic (Figure 4). The detailed soil profile description (Appendix 1 Table 27) is based on records from a soil pit, the location of which is not known. The profile was described as having a Principal Profile Form Um6.34 and affinities with the xanthozem Great Soil Group. Soil chemical analyses, based on multiple bulked samples taken at various depths from random locations, are presented in Appendix 1 Table 28. Soil bulk density and moisture retention data are given in Appendix 1 Table 29, soil hydraulic parameters in Appendix 1 Table 30 and particle size data in Appendix 1 Table 31.

Plot 7 (EP29) Mount Fisher

Location, Landform and Climate

The Mount Fisher plot is located near the northern end of the Cardwell Range about 8 km west-southwest of Millaa Millaa (Table 1, Figure 20) in Malaan National Park (previously State Forest 650) within the Wet Tropics World Heritage Area. Current access to the plot is by foot along about 4.5 km of abandoned logging road from the gate at the end of Kjellberg Rd (Millaa Millaa 1:50,000 AGD 1966 349000 8060600, GDA 1994 349115 8060776). The plot was set out on 3 November 1975, and the establishment report (K. D. Sanderson, 11 May 1976) states the purpose was “to examine the structure and species composition of typical high altitude rainforest on Mount Fisher” (but see geological and landform descriptions below).

This plot lies at 1200 m on a major ridgeline leading to the summit of Mount Fisher (1385 m) and is the highest elevation sampled in the 20 plots of the CSIRO series (Table 2). The 100 m axis runs on a bearing of 20° across a broad ridge, this axis being more-or-less level except in the most northeastern subplots that rise at about 15°. The 50 m plot axis runs parallel to the ridgeline at 290° down a 15° slope. The major landform elements of the site are ridge crest and upper slopes, although a minor shallow drainage line runs through the centre of the plot (in Subplots K, J, I and exiting between trees E19 and E21) dropping along a 17° slope. The commencement corner (Subplot A) is located in the southeast corner of the plot, and the subplot layout is as represented on Figure 3. The buffer zone is intact.

The dominant soil parent material of this plot is rhyolite. Although Mount Fisher is a basaltic volcano of early Quaternary age, the plot itself lies on an inlier of older Permian acidic Glen Gordon Volcanics (Bultitude *et al.* 1997) exposed by erosion. In the vicinity of the plot, outcrops of rhyolite occur in roadside cuttings, and much of the surface of the plot is covered with rhyolitic gravel. This localised rhyolitic section of the ridgeline contrasts strongly with the adjacent and extensive basaltic mid- and upper slopes of Mount Fisher, which is probably the most elevated volcanic vent in northeastern Australia. Some early descriptions of the plot incorrectly report the soil parent material of the plot as basalt.

In terms of the climatic zones of Tracey and Webb (1975) the site is cloudy wet (Table 9). With a rainfall Coefficient of Variation value of 67, the rainfall pattern at Mount Fisher is the least seasonal of all the 20 CSIRO plots (Table 5).

Forest Structure, Type and Floristics

The rainforest on this plot is a very tall closed forest. The canopy height ranges between 20 and 27 with a conspicuous subcanopy between 14 to 19 m (Figure 21). The tallest trees are *Syzygium endophloium* (30 m) and *Aceratium doggrellii* (28 m). The Atherton Palm *Laccospadix australasica* and the Gristle Fern *Blechnum cartilagineum* are very conspicuous components of the midstorey and understorey respectively. The forest type on this rhyolitic site is Simple Microphyll Vine-Fern Forest (SMiVFF), i.e. type 9 of Tracey and Webb (1975) and Tracey (1982). Physiognomically, this type contrasts strongly with the adjacent Complex Notophyll Vine Forest (type 5a) on the surrounding basaltic soils. All species recorded from the plot at the time of establishment are listed in life form groups in Appendix 2 Table 7. *Balanops australiana*, *Elaeocarpus ferruginiflorus* and *Steganthera macooraia* are key species that confirm the structural/ environmental classification.

The plot description indicates that the trees *Cryptocarya densiflora* and *Sphenostemon lobosporus* dominate the stem frequencies list (11% and 8.5% respectively), while *Sphenostemon lobosporus* and *Elaeocarpus foveolatus* dominate the contributions to basal area (12% and 11% respectively).

This plot has moderate to low values for total species richness (150) and for life forms (7) but these values are comparable to those of other high altitude cloudy sites on infertile soils such as Plot 2 (EP3) Mount Haig, Plot 19 (EP43) Mount Baldy and Plot 8 (EP30) Agapetes Logging Area (Table 13). The plot ranks thirteenth in tree species richness with a moderate to low value of 88, while the proportion of tree species (72%) falls in the moderate class (72% to 73%).

Limited *Flindersia* sapling and seedling data are held in the plot files and electronic archive.

Disturbance History and Stand Structure

At the time of plot establishment the site was described as “relatively free of recent disturbance” (plot establishment report, K. D. Sanderson, 11 May 1976). Logging operations commenced in adjacent areas during plot establishment but caused no structural damage within the buffer zone.

This site features a combination of high stem density values (990 stems $\geq$10 cm ha^{-1}) with only a low to moderate basal area (45.5 m^2 ha^{-1}). The limited comparative data available from CSIRO plots 2, 5, 8 and 19 (Table 11) and the transect drawing of Tracey (1982) suggest the stem density value is typical of this structural type. This plot has a high abundance of stem suckers and naturally occurring low branching or multi-stem form trees. These distinctive structural characteristics and the low basal area may be explained by the adverse site conditions including high elevation, poor water holding capacity, low soil nutrients, possible soil toxicity, and the ridgetop position exposed to the dominant southeasterly winds.

Excluding a 1995 record of a large tree fall, no significant disturbances have been recorded on the plot during the 12 measurements that span 27 years of observations (Table 6).

Soil Profile and Characteristics

Soil depth and characteristics appear fairly uniform across the plot. Using selected chemical analysis data from the preliminary survey (Table 12) the soil at this site was assessed as oligotrophic (Figure 4) typical of rhyolitic soils. The brief soil profile description (Appendix 1 Table 32) is based on records from a soil pit, the location of which is not known. This profile was not formally referred to a Great Soil Group in the file records. Soil chemical analyses, based on multiple bulked samples taken at various depths from random locations, are presented in Appendix 1 Table 33. Soil bulk density and moisture retention data are given in Appendix 1 Table 34. In some early documentation of this plot, the soil parent material was described as basalt. Limited soil particle size data from the preliminary soil survey are given in Appendix 1 Table 35.

Plot 8 (EP30) Agapetes Logging Area

Location, Landform and Climate

The Agapetes Logging Area plot is located near the southern margin of the Windsor Tableland adjoining a section of the Great Dividing Range (Table 1, Figure 22) in Mount Windsor National Park, possibly with some of the plot on the adjacent Mount Windsor National Park Recovery, (both previously Agapetes Logging Area of State Forest 144) inside the Wet Tropics World Heritage Area. The site lies 27 km west of Daintree Village on the Daintree River. Access is along the Mount Windsor Forestry Road system. The plot was set out in June 1976 to examine the structure and species composition of a typical high altitude rainforest on Windsor Tableland (plot establishment report, K. D. Sanderson, 14 April 1977).

The plot locality lies on the western headwaters of Spencer Creek that flows into the McLeod River. The site is at 1060 m elevation along the northeastern side of a major ridge (an ancient erosion-residual) rising to 1186 m on an otherwise undulating to rolling low hills landscape that is a dissected plateau remnant. The plot includes upper, middle and lower slope landform elements as well as a small section of hillcrest. The 100 m axis of the plot lies along a bearing of 15°, roughly following the contour just below the local ridgeline. The short axis bears 105° and runs down slope (across the contour lines) on a fairly uniform grade of around 11%. About 15 m west of the lower margin of the plot (at the base of the slope), a fairly substantial gully, around 5m deep and with some steep sides around large granite boulders, drains an extensive area including part of the hill to the west of the road. A smaller dry gully passes through Subplots B, C, D and H. The commencement corner (Subplot A) is located in the southeast corner of the plot, and the subplot layout is as represented on Figure 3. The nearest road lies about 250 m south along the ridgeline, and the buffer zone is intact. At the time of plot establishment, a location survey was undertaken from the plot to a pegged position on the then unsurveyed access road.

Outcrops of coarse-grained granite of Late Carboniferous to Early Permian age (Bain and Haipola 1997) occur along the main ridgeline and in gullies in the vicinity of the plot. Soil depths and characteristics probably vary along the catena from the ridgetop to lower slope positions. The rainfall distribution pattern is amongst the least seasonal of the CSIRO plots (Table 5) and, in terms of the climatic zones of Tracey and Webb (1975), the site is cloudy wet (Table 9).

Forest Structure, Type and Floristics

This rainforest is a very tall to extremely tall closed forest. The upper canopy ranges between 22 and 37 m (Figure 23), being "quite variable in height and density" (Stocker 1983). At establishment, the tallest trees were *Pouteria papyracea* and *Elaeocarpus bancroftii* (both 37 m) with *Musgravea heterophylla*, *Cardwellia sublimis* and *Darlingia darlingina* at 36 m. In terms of both stem frequency and basal area contribution, *Ceratopetalum succirubrum* is the most important species (plot description). Five species of *Flindersia* occur within the plot, *F. acuminata, F. bourjotiana, F. brayleyana, F. ifflaiana* and *F. pimenteliana.* The subcanopy was dominated by *Ceratopetalum succirubrum* and *Brombya platynema*, while *Cyathea rebeccae* was conspicuous in the understorey (Stocker, 1983). The plot has moderately high values for all-species richness, tree species richness and life forms (Table 13). The proportion of tree species (75%) falls in the high range (75% to 76%), being typical of structurally simple forests from cloudy sites in upland and highland settings.

This forest appears to be a transitional type of Simple Notophyll to Microphyll Vine-Fern Forest (SN/MiVFF), i.e. type 8/9 of Tracey and Webb (1975) and Tracey (1982). All species recorded from the plot at the time of establishment are listed in life form groups in Appendix 2

Table 8. The floristic composition of this plot is somewhat unusual, as noted for *Flindersia* species above. While species such as *Balanops australiana*, *Ceratopetalum succirubrum* and *Syzygium wesa* are typical of forests of this environmental setting, many species at the site are "generalists" occurring over a wide range of altitudinal settings and soil types. Further, there is a "dry" component in the plot flora that is consistent with the occurrence of many large kauri trees (*Agathis robusta*) nearby on the ridge to the south of the plot.

Limited *Flindersia* sapling and seedling data are held in the plot files and electronic archive.

Disturbance History and Stand Structure

At the time of plot establishment, logging activities had not reached the vicinity of the plot (plot establishment report, K.D. Sanderson, 14 April 1977). Logging activities that commenced during plot establishment did not affect the buffer zone or plot areas. At establishment, there was no evidence of recent disturbance from natural events, and no significant disturbances have been recorded in the 10 enumerations spanning 26 years (Table 6).

The available file descriptions of the plot differ in detail, and, in some regards, do not correspond with the subplot stem density or height data. In his brief site description, Stocker (1983) suggested that the variation in the canopy height and density was suggestive of past cyclonic disturbance, and further proposed that this canopy variability determined the understorey density that ranged "from dense to almost absent across the plot". Referring to the vicinity of Subplot C, the file description reported "On one side (of the plot) near a small gully, the canopy is more open and on average appears lower in stature, and tree stems do not reach anywhere near the sizes of those situated in the more luxuriant areas. The understorey is abundant and retards movement of people to some degree". A file note adds to the description, noting "On the better formed portion of the plot, the flora is characteristic of good quality rainforest with (a) very entire upper canopy at 25-30 metres and understorey almost absent". This record continues, "Upper canopy height in the poorer section is approximately the same as the remainder of the plot but large trees are less numerous causing a great deal more light to penetrate to lower levels of the canopy and in some places to the ground". Most probably, it is the increased understorey and density of trees less than 10 cm dbh that give the impression that some sections of the site are "poorer" (M. Bradford, personal observation 2002).

This plot features the highest stem density (1170 stems ≥10 cm ha^{-1}) and the fourth highest basal area (64.6 m^2 ha^{-1}) recorded from the CSIRO plots (Table 11, maximum values). From the limited comparable quantitative data available (CSIRO plots 2, 4, 5, 7, 8, 19 and 20) and the transect drawing of Tracey (1982), it appears that this combination of values is typical of type 8/9 rainforest.

Soil Profile and Characteristics

Using selected chemical analysis data from the preliminary survey (Table 12) the soil at this granitic site was assessed as oligotrophic (Figure 4). The detailed soil profile description (Appendix 1 Table 36) is based on records from a soil pit, the location of which is not known (an important issue given the variability in landform elements across the plot). The profile was described as having a Principal Profile Form Gn3.14 and affinities with the red podzolic Great Soil Group. Stocker (1983) recorded "The yellowish clay loam soil contained an increasing quantity of partially decomposed granitic gravel with depth." Soil chemical analyses, based on multiple bulked samples taken at various depths from random locations, are presented in Appendix 1 Table 37. Soil bulk density and moisture retention data are given in Appendix 1 Table 38 while soil hydraulic data are presented in Appendix 1 Table 39 respectively.

Plot 9 (EP31) Woopen Creek

Location, Landform and Climate

The Woopen Creek plot is located about 22 km west of Innisfail (Table 1, Figure 24) in Wooroonooran National Park within the Wet Tropics World Heritage Area. At the time of plot establishment in August 1976, this locality was in Barong Logging Area, State Forest 755. The original access to the plot lay along the now-abandoned logging road from the end of Woopen Creek Road (at Bartle Frere 1:50,000 AGD 1966 GR 378600 8065000, GDA 1994 378715 8065176). The original 12 km access route to this plot has become impossible as most bridges have been removed (25 October 1988) and the logging road is now covered with dense Giant Bramble (*Rubus alceifolius*) and Lantana (*Lantana camara*). In 2005, an alternative access route was found via the old "Nerada" tea plantation and across the North Johnstone River.

The plot establishment report (J. D. Fitzsimon, undated) states that the object of this plot was "to examine the structure and species composition of rainforest on the coastal fringe of the Barron River Metamorphic soils. Rainforest on the site is of particular interest because of the dominance of one particular species, *Backhousia bancroftii*, in relatively large (size) classes." A set of summary notes records that the plot was established in "a distinctive and locally isolated type of coastal rainforest, dominated very definitely by the one major tree species, viz*. Backhousia bancroftii* or Johnstone River Hardwood."

This plot lies at about 80 m elevation and, according to the plot notes, "is located on relatively uniform terrain sloping only slightly to the south, towards Badgery Creek, a tributary of the North Johnstone R" (Figure 24). The establishment report specifies "The long axis of the plot slopes gently towards a dry gully along a bearing of 178° 30', while the short axis follows the contour on a bearing of 88° 30'." The dominant landform element of the plot is recorded in the old soils database records as "lower slope". A shallow and usually dry gully, about 10 m wide, cuts across the southeast corner of the plot, draining through Subplot P to Subplot N. The commencement corner (Subplot A) is located in the northwest corner of the plot and the subplot layout is as on Figure 3. There are no comments recorded on the condition of the buffer zone.

In the past, there was some doubt about the nature of the soil parent material for this plot and the available original data are referred to below. It appears that the plot is located on a mixed alluvial soil derived mainly from metasedimentary parent materials on a remnant of an extensive alluvial terrace. Such relict terrace landforms with alluvial soils partially derived from basalt are widespread in the lower North Johnstone catchment and are, or were, often characterised by rainforests dominated by *B. bancroftii*.

In terms of the climatic zones of Tracey and Webb (1975) the site is very wet (Table 9). With a Rainfall Coefficient of Variation value of 78, the rainfall pattern at Woopen Creek is moderately seasonal (Table 5).

Forest Structure, Type and Floristics

The rainforest on this plot is a very tall to extremely tall closed forest. The canopy height ranges generally between 20 to 35 m, with some sections over 40 m (Figure 25) though there are "very few trees of middle-level canopy heights" (summary notes). In 13 of the 16 subplots, the tallest tree is *B. bancroftii* with the highest reaching 44 m in Subplot A (summary notes). This forest is a floristic variant of Complex Mesophyll Vine Forest (CMVF), type 1a (Tracey and Webb 1975, Tracey, 1982) determined by the often-localised cyclonic-disturbance settings of the district, i.e. a lociation (sensu Webb and Tracey 1981). All species recorded from the plot at the time of establishment are listed in life form groups in

Appendix 2 Table 9. As a numerically dominant canopy tree, *B. bancroftii* is the key species that distinguishes this forest as a lociation within the CMVF type. The only other trees that occur in the upper canopy are *Castanospermum australe* and *Cardwellia sublimis*, as well as the epiphytic *Schefflera actinophylla*. Table 13 indicates the total species richness is high, and life forms and tree species richness are moderate. However, fewer than half the tree species are represented in the enumerated stems, the majority occurring in the understorey. Trees species constitute only 66% of the total species list, this low to moderate contribution being balanced by the highest species count for both shrubs (19, 12% of all species) and herbs (11, 7% of all species) in the plot series.

Disturbance History and Stand Structure

The summary notes record that "The plot has been established in a previously unlogged area, although operations have commenced in adjacent rainforest since that date. Aerial photos and ground observation of exposed areas upstream of the plot site reveal marked vegetation effects of past cyclone damage." The effects of the selective logging operations were outside the bounds of the buffer zone, although the site "lies beside a newly formed road" (plot establishment report). Stocker (1983) gives further details: "While there was no evidence of logging or cyclone damage within the plot, the results of past severe cyclone damage were obvious in nearby areas where dense thickets, locally known as "cyclone scrubs", were a feature of the landscape. The upper canopy of the trees in the plot was dense and well developed. It was however open enough to allow moderately dense clumps of *Calamus* spp. to survive in a suppressed state on the forest floor. Few other tree species reached the upper canopy although aerial photographs revealed that large crowns of the woody hemiepiphyte, *Schefflera actinophylla*, were much more prominent than would be expected from a ground view. The most conspicuous species at mid canopy level was *Myristica insipida*." Other files notes indicate the disturbed context of the location: "Because of this disturbance the site for the plot was by necessity a relatively undisturbed area to enable persons to move about reasonably freely."

In February 1986, Tropical Cyclone *Winifred* caused considerable structural damage creating large gaps from fallen trees and debris. A scaled diagram of this damage and gaps was drawn January 1987. By 1988 these gaps were invaded by Stinging Tree (*Dendrocnide moroides*). However in 1990 the understorey appeared to be recovering and the Stinging Trees were becoming less dense. No other forms of disturbance were recorded during the 9 measurements spanning 29 years of records (Table 6).

This site has the lowest stem density values (484 stems $\geq$10 cm ha^{-1}) in the series of 20 plots and a low basal area of 43.4 m^2 ha^{-1} (Table 11, maximum values). At the time of plot establishment, *B. bancroftii* constituted 34% of the ≥10 cm dbh stems on the plot, i.e. 81 of 238 enumerated stems and 65.7% of the total basal area (undated summary notes). According to the plot establishment report, *B. bancroftii* "would constitute about eighty percent of the millable timber for that area." The summary notes also comment that "Basal area for the rainforest stand at the plot site … … is largely taken up by *Backhousia bancroftii*", continuing "In view of the relatively fewer number of trees on which such B.A. is accumulated logging volumes <u>could</u> be particularly high in exploitation of this rainforest stand during logging."

Soil Profile and Characteristics

The detailed soil profile description (Appendix 1 Table 40) is based on records from a soil pit, the location of which is not known. This profile was described as having a Principal Profile Form Gn3.21 but was not formally referred to a Great Soil Group in the file records. Soil chemical analyses, based on multiple bulked samples taken at various depths from random locations, are presented in Appendix 1 Table 41. In this review, the soil parent material has been described as alluvium, probably derived from metamorphic rocks but possibly with some basaltic alluvium input. Previous descriptions (e.g. Beadle 1981, Stocker and Unwin 1989) described the soil parent material as metamorphic although Stocker (1983) correctly suggested, "The deep red sandy loam soil on this plot did not appear to have the massive clay subsoil characteristic of many soils derived from metamorphic parent materials. Surrounding soils of basaltic origin may have also influenced its properties". Doubts about the soil parent material were also obvious in the undated summary notes in which the sentence relating to metamorphic soil parent materials was ruled through. The old soils database records the substrate material as "unidentified unconsolidated material" and the surface horizons are dominated by sand (Appendix 1 Table 42). Despite the possible basaltic content of the soil parent material, this site is relatively nutrient poor (Table 12, Figure 4).

Plot 10 (EP32) McIlwraith Range

Location, Landform and Climate

The McIlwraith Range plot is located about 32 km northeast of Coen near the headwaters of Leo Creek in the McIlwraith Range (Table 1, Figure 26) on Cape York Peninsula. At the time of plot establishment in September 1975, the tenure was Timber Reserve 14 McIlwraith Range, but is now Unallocated State Land (USL) although Environmental Protection Agency staff have indicated an intention to declare a National Park in this area in the future. Current access to the plot is by four-wheel drive vehicle only along a rough track that leads to the abandoned Leo Creek mining area at 13° 42' 50" S, 143° 22' 55" E. The plot establishment report (K. D. Sanderson, c. September 1975) states that the object of this plot was "to examine the structure and species composition of rainforest on McIlwraith Range, Cape York Peninsula".

According to the plot establishment report "The plot site is on a fairly indistinct ridge that appears to run in a southwesterly direction" with the "topography flat to undulating and slope uniform". After some consideration, the altitude was determined as 450 m. From the commencement corner (Subplot A), the 100 m axis of the plot follows the contour of the ridge in a southeast direction, bearing 135°. The 50 m axis runs across the contours on a slight downhill slope in a southwesterly direction, bearing 225°. The plot thus encompasses upper and midslope landform elements. There are no drainage gullies in the vicinity of the plot, and the nearest permanent creek crosses the access track to the Leo Creek mine about 300 m before the plot. Subplot A is located in the northern corner of the plot, the subplot layout being a mirror image of that represented on Figure 3. The buffer zone was intact and unaffected by roads or tracks. The location of the plot was determined initially by chain and compass survey to a sclerophyll open forest pocket that was visible on aerial photographs, with the position of this pocket being confirmed more recently by a handheld global positioning system (GPS) in 1998.

The field notes for this plot record no rock outcrop on the site, and show uncertainty as to whether the soil parent material was sandstone or shale (Permanent Plot Soil Database Records). Stocker (1983) observed that the underlying rocks were "metamorphic shales although most of this poorly known region is underlain by granite." This description suggests that the plot locality falls on a small inlier of 1800 to 1600 Ma (millions of years) old Palaeoproterozoic Coen Metamorphics (predominantly metasediments, as extensively exposed both 5 km to the northwest and 5 km southeast of the site) within the more widespread Early Devonian granites (Whitaker and Gibson 1977, Bain and Halpola 1997). The situation may be further complicated by the sequence of deeply weathered, old land surfaces observed in this area (Whitaker and Gibson 1977). Because of the fairly uniform topography of the plot, soil depths and characteristics are expected to be relatively similar within the plot, although the patchy distribution of palms suggests that some local differences in internal soil drainage may occur. No local rainfall data are available, but, based consideration of records from Coen, the rainfall pattern at the site is probably moderately to strongly seasonal, though possibly augmented by some mist or cloud occurrences. Extrapolation of the climatic zones of Tracey and Webb (1975) suggests the site may be cloudy moist (Table 9) although the lower latitude may require adjustment of this classification.

Forest Structure, Type and Floristics

In structure, the rainforest on the plot is a tall to very tall closed forest. The upper canopy ranges from 18 to 25 m up to 30 m (Figure 27). While the tallest tree on the plot is *Acmena hemilampra* (30 m), the most common tall tree is *Xanthostemon chrysanthus* (24 to 28 m). The fan palm *Licuala ramsayi* is a common and conspicuous midcanopy component. Stocker (1983) described the understorey as moderately dense (to the point of retarding movement to some degree), being "composed of tree species regeneration, vines and pandans", as well as young fan palms. At the time of plot establishment, *X. chrysanthus* constituted 23.4% of the basal area from only 13 stems (Stocker 1983) although *L. ramsayi* and *Cryptocarpya vulgaris* dominated the stem frequencies at 16% and 10% respectively (plot description). In physiognomic terms, this forest is a hybrid type with features of Mesophyll Vine Forest, fan palm variant (MVF) and Simple Notophyll Vine Forest (SNVF), approximating types 2a/8 of Tracey and Webb (1975) and Tracey (1982).

All species recorded from the plot at the time of establishment are listed in life form groups in Appendix 2 Table 10. Stocker (1983) stated that the floristic affinities of this northern rainforest were with rainforests to the south rather than with nearby northern lowland rainforests represented by Plot 18 (EP42) Iron Range. Results from the floristic analysis undertaken by Kanowski and Graham strongly support this view.

The total species richness (112) and tree species richness (71) are low in comparison with other CSIRO plots, being ranked seventeenth and eighteenth respectively (Table 13). The species richness is similar to the other northern site in the series, Plot 18 (EP42) Iron Range. At 63%, the tree species percentage was low with only the biogeographically distant Plot 14 (EP37) Eungella having smaller values. However, lifeforms were moderately abundant (9) perhaps due to the somewhat unusual combination of fan palms, palms shrubs, treeferns and pandans. Vines constituted an important proportion of the flora (13%) while the epiphyte species richness ranked as moderate, being similar to some of the high altitude sites such as Plot 4 (EP9) Robson LA, Plot 2 (EP3) Mount Haig or Plot 8 (EP30) Agapetes Logging Area.

Disturbance History and Stand Structure

Stand Structure, Floristics and Possible Past Disturbance

The only evidence of human activities in this virgin rainforest area was the access track into the Leo Creek gold mine. Although there was no evidence of recent cyclone damage at the time of plot establishment, Stocker (1983) noted that the *Xanthostemon chrysanthus* and *Blepharocarya involucridgera* appear to show only intermittent recruitment. Periodic disturbance from cyclones or storms, possibly in combination with regional climatic events such as drought, may well be a factor in explaining the unusual dominance of the former species, while the latter is a widely acknowledged "disturbance response" species that regenerates in storm damaged rainforests and also colonises open *Eucalyptus* forests. No significant physical disturbances have been recorded on the plot during the 9 measurements spanning 23 years of observations.

Decline in Podocarpus grayae

Seven individuals of *Podocarpus grayae* (previously referred to as *P. neriifolius*) were enumerated in 1975. By 1998, only 3 of these remained alive. The impact of a putative pest or disease, which has resulted in the deaths across a wide range of size classes of many *P. grayae* in and adjacent to the plot, is detailed by Stocker (1983, pp. 152, 231-237), based on plot enumerations and additional data from adjacent transects.

This site has the lowest basal area value (30.6 m^2 ha^{-1}) in the series of 20 plots but a mid-range stem density of 894 stems ≥10 cm ha^{-1} (Table 11, maximum values). Five of the next six plots in ascending rank order of maximum basal area show either disturbance by disease, past clearing, cyclonic damage at plot or site level, or unusual species dominance thought related to cyclonic disturbance, while the other is a seasonally deciduous rainforest from the northern biogeographic area. However, no other quantitative data are available from Cape York upland rainforests to allow further local comparisons.

Soil Profile and Characteristics

The soil at this site was described by Stocker (1983) as a deep reddish sandy loam. Using selected chemical analysis data from the preliminary survey (Table 12) the nutrient status was assessed as oligotrophic (Figure 4). The detailed soil profile description (Appendix 1 Table 43) is based on records from a soil pit, the location of which is not known. This profile was not formally referred to a Great Soil Group in the file records. The abundance of fan palms suggests poor internal soil drainage and possible soil chemical toxicity associated with the highly acidic profile that is evident in the soil chemical analyses, based on multiple bulked samples taken at various depths from random locations, as presented in Appendix 1 Table 44. Soil bulk density and moisture retention data are given in Appendix 1 Table 45, soil hydraulic parameters are presented in Appendix 1 Table 46 and particle size datasets are given in Appendix 1 Table 47 and Appendix 1 Table 48.

Plot 11 (EP33) Curtain Fig

Location, Landform and Climate

The Curtain Fig plot is located on the Atherton Tableland (Table 1, Figure 28) in Curtain Fig National Park (previously State Forest 452) inside the Wet Tropics World Heritage Area. The site is 2 km southwest of Yungaburra on the western side of the Yungaburra to Malanda road, immediately adjacent to the site of a now-demolished CSIRO canopy research tower and not far from the well-known tourist feature, the Curtain Figtree. The plot was established in March 1976. The establishment report (K. D. Sanderson, 10 March 1978) states that the object of this plot was “To examine the structure and species composition of rainforest established on stony and relatively unweathered basalt soils on the Atherton Tableland”.

The plot locality lies at 720 m elevation on a plateau landform, typically of undulating plain to rolling rise patterns, that developed by infilling of an older landscape by a series of basaltic lava flows (Stephenson *et al.* 1980). The majority of the plot lies falls on a flat landform element although the external edges of Subplots L and P, and all of Subplot M together with adjacent sections of Subplots I and N, occupy lower to mid-slope landform elements on eroded basaltic rises (mostly from 3 to 5 m high) of characteristic vesicular basalt boulders (Figure 29). The 100 m axis of the plot lies along a bearing of 305°, and the short axis bears 215°. The commencement corner (Subplot A) is located in the southeast corner of the plot, and the subplot layout is as represented on Figure 3. The buffer zone is intact and, together with the immediately adjacent forest area, has been the site for numerous research activities (see publications list in Appendix 3).

The flat areas at this site are accumulations of soil and gravel between the residual low rises, and soil depths and characteristics vary with the distance from the basaltic outcrops and the proportions of gravel and cobbles. There is no soil cover on the boulder heaps or stony rises. No surface water flows or drainage channels are evident in this vicinity, or in this section of forest. The comparatively low annual and driest quarter rainfall values produce a seasonal moisture environment (Table 5) and many canopy and understorey species in this forest wilt during drier parts of the year. In terms of the climatic zones of Tracey and Webb (1975), the site is dry (Table 9). Some meteorological and soil temperature data were collected by an electronic weather station from a clearing to the south of the site on Coleman's farm. Weekly rainfall data are held from late April 1985 to July 1986. Air temperature records run from late April 1985 to July 1987 while soil temperature data (two litter values and from 25, 75, 125 and 175 mm depths, two replicate sites) are available from December 1986 to June 1987. A printout of these data is held in the Permanent Plot Files. At some time, a small Stevenson Screen was located 6 m northwest of tree B2.

Forest Structure, Type and Floristics

This rainforest is a very tall to extremely tall closed forest. The upper canopy generally ranges between 28 and 35 m (Figure 30) and the tallest trees on the subplots range from 32 to 43 m in height with *Argyrodendron* sp. (Boonjee BH 2139RFK) at 43 m, *Aleurites rockinghamensis* at 43 m and *Toona ciliata* at 42m. There is no layering of the vegetation into strata above the 15 m level. A distinctive, dense, and locally impenetrable, understorey is present in many areas, consisting of a dense *Hodgkinsonia frutescens* shrub layer to 1.5m high together with abundant basal rosettes of *Calamus caryotoides*. However, this *H. frutescens* understorey is conspicuously absent in two large patches on the plot, running from Subplot A to C, the other from J to L (Figure 29).

At establishment, the Shining Leaved Stingingtree, *Dendrocnide photinophylla*, was the most important species in terms of both stem frequency (16%) and basal area contribution (12%) (plot description). While *Argyrodendron peralatum* is the next most abundant tree species (10.5%) in the ≥10 cm dbh size classes and is a common species in the upper canopy, only a few hundred metres distant, *Argyrodendron* sp. (Boonjee BH 2139RFK) dominates the canopy (Proctor-Gray 1985). Other characteristic and immediately recognisable species of the upper canopy include *Flindersia brayleyana*, *Aleurites rockinghamensis* and *Toona ciliata*. This Complex Notophyll Vine Forest, i.e. type 5b of Tracey and Webb (1975) and Tracey (1982), is characterised by a seasonally sparse canopy (Tracey 1982). All species recorded from the plot at the time of establishment are listed in life form groups in Appendix 2 Table 11. Key tree species that confirm the structural/environmental classification include *Alloxylon flammeum, Firmiana papuana, Flindersia schottiana* and *Viticipremna queenslandica*. The recorded species are typical of the type in this area. Of the taxa that occur on the plot, *Alloxylon flammeum* is considered "vulnerable" while *Firmiana papuana* and *Sauropus macranthus* are recognised as "rare" (Queensland Herbarium 2002).

The plot values for all species richness, tree-species richness, life form numbers as well as the percentage of tree species for this plot are low when assessed against data from the other CSIRO plots (Table 13) but the values are typical of the type (see Hopkins *et al.* 1996). Vines and shrubs are important components of the flora at this plot, representing 14% and 10% respectively of all species.

Disturbance History and Stand Structure

Pre-European Fire History

Charcoal was found at depths of 0.25 m to 0.75 m in five soil pits on this site during 1995 and two of the recovered fragments were submitted for radiocarbon dating during 2003. One charcoal fragment provided a radiocarbon date of 7790 ± 70 years BP (CSIRO sample L34 S1.5, ANSTO code OZG734, Table 8). The corresponding calendar year ages, together with the interval probabilities, are 6642 BC - 6562 BC (63.3%) and 6558 BC - 6509 BC (36.7%). The other charcoal fragment provided a radiocarbon date of 1080 ± 40 years BP (CSIRO sample L34 S2.6, ANSTO code OZG736, Table 8). The corresponding calendar year ages, together with the interval probabilities, are 911 AD - 914 AD (11.8%) and 970 AD - 1017 AD (88.2%). Due to the small fragment sizes, no taxonomic determinations were possible.

The 7000-year difference between the ages of these charcoal fragments shows the great dangers in making ecological or historical interpretations from undated charcoal fragments. The older date is consistent with the regional and local charcoal records associated with the Late Quaternary vegetation change from eucalypt dominated pyrophytic vegetation to rainforest (Hopkins *et al.* 1993, Chen 1986, 1988). In the case of the younger charcoal, the 1000-year age of the wood makes it unlikely that the burning and charcoal formation was of European origin. It is not possible to distinguish between the more probable sources of the charcoal, i.e. burning of rainforest debris following a major storm or cyclone, or some local aboriginal cultural or domestic activities.

Tenure History, Forest Preservation and Logging Disturbance

By the early 1900s, the land subsequently occupied by the Curtain Fig State Forest was surveyed for agricultural subdivision (1911 cadastral map, Parish of East Barron). However, the site was spared from agricultural clearing because it contained only rocky ridges and gravely and excessively drained soil that was totally unsuited to cultivation or grazing. Broad scale logging activities were not possible as the timber smashed on falling and the rocky ridges precluded extended hauling of logs to the adjacent pasture or roads (G. Putt, personal communication). In 1976 there was "some sign of selective felling, probably in the early 1920s" (plot establishment report). According to the plot description "This plot has perhaps been subjected to periodic disturbance, ie, removal of *Gmelina fasciculiflora* and *Castanospermum australe* for fence posts and occasional *Toona australis* for timber, being in close proximity to Yungaburra, one of the oldest established farming and saw-milling communities on the Atherton Tableland".

Pre-European Historical Catastrophic Disturbances and Fire

The life history attributes of many of the canopy species, as well as the demographic characteristics of their populations on and adjacent to the plot, suggest that past catastrophic disturbances have been important at this site. The impacts of drought and, possibly, fire during 1915 probably were compounded by the effects of the 1918 cyclone (Stocker 1983, West *et al.* 1988). Forest damage from that cyclone in the Boar Pocket Rd area, 14 km northeast of the plot, was graphically described by Bryde (1977). The dominance of large *D. photinophylla*, as well as the irregular recruitment and recent near-synchronous mortality of *A. rockinghamensis* in areas adjacent to the plot support interpretations based of such styles of perturbation.

Post-establishment Natural Disturbances

No structural damage from recent natural events was evident when the plot was established in March 1976. No disturbances such as extensive gaps were noted in the 22 year record with a total of 11 measurements, but mortality and structural damage associated with drought were observed in the 1990s (Table 6). At establishment, the plot featured the highest basal area (69.8 m^2 ha^{-1}) recorded from the CSIRO plots (Table 11, maximum values). However, the post-1990 mensuration data reveal a dramatic decline in basal area associated with mortality that is dispersed across the plot for a wide range of size classes and life-history types including typical secondary, late secondary and primary species. Plot records show that 33 enumerated trees died in the period 1990 to 1995, and a further 16 by 1998. Most of this mortality appears directly related to the impacts of severe water stress during a drought that occurred from late 1991 until December 1993. Soil water modelling (Hopkins *et al.*, unpublished) using meteorological data from Yungaburra town indicated that, when water stress intensity and duration were considered jointly, the conditions predicted by the model for October 1992 were unique in the preceding 89 years, with an Average Water Stress Intensity of 181.7 mm, a Water Stress Duration Index of 73.3% and, for the third consecutive year, a Monthly Average Water Stress Intensity of >180 mm.

Detailed observations during this period revealed that many of the surviving trees suffered major structural damage caused by water stress. Ends of branches died back by several metres (e.g. *C. australe*) and substantial declines in leaf area index occurred in both the canopy and understorey. The understorey shrub *H. frutescens* was virtually leafless during the later stages of the drought. Many canopy stems and understorey rosettes of *Calamus* spp. also died. It seems likely that the impending deaths of some of the oldest large canopy trees were hastened by this event, while the mortalities in the smaller size classes probably represent competitive failure under severe water stress.

With the return of typical annual rainfall patterns, the understorey redeveloped rapidly. In the high light intensities below the new inter-canopy gaps, the Stinging Tree *D. moroides* germinated and established forming dense impenetrable thickets that persisted until the damaged upper canopies expanded and more typical canopy foliar cover re-established. Some exotic species also established in the inter-canopy gaps at this time (Hopkins *et al.*, unpublished).

The maximum plot stem density value, 630 stems ≥10 cm ha^{-1}, is the fourth lowest of the plot series and this characteristic probably accounts for the visually imposing appearance of the forest under typical rainfall conditions. From the limited remaining and relatively intact examples of this or closely related types (e.g. 5a, 1b, or 5b/1b as at Malanda Falls) it appears that this combination of high basal area and low stem density was typical of the type.

Soil Profile and Characteristics

Of the 20 CSIRO plots, this one has the highest soil nutrient status, being ranked as eutrophic (Table 12, Figure 4). The detailed soil profile description (Appendix 1 Table 49) is based on records from a soil pit adjacent to the plot near the access track. According to the general description of Laffan (1988), this profile has a Principal Profile Form Uf6.31 and falls within the Prairie Great Soil Group. After no doubt observing the excavations associated with the supports for the research tower, Stocker (1983) noted, “the soil volume was very restricted by numerous basalt boulders throughout the profile.” Soil chemical analyses (second series), based on multiple bulked samples taken at various depths from random locations, are presented in Appendix 1 Table 50. Soil bulk density and moisture retention data are given in Appendix 1 Table 51 while soil hydraulic parameters are presented in

Appendix 1 Table 52. Soil particle size data from four unrecorded positions are given in Appendix 1 Table 53. Soil particle density data are presented in Appendix 1 Table 54.

Plot 12 (EP43) Russell River

Location, Landform and Climate

The Russell River plot is located east of Boonjie, at the base of the southwestern flank of Mount Bartle Frere (Table 1, Figure 31) about 10 km southeast of Butchers Creek, or 15 km west of Miriwinni. The site lies within Wooroonooran National Park in the Wet Tropics World Heritage Area. The previous land tenure was Gosschalk Logging Area, State Forest 755, and the area was intended for logging. It now is accessible only on foot, initially along the abandoned logging road that leads to the Russell River from the registration point for the Bartle Frere walking track (about 1 hour, 15 minutes walk), then by an indistinct route along the proposed logging road down the valley, and finally up a major erosion gully that runs past the plot a few metres west of the commencement corner of Subplot A (about 12 minutes walk from the Russell River crossing). The route of the historic Russell River valley pack track passes through the site entering the plot in the vicinity of the external boundary of Subplots I and E, and exiting roughly between Subplots A and B. The plot establishment report (K.D. Sanderson 29 September 1977) states that the object of this plot was “to examine the structure and species composition of rainforest on the lower southwest slopes of the Mount Bartle Frere/Bellenden Ker Range”. The plot was established in November 1976 (Stocker 1983).

The site is located on the northern side of the Russell River valley in a foothill setting at 380 m. Much of the valley floor adjacent to the river is constituted by alluvial terraces or large depositional fans dissected by gullies of ephemeral streams. The geomorphology of the plot is complex (Figure 32) and this was not recognised in previous descriptions of this site. The eastern margin of the plot (Subplots H, L and P) lies on the foot- and midslopes of a ridge that is a remnant of a basaltic lava flow that originated from the Lamins Hill shield volcano on the eastern margin of the Atherton Tableland. Basalt rocks from near the summit of this vent and from the lower Russell River valley were dated at 0.9 Ma and 1.4 Ma respectively (Whitehead and McDougall 1991). Subplot P is bisected by a steep-sided gully that discharges its basaltic sediment load onto a small alluvial fan covering parts of Subplots J, K, N and O. The margin of another small fan lies across Subplots D and C. The remainder of the plot is located on an old, inactive alluvial terrace primarily granitic in origin. The southern 100 m axis of the plot runs across flat ground at 200°, roughly parallel to the basaltic ridge. The short axis bears 110° and, at the eastern end, runs onto the ridge up a slope of about 15°. The commencement corner (Subplot A) is located in the southwest corner of the plot and the subplot layout is a mirror image of the layout represented on Figure 3.

Boulders of coarse-grained granite (see Willmott *et al.* 1988a, b) occur across the whole plot including on the surface of the basalt ridge. A deep krasnozem soil is developed on the basalt, and basaltic alluvium has greatly enriched much of the plot, either in the fan deposits or mixed with the deep soils of the relict terrace that is predominantly granitic in origin. Fragments of metamorphic rock are also reported from the site. Such geomorphological settings, or related variants, are relatively common along the northern side of the upper valley of the Russell River. The rainfall pattern, as interpreted from the Rainfall Coefficient of Variation (72), is amongst the least seasonal of the 20 CSIRO plots (Table 5) with the moisture index value being the third highest. In terms of the climatic zones of Tracey and Webb (1975) the site is wet to very wet (Table 9).

Forest Structure, Type and Floristics

Structurally, the rainforest on the plot is a very tall to extremely tall closed forest with an extremely uneven canopy. In the earlier forestry-based terminology used by Stocker (1983) and in the plot notes, the highest trees were referred to as emergents. The upper canopy ranges from 30 to 35 m with the highest trees, specifically *Argyrodendron peralatum*, *Alstonia scholaris* and *Beilschmiedia bancroftii*, attaining 45 m (Figure 33). Below, a somewhat separate subcanopy layer extends from 15 to 25 m below which the midstorey and groundstorey has an open appearance.

The plot notes reported a contrast in vegetation structure across the plot and attributed this to the "topographic difference", but this observation is not supported by the stem data. Floristic differentiation in species composition across the soil types is limited to three species which are abundant (>4 individuals) on the flat but absent from the slope, *Doryphora aromatica* (7), *Macaranga inamoena* (4) and *Niemeyera prunifera* (4), and two species abundant on the slope but absent from the flat, *Litsea leefeana* (7) and *Garcinia gibbsiae* (4). In the plot notes, the use of *Geissois biagiana* as an example of such floristic differentiation was incorrect as it is represented by only one individual on the plot (Subplot O).

At establishment, the plot description indicates that *Rockinghamia angustifolia* and *Opisthiolepis heterophylla* dominated the stand in terms of stem abundance (8.3% and 8.0% respectively) while the main basal area contributions were spread across four species, *Tetrasynandra laxiflora* (11%), *Argyrodendron peralatum* (9.9%), *Alstonia scholaris* 9.6%) and *Opisthiolepis heterophylla* (8.5%). In this type, Complex Mesophyll Vine Forest, i.e. type 1a of Tracey and Webb (1975) and Tracey (1982), as is characteristic, hemi-epiphytes are abundant, with "*Pothos longipes, Freycinetia* and *Piper* spp., making d.b.h. measurements difficult at times" (plot notes). All species recorded from the plot at the time of establishment are listed in life form groups in Appendix 2 Table 12. Many of the species on the plot occur widely throughout the coastal lowlands and in the forests of the wet escarpment, and the recorded species are typical of the type in this area. The tree *Haplostichanthus* sp. (Johnstone River LWJ471) and the shrubs *Ixora baileyana* and *Lasianthus strigosus* are characteristic of lowland complex rainforests.

The total species richness value for this plot is moderately high, ranking fifth highest of the CSIRO series of 20 plots, but has 45 fewer species than the maximum recorded at Plot 4 EP9 Robson Creek (Table 13). The moderate tree-species richness lies in the mid-range at 99, constituting only 64% of the total species, due to the combined high contributions of shrubs and vines along with the epiphytic species. Seven life forms were recorded at establishment, ranked as moderate to low in this plot series, and this value is comparable to some of the more unusual complex forests of the series, i.e. Plot 7 (EP29) Mount Fisher, Plot 14 (EP37) Eungella, Plot 15 (EP38) The Crater and Plot 18 (EP42) Iron Range.

Disturbance History and Stand Structure

No structural damage from recent natural events was evident when the plot was established in November 1976 and there was no evidence of logging activity (plot establishment report and Stocker 1983). Across the plot, the historic pack track was evident from an indistinct linear depression possibly having a lower understorey density, but no pattern of disturbance amongst the subcanopy or canopy trees was immediately evident. The 26 year plot record, based on 10 measurements, indicates no localised large disturbances were recorded until the passage of Tropical Cyclone *Winifred* in 1986 though some localised gaps have been recorded subsequently (Table 6). The basal area of 51.6 m^2 ha^{-1} recorded from the CSIRO plots (Table 11, maximum values) lies towards the lower end of the range for plots in the Wet Tropics region that had not been affected in the recent past by cyclones (i.e. 45 to 69.8 m^2 ha^{-1}).

The maximum plot stem density value, 604 stems ≥10 cm ha^{-1}, is the third lowest of the plot series. It accounts for the visually appealing and open appearance of the mid- and subcanopy, being typical of undisturbed examples of the type.

Soil Profile and Characteristics

Using selected chemical analysis data from the preliminary survey (Table 12) the mixed basaltic and granitic alluvial soils at this site were assessed as mesotrophic to eutrophic (Figure 4). However, as described above, there are strong contrasts in nutrient levels in the soil parent materials across the site. The detailed soil profile description (Appendix 1 Table 55) is based on a soil pit on a flat section of the site although the exact location is not known. Presumably referring to the pit profile, Stocker (1983) reported, "The deep brown sandy soil appeared to be derived mainly from granites." The profile was not attributed to a Great Soil Group in the file records. Soil chemical analyses (second series), based on multiple bulked samples taken at various depths from random locations, are presented in Appendix 1 Table 56. It is not known if this sampling took account of the geological differences across the site. Limited soil particle size data from the preliminary soil survey are given in Appendix 1 Table 57.

Plot 13 (EP35) Whyanbeel

Location, Landform and Climate

The Whyanbeel plot is located to the west of the coastal Dagmar Range in the intensely dissected headwaters of Barratt Creek (Table 1, Figure 34) about 13 km north northeast of Mossman. Currently, the site is Unallocated State Land (USL) within the Wet Tropics World Heritage Area. Previously, the site fell in either Barratt Logging Area, State Forest 206 or Chinaman Logging Area, Timber Reserve 55. It now is accessible only on foot along an abandoned, ridgetop vehicle track around 600 m long (commencing at electricity pole JA2, previously numbered 227, approximate location Mossman 1:50,000 AGD 1966 GR 321250 8191450, GDA 1994 321365 8191626), about 10 km from the southern end of the electricity line vehicle access track off Whyanbeel Road (at Mossman 1:50,000 AGD 1966 GR 320800 8188100, GDA 1994 320915 8188276). Detailed access instructions are held in the plot file. The plot was established in May 1977 (Stocker, 1983) and the establishment report (K.D. Sanderson, 6 March 1978) states the object was "to examine the structure and species composition of rainforest on the lower coastal ranges north of Mossman".

The site lies along the southeastern side of a ridge at 230 m elevation on a rolling low hills landscape that is a dissected plateau remnant. Landform elements represented on the plot include upper, middle, and lower slope as well as gully (Subplots D and H only) and a small section of hillcrest (Subplot A). The 100 m axis of the plot lies on a bearing of 65°, almost parallel to, and just below the ridgeline, falling gently to the northeast end (on a slope of 5°) and moderately at the southwest end (10° slope). The short axis bears 155° and runs down a fairly uniform slope of 15°. The commencement corner (Subplot A) is located in the northwest corner of the plot and the subplot layout is a mirror image of the layout represented on Figure 3. The buffer zone is intact.

Across this rolling landscape, metasediments (typically micaceous greywacke) of the Middle Devonian-Lower Carboniferous Hodgkinson Formation (Amos and de Keyser 1964) form relatively shallow and infertile soils. At the plot site, along the ridge and upper slopes, soils are locally skeletal, often with outcrops of white quartz (see mining disturbance below). The rainfall pattern, as interpreted from the Rainfall Coefficient of Variation, is seasonal (Table 5). In terms of the climatic zones of Tracey and Webb (1975) the site is wet (Table 9).

Forest Structure, Type and Floristics

Structurally, the rainforest on the plot is a very tall closed forest. The surface of the upper canopy ranges generally between 26 m and 30 m (Figure 35) with the tallest trees being *Alstonia muelleriana* at 35m and three individuals of *Acacia celsa* at 30 m. Stocker (1983) noted that the canopy was fairly low and relatively compact. The plot description specifies "The more densely foliated section of the canopy is at the 15-20 metre mark … … there being no clear demarcation of categories (of strata)". Even in 2001, occasional large low branching trees were still present, indicating that sections of the canopy of the site were relatively open or broken in the recent past. At establishment, *Endiandra wolfei* was most important in terms of stem density at 10% while *Acacia celsa* contributed 12.9% of the basal area with *Flindersia bourjotiana* the next important at 7.7% (plot description). The understorey is relatively sparse and consists mainly of overstorey tree species and shrubs. The tree fern *Cyathea rebeccae* is abundant in some parts of the plot (Stocker 1983). This site is a typical example of regularly disturbed Mesophyll Vine Forest, i.e. type 2a of Tracey and Webb (1975) and Tracey (1982). Stocker (1983) noted the resemblance between the vegetation of this site and that at Plot 3 (EP4) Little Pine Creek. However, the Whyanbeel site lacks the fan palm understorey characteristic of the Little Pine Creek locality.

All species recorded from the plot at the time of establishment are listed in life form groups in Appendix 2 Table 13. Although many of the species on the plot occur widely throughout the coastal lowlands, both *Argyrodendron* sp. (Whyanbeel BH 1106RFK) and *Backhousia hughesii* are distinctive trees with somewhat restricted geographic distributions (Hyland and Whiffin 1993).

For this plot, the total species richness of 121 lies in the lower mid-range of the series. The tree-species richness also lies in the lower mid-range at 89 but represents 74% of the total species richness, ranking moderate to high in this regard. This may be due to the unusually low number of vine species (5) that represent only 4% of the total species recorded. At 11, the number of life forms is the joint highest in the plot series (Table 13).

Limited *Flindersia* sapling and seedling data are held in the plot files and electronic archive.

Disturbance History and Stand Structure

Pre-establishment Cyclones and Forest Structure

They are four descriptions of this site available, the plot establishment report, the plot description, Stocker (1983) and West *et al.* (1988). Despite some differences in interpretation, all note that this site has been disturbed by cyclones in the past. Key features used in these interpretations were "a high frequency of smaller sized stems and the occasional large sized tree of an early successional species" (plot establishment report), "the flora … has a vigorous appearance which could be mostly due to the very early age of the stand and predominance of early successional and therefore relatively fast growing light responsive species" (plot description), while Stocker (1983) recorded the presence of "many signs of repeated cyclone damage" with some "cyclone scrub patches and recent windfalls within a few hundred metres of the plot". Stocker (1983) also noted that there were only two large trees in the 80-90 cm dbh class at plot establishment. One, an *Acacia celsa* subsequently died while the other "a slow growing *Backhousia hughesii* was probably a relic from forest which existed prior to the last catastrophic disturbance". In the most recent description (West *et al.*, 1988), the structure is referred to as being "in the late stages of recovery from a catastrophe which, at this site, would have almost certainly been severe cyclone damage".

This view is supported by the plot floristics, as noted by West *et al.* (1988), particularly in the presence of *Acacia celsa*, *Alstonia muellerana, Flindersia bourjotiana* and *F. pimenteliana* in the upper canopy. In the regional forest mapping by Tracey and Webb (1975), this district was represented as a mosaic of type 2a Mesophyll Vine Forest and type 12c Vine Forests with Acacia, a pattern usually indicative of regular disturbance.

Post-establishment Disturbances and Cyclones

A number of disturbances have been recorded during the 11 censuses over 25 years at this plot (Table 2). After establishment in May 1977, large gap disturbance was evident at the next enumeration in 1979 (Table 6). The site was then disturbed by strong winds associated with Tropical Cyclone *Winifred* in 1986 and further gap disturbance was noted in 1991.

A site inspection during 2001 revealed that severe Tropical Cyclone *Rona* (12 February 1999) caused some damage on and adjacent to the plot, and tree falls resulting from this disturbance were mapped on that visit. (Plot file notes, however, predicted no damage to the plot from this cyclone, emphasising the importance of regular site appraisals.)

On this plot, the low basal area of 44.0 $m^2 ha^{-1}$ (Table 11, maximum value) probably reflects a history of repeated disturbance by cyclones. This basal area value lies towards the lower end of the range recorded from the 20 CSIRO plots, and as noted previously, is much lower than the 63.6 m^2 ha^{-1} value determined for a typical MVF site at El Arish by Webb and Tracey, as reported by Hopkins *et al.* (1998). The history of repeated cyclonic disturbances is also likely to account for the high stem density of 1002 stems ≥10 cm ha^{-1} (Table 11, maximum value) recorded on the Whyanbeel plot.

Pre-European Fire History

Charcoal fragments were found at a depth of 0.1 m to 0.2 m in only one of six soil cores taken from this site during 2000 (Table 7). A single charcoal fragment from hole 1 provided a conventional radiocarbon date of 1950 ± 40 years BP (CSIRO sample L51 H1.3, ANSTO code OZF176). The corresponding calendar year age or intervals, together with the interval probabilities, are 35 AD - 36 AD (12.4%); 55 AD - 89 AD (58.7%); 101 AD - 121 AD (28.9%). Due to the small fragment sizes, no taxonomic determination was possible.

Because of the limited extent of the charcoal (Table 7), it is not possible to recognise or distinguish between the most probable sources of the charcoal, i.e. burning of a pre-existing *Eucalyptus* open forest now replaced by rainforest, burning of debris from a rainforest (possibly dominated by *Acacia*) following a major storm or cyclone, or aboriginal activities along the ridgetop.

Mining Disturbance and Pre-establishment Cyclones

According to the plot description "The rough track into the area provided access for mining activity in the vicinity of the plot and some disturbance of the earth in the plot is evident, caused by prospecting and the sampling of quartz outcrops. This mining activity occurred probably 20 years ago and has caused no obvious damage". The plot establishment report refers to this activity as "small diggings" throughout the plot. A recent inspection confirms that these disturbances were at an insignificant scale.

Soil Profile and Characteristics

Using selected chemical analysis data from the preliminary survey (Table 12) the soil derived from the metasediments at this site was assessed as oligotrophic (Figure 4) confirming the view expressed earlier in the plot description. The detailed soil profile description (Appendix 1 Table 58) is based on field records from a soil pit located adjacent to the plot although the exact position is not known. This profile was not formally referred to a Great Soil Group in the file records. Stocker (1983) noted, “The gravely reddish loam surface soil was underlain by a massive clay subsoil.” Soil chemical data (second series) are presented in Appendix 1 Table 59. Limited soil particle size data from the preliminary soil survey are given in Appendix 1 Table 60.

Plot 14 (EP37) Eungella

Location, Landform and Climate

The Eungella plot is located on the southern section of the Clark Range (Table 1, Figure 36) in Crediton State Forest (previously referred to as Range Logging Area of State Forest 679) on the headwaters of Endeavour Creek. The site is about 16 km southwest of Finch Hatton township in the Pioneer River valley west of Mackay. Vehicular access to the plot requires negotiation with the adjacent landowner. By road, the plot is about 15 km from the Broken River Bridge, and the 2001 access details are recorded on the plot files. In 2005 it was discovered that the alignment of the Mackay Highlands Great Walk (constructed by the Queensland Parks and Wildlife Service in 2002) passed through the buffer zone of the plot, providing easier local access. The plot establishment report (K.D. Sanderson 14 November 1978) states that the object of this plot was to examine the structure and species composition of highland rainforest in a geographically isolated belt of rainforest on Clarke Range, south of Eungella National Park. The plot was established in June 1977.

The plot lies at an altitude of 920 m on the eastern margin of a major broad ridge that is a plateau remnant. The 100 m axis of the plot parallels this major ridgeline on a bearing of 184°. The 50 m axis runs down slope bearing 94°. The eastern margin of the plot lies about 60 m from the edge of the escarpment. The bulk of the plot lies on midslope landform elements sloping eastwards at between 6° and 3.5°, although a minor ridge runs from Subplot I to Subplot L with associated small upper slope elements. On the northern margin of the plot, a dry gully about 3 m deep and wide runs eastwards through the buffer zone before turning southeast and passing through Subplot D. Subplot A is located in the northwestern corner of the plot and the subplot layout is as represented on Figure 3. While no recent logging activities have disturbed the buffer zone, cattle occasionally stray into this area from the cleared paddock about 150 m to the north.

In contrast to the northern section of the Clark Range where extensive granitic landscapes are represented in Eungella National Park, much of the southern Clark Range, of which the plot locality is typical, is capped by basalt of the Nebo Province (Early Miocene to Palaeocene, between 34.2 and 21.5 million years in age, see Stephenson *et al.* 1980) on which deep and relatively fertile soils have developed. Extrapolation of the climatic zones of Tracey and Webb (1975) suggests the site is cloudy wet (Table 9). Although no model climatic data are available, the estimated rainfall lies in the mid-range of the CSIRO plots (Table 5) and the relative seasonality of precipitation is probably moderate to low.

Forest Structure, Type and Floristics

Structurally, the rainforest on the plot is a very tall to extremely tall closed forest with an uneven canopy. In the earlier forestry-based terminology, some of the conspicuous and relatively abundant highest trees were referred to as emergents (plot notes). The upper canopy ranges from 25 m to 40 m with *Acmena resa* being a conspicuous component (Figure 35). At establishment, the tallest tree heights in all subplots ranged from 31.8 m to 42 m with *Alphitonia petrei* at 42 m, *Acmena resa* at 41m and *Argyrodendron actinophyllum* ssp. *diversifolium* at 41 m. This rainforest is "most impressive with a well developed upper canopy over most of the plot and a mid canopy dominated by the palm *Archontophoenix cunninghamiana*" (Stocker 1983) up to 15 m high (plot notes). The understorey is described as "virtually non-existant" under the more densely closed sections of the canopy, though sections of the plot have a dense ground cover of *Pollia macrophylla* to 0.5 m high. Hemi-epiphytes are conspicuous on the lower section of tree trunks (Stocker 1983).

This forest is a feather palm variant of Complex Notophyll Vine Forest (CNVF) and represents a lociation (Webb and Tracey 1981) determined by the environmental setting of the site where in addition to a relatively high orographic rainfall, abundant moisture is intercepted from clouds that roll across the margin of the escarpment and some local restriction of drainage may also occur. The parent CNVF type is comparable to type 5a of Tracey and Webb (1975) and Tracey (1982). All species recorded from the plot at the time of establishment are listed in life form groups in Appendix 2 Table 14. *Argyrodendron actinophyllum* spp. *diversifolium* is a species that confirms the structural/ environmental classification. The recorded species are typical of the type in this Central Queensland area.

Total species richness and tree species richness are the lowest of the plot series, at 84 and 48 respectively, reflecting the biogeographic location. The comparative ranking by life forms is moderate to low (7). The contributions of the tree species to the total species set is also the lowest in the series (57%) due to the high proportion of epiphytic and hemi-epiphytic species on the plot (15% and 4% respectively, both highest ranking in the series), the moderate numbers of vine species (11%) and the and the importance of herbs (7%).

Tabulations in the plot description show that *A. resa* clearly dominates the basal area of the stand (38%) followed by *Cryptocarya angulata* (13%), *Argyrodendron actinophyllum* ssp. *diversifolium* (10%), *Syzygium wesa* (9%) and *A. cunninghamiana* (7%). In contrast, this palm dominates the stem frequencies (29%) followed by *C. angulata* (19%) and *Dendrocnide photinophylla* (8.5%) while the structurally important *A. resa* ranks fifth, and contributes only 3.9% of stems.

Disturbance History and Stand Structure

Historical Catastrophic Natural Disturbances

In 1977, there was no evidence of recent natural disturbance (plot establishment report). In his preliminary analysis of the stand structure, Stocker (1983) noted that the three tree species with the largest individuals, *A. resa*, *S. wesa* and *A. actinophyllum* ssp. *diversifolium* "regenerate only periodically although recent conditions on the plot may not have allowed *A. resa* to regenerate at all", suggesting this latter species "may be something of a relic out of tune with the recent environment". The presence of such long-lived disturbance-responsive canopy species suggests periodic disturbances either on a broad scale, such as catastrophic regional drought or cyclonic destruction, or with a more localised impact such as thunderstorm wind tracks, are responsible for some aspects of the canopy species composition as well as the size class distribution. As at Plot 11 (EP33) Curtain Fig, the presence of numerous mid-canopy individuals but very few saplings or groundstorey representatives of *D. photinophylla* also suggests that periodic disturbances may be important at the Eungella site.

Past Logging

At plot establishment, there was no sign of any logging activity on the actual plot site (plot establishment report). Evidence of the logging that occurred probably 30 to 40 years previously, was obvious in the surrounding area (Stocker 1983), but was highly selective. Stumps and debris of *Gmelina leichhardtii*, a very durable species often used for fencing, were evident at the northern end of the site in 1977 (plot notes). It may be that the adjacent logging activity had " some effect on understorey growth in certain areas of the plot" (plot notes).

Post-establishment Disturbances and Cyclones

The 28-year data record (spanning 10 measurements) shows large gap disturbance was evident in the 1983 enumeration, with subsequent disturbance by cyclonic winds in February 1989, and further gap disturbance in 2001 (Table 6).

Assessed against data for the 20 plots, this plot has a high basal area (63.2 m^2 ha^{-1}) and moderate stem density values (880 stems ≥10 cm ha^{-1}), these values being typical of undisturbed CMVF or CNVF (Table 11, maximum values).

Soil Profile and Characteristics

Using selected chemical analysis data from the preliminary survey (Table 12) the basaltic soil at this site was assessed as mesotrophic to eutrophic (Figure 4). The detailed soil profile description (Appendix 1 Table 61) is based on field records from a soil pit located adjacent to the plot although the exact position is not known. This profile was referred to the krasnozem Great Soil Group and Principal Profile Form Gn3.14 in the file records, being also described as a red well structured sandy loam with the clay content gradually increasing with depth (Stocker, 1983). Soil chemical data (second series) are presented in Appendix 1 Table 62. Soil bulk density and moisture retention data are given in Appendix 1 Table 63 while soil hydraulic parameters are presented in Appendix 1 Table 64. Soil particle size data are shown in Appendix 1 Table 65.

Plot 15 (EP38) The Crater

Location, Landform and Climate

This plot is about 17 km due south of Atherton on the Hugh Nelson Range (Table 1, Figure 37) in the Herberton Range Forest Reserve (previously referred to as State Forest 194 Barron). It lies just outside the boundary of the Wet Tropics World Heritage Area close to the northern margin of the Mount Hypipamee National Park. Access to the plot is along the Plath Rd to Rolley Rd connecting road, followed by a walk of about 0.5 km along an overgrown abandoned vehicle track through open forest (see plot files for full details). This plot was established in September 1977 as part of a study of the dynamics of rainforest-eucalypt forest boundaries in the Herberton Highland (see Unwin 1983, Unwin *et al.* 1985, Unwin 1989) and was incorporated the "EP" series of CSIRO study plots. This plot was established in September 1977.

The plot is located on a moderately inclined slope of southeasterly aspect at 1000 m (see geomorphology description below). From the northeastern commencement corner (Subplot A), the 100 m axis of the plot runs more or less parallel to the adjacent ridgetop in a westerly direction (bearing 265°) and the 50 m axis runs downhill bearing 175° with slope values around 12 ° to 14 °.

The plot includes upper, mid- and lower slope landform elements as well as a section of relict valley flat. The subplot layout is as represented on Figure 3 with a complete buffer zone. At plot establishment, there was no evidence of recent disturbance within the buffer zone (but see disturbance history below).

Field inspections carried out for this review revealed that the locality has relatively complex geological and geomorphological settings that have not been adequately described in earlier reports on this plot. The Hugh Nelson Range is composed mainly of rhyolitic and granitic rocks with overlying basaltic lava flows and pyroclastic deposits. The ridge on which the plot occurs is part of a broad range crest that is an elevated plateau with relatively low relief characterised as undulating low hills. For example, immediately south of this plot on this plateau, a 1 km long section of the Barron River has a gradient of only 2%. The bounding escarpments of the plateau are clearly evident to the west in the headwaters of North Nigger Creek (now referred to as North Wondecla Creek), particularly at Halls Falls (Atherton 1:50,000, AGD 1966 335000, 8074300, GDA 1994 335115, 8074476), and, to the east, on the Barron River below Dinner Falls (Atherton 1:50,000, AGD 1966 339300, 8072500, GDA 1994 339415, 8072676) or in the headwaters of Poona and Kauri Creeks. The actual plot site lies only 1 km northwest of the Hypipamee Diatreme and 4 km west-northwest of the remnant crest of the Malanda shield volcano (Stephenson *et al.* 1980). Basaltic rock fragments excavated from the plot indicate that basaltic pyroclastics blanketed the plot locality at the time of one or both of these events. While now weathered and substantially eroded, some of this relatively fertile soil parent material is retained on lower slopes and in valley infills, strongly influencing forest composition and physiognomy. On and adjacent to the plot, loose rocks and scattered outcrops of rhyolite and coarse-grained granite commonly occur. Weathered rhyolitic outcrop is exposed in the creek bed immediately downslope of the plot. This creek is incised at least 8 m into the valley infill of friable, dark grey sandy loam. On the plot, similarly textured but lighter coloured soil profiles are at least 0.6 m deep on the most elevated sections, and more than 1 m deep on the lower slopes. Some soil charcoal was recovered from one small pit on the site at a depth of 0.5 m (Appendix 1 Table 67). In terms of the climatic zones of Tracey and Webb (1975) the site is cloudy moist (Table 9) and the rainfall pattern is of moderate to low seasonality (Table 5).

Forest Structure, Type and Floristics

At establishment, the structure of the rainforest on the plot was a very tall to extremely tall closed forest. The uneven upper canopy varied in height between 30 and 38 m with the tallest trees being *Geissois biagiana*, *Ficus* spp. and *Flindersia brayleyana* (Figure 38). The understorey of most of the plot has always been relatively sparse. The plot description indicates that stem frequencies were dominated by *Cryptocarya onoprienkoana* (13%) and *Franciscodendron laurifolium* (11%) while the highest basal area contributions were from *Geissois biagiana* (16%), *Cryptocarya onoprienkoana* (12%) and *Franciscodendron laurifolium* (11%).

This forest is Complex Notophyll Vine Forest (CNVF), i.e. type 5a of Tracey and Webb (1975) and Tracey (1982). Characteristic physiognomic features of this forest type such as well-developed buttresses and strangling figs are abundant at this site. Previous descriptions of the forest type on this plot (e.g. Stocker 1983) appear to have been based on the regional mapping class rather than field observation, interpretation or analysis of the forest features and soils at the site. All species recorded from the plot at the time of establishment are listed in life form groups in Appendix 2 Table 15 and are typical of the complex type at this altitude. In combination, the key species that support the structural /

environmental assessment are *Doryphora aromatica*, *Franciscodendron laurifolium*, *Geissois biagiana*, *Sloanea australis* ssp. *parviflora* and *Haplostichanthus* sp. (Topaz LWJ 520).

The life forms recorded rank as moderate to low (7), the total species richness as moderate (141), the tree species richness as moderate (95), and the tree species percentage as low to mod (67%). Vine species are particularly important at this site, having the second highest number of species in the plot series (21) contributing 15% of the species on the site.

Disturbance History and Stand Structure

Natural Disturbances and Past Logging

Details of the disturbance history of this plot are based on observations during 11 measurements over 25 years (Table 2). At establishment, there was no evidence of disturbance from natural events within the plot and buffer area. However, file records indicate that, at establishment, the plot contained two or three large stumps of *Flindersia brayleyana* (one of which was still visible in 2000) and an old snig track in the northwestern section of the plot. These features indicate that selective logging occurred in the past, probably prior to 1960. The plot notes record "The disturbed section of the plot is approximately one-third of the total plot area and has recovered to a certain extent."

Patch Death Phenomenon

In 1989, a "patch death" phenomenon (commonly associated with *Phytophthora cinnamomi*, but also linked with lightning strikes as at Plot 5 (EP18) Mount Lewis) was observed in Subplots O and P. File notes record the upper canopy to be dead or dying, and the understorey as thin and scattered. By 1998, the canopy had re-established in this area and no further localised deaths were evident in 2000. No formal assessment of a *P. cinnamomi* infestation was undertaken (B.N. Brown, personal observation 2000).

Context and Rainforest Development

Although Unwin (1983) referred to the presence of several moribund *Eucalyptus grandis* surrounded by relatively young rainforest, these trees were still alive in 2000. They are located only on the ridgetop above the plot where the nutrient poor and locally skeletal soils contrast strongly with the deeper soil profile typical of most of the plot, and their occurrence reflects the often fine-grained forest type pattern in such settings. There is no evidence to suggest that the rainforest of the plot is "young rainforest" (cf. Stocker 1983).

Structural Characteristics

Despite the well-developed nature of the rainforest on this plot and a low to moderate stem density of 764 stems ≥10 cm ha^{-1}, it has only a low to moderate basal area of 49.9 m^2 ha^{-1} (Table 11, maximum values). Disturbances associated with past logging and the effects of dieback are probable explanations (Table 6).

Soil Profile and Characteristics

Using selected chemical analysis data from the preliminary survey (Table 12) the soil from the mixed parent materials at this site was assessed as mesotrophic (Figure 4). No detailed soil profile description was available in the plot file. In August 2000, new soil samples were taken at upper slope and lower slope positions to account for the variation in the catena across the plot. At each position, the profile was sampled by three auger holes and the stratified samples were bulked. The corresponding soil chemical analyses for the upper and lower slope locations are given in Appendix 1 Table 66 and the fertility differences between the upper and lower slope sampling positions are clearly evident. Recently sampled, near surface soil bulk density data for contrasting upper, mid- and lower slope positions across the plot are presented in Appendix 1 Table 67.

Plot 16 (EP40) Agapetes Scientific Area

Location, Landform and Climate

The Agapetes Scientific Area plot is located near the drier southern margin of the Windsor Tableland adjoining a section of the Great Dividing Range (Table 1, Figure 39) in Mount Windsor National Park (previously Agapetes Scientific Area of State Forest Reserve 144) inside the Wet Tropics World Heritage Area. The site lies 23 km west southwest of Daintree Village on the Daintree River, or 36 km northwest of Mossman. Access is from the Mount Windsor Forestry Road system. The plot was set out in October 1978. Although no plot establishment report has been found, the intent no doubt was to examine the structure and species composition of “the tall dry upland rainforest on granitic soil” (Stocker 1983).

The plot locality lies in the central southern section of the Spencer Creek catchment above the McLeod River. The site is at 800 m elevation along the northwestern side of a minor ridge that rises to 824 m on a rolling low hills landscape that is a dissected remnant of an ancient plateau. The plot includes extensive ridge, upper and midslope landform elements as well as lower slope and gully settings. The 100 m axis of the plot lies along a bearing of 55°, roughly along the ridgeline. The short axis bears 145° and generally runs down slope. While much of the southern section of the plot is a fairly uniform midslope setting, the northern portion features a side ridge and associated gullies (see file records sketch map). The commencement corner (Subplot A) is located in the southeastern corner of the plot, and the subplot layout is as represented on Figure 3. The nearest logging track lies across the creek to the west of the plot and the buffer zone is intact. On the 1986 Queensland Department of Forestry 1:50,000 Mount Spurgeon map, the plot appears to be about 200 to 300 m away from the wet sclerophyll forest margin to the southwest, or about 400 m away to the southeast.

Stocker (1983) described outcrops or residual corestones of coarse-grained granite in the vicinity of the plot and suggested weathering probably exceeded 5 m in depth. However, soil characteristics are likely to vary along the various catenas from the ridgetop to lower slope positions. The soil parent material is Late Carboniferous to Early Permian granite (Bain and Haipola 1997). The rainfall distribution pattern is moderately seasonal (Table 5) and, in terms of the climatic zones of Tracey and Webb (1975), this upland to highland site is moist to marginally wet (Table 9).

Forest Structure, Type and Floristics

This rainforest is a very tall to extremely tall closed forest with the upper canopy ranging between 30 m and 41 m (Figure 23). The tallest trees are *Agathis robusta* (41 m, three at 36 m) and *Argyrodenron polyandrum* (36 m and 35 m). In terms of overall stem frequency *Backhousia hughesii* clearly dominates (24% of stems) although *Mallotus polyadenos* was the most frequent species amongst subcanopy stems (plot description). This record also shows that basal area contributions are dominated by *A. robusta* (32%) closely followed by *B. hughesii* (26%). The plot has low values for all-species richness (118) and moderate to low for tree species richness (86), while the number of life forms is the joint lowest (6) with Plot 11 (EP33) Curtain Fig and Plot 20 (EP44) Fantail Logging Area in the series (Table 13). The proportion of tree species (73%) falls in the moderate range (69% to 74%) that appears to represent somewhat “disturbed” or “stressed” sites.

This forest is a representative example of Complex Notophyll Vine Forest with emergent *A. robusta*, i.e. type 6 of Tracey and Webb (1975) and Tracey (1982). All species recorded from the plot at the time of establishment are listed in life form groups in Appendix 2 Table 16. Key species that confirm the structural/ environmental classification are *A. robusta* and *Argyrodendron polyandrum*, and the recorded species are typical of the type in this area.

Disturbance History and Stand Structure

At the time of plot establishment, logging activities had not reached the vicinity of the plot (Stocker 1983) and subsequently did not affect the buffer zone or plot areas. At establishment, there was no evidence of recent disturbance from natural events. No significant disturbances have been recorded during the 9 measurements over a 24 year period (Table 6).

On this plot, values for both basal area (61.2 m^2 ha^{-1}) and stem density (996 stems ≥10 cm ha^{-1}) fall towards the higher end of the ranges recorded from the 20 CSIRO plots (Table 11, maximum value) and appear typical of well developed undisturbed rainforests in north Queensland. Comparable quantitative data from similar undisturbed forests of the Tinaroo Range area show basal areas of 62 and 71 m^2 ha^{-1} and stem densities of 960 and 1090 stems ≥10 cm ha^{-1} respectively (CSIRO 20 m by 20 m plots, unpublished data) and the transect drawing of Tracey (1982), suggest that this combination of values appears typical of type 6 rainforest.

Soil Profile and Characteristics

Using selected chemical analysis data from the preliminary survey (Table 12) the soil at this granitic site was assessed as oligotrophic (Figure 4). The detailed soil profile description (Appendix 1 Table 68) is based on records from a soil pit, the location of which is not known (an important issue given the variability in landform elements across the plot). In the soil data base records the profile was described as having affinities with the earthy sand Great Soil Group and a Principal Profile Form Uc. Stocker (1983) recorded “The yellowish loamy soil contained quantities of gravel derived from partially decomposed granite.” Soil chemical analyses, based on multiple bulked samples taken at various depths from random locations, are presented in Appendix 1 Table 69. Soil bulk density and moisture retention data are given in Appendix 1 Table 70 while soil hydraulic parameters are presented in Appendix 1 Table 71.

Plot 17 (EP41) Oliver Creek

Location, Landform and Climate

This plot lies adjacent to Oliver Creek in the Daintree National Park within the Wet Tropics World Heritage Area, about 7 km south-southwest of Cape Tribulation (Table 1, Figure 41). At the time of plot establishment in November 1977, the area was Vacant Crown Land, and the file records from that time refer to this location as “Arsenic Creek”. Access is by foot along the western bank of Oliver Creek for approximately 200 m upstream from the road bridge on the Cape Tribulation road. No documentation for the plot establishment proposal is on file.

The plot lies on the landward margin of the coastal plain at about 15 m elevation immediately adjacent to the footslopes of Mount Hemmant (1065 m). Both the 100 m axis (bearing 336°) and the southern 50 m axis (bearing 246°) run across the western margin of the Oliver Creek valley. Subplot A is located in the southeastern corner of the plot approximately 120 m west of the main creek channel. The plot layout is as represented on Figure 3 and includes a complete buffer zone.

The plot is located on a gently inclined (3° to 5°), poorly sorted fan deposit at the base of a steeply rising gully (c. 18°) in the Mount Hemmant footslopes. Surface soil parent materials predominantly are Palaeozoic metasediments of the Hodgkinson Formation (see Arnold and Fawckner 1980) that outcrop on the adjacent ridge, while deeper valley infill may include a granitic component from the headwaters of Oliver Creek. (Some earlier file records refer to the substrate at this site only as granitic in origin.) Weathered metamorphic gravel and cobbles cover most of the surface of the plot. An ephemeral creek enters the plot through Subplot P (Figure 42) and gully-head erosion in this creek is actively reworking the upper sections of the fan. During peak flows, this creek overflows its channel and discharges over the plot, depositing new debris and disturbing and shifting the previous deposits. In terms of the climatic and altitudinal zones of Tracey and Webb (1975) this is a very wet lowland site (Table 9) but with a moderately seasonal rainfall pattern (Table 5).

Forest Structure, Type and Floristics

In structure, the rainforest on the plot is a tall to very tall closed forest with the uneven upper canopy ranging mostly between 25 and 30 m with the highest sections to 34 m. The tallest trees are *Lindsayomyrtus racemoides* at 42 m and *Storckellia australiensis* at 34 m (Figure 43). Floristically, the plot is unusual with four canopy tree species constituting more than half the ≥10 cm dbh stems on the plot, viz. *Lindsayomyrtus racemoides* (137 stems) *Ryparosa javanica* (32 stems), *Idiospermum australiense* (27 stems) and *Storckiella australiensis* (19 stems). In terms of basal area, the plot is dominated by *Lindsayomyrtus racemoides* (38%) and *Idiospermum australiense* (16%) with *Storckiella australiensis* contributing 9%. This forest is a floristic variant of Complex Mesophyll Vine Forest (CMVF), type 1a (Tracey and Webb 1975; Tracey 1982) determined by the fluvial geomorphic processes and local edaphic setting of the cobble-strewn alluvial fan, i.e. a lociation (Webb and Tracey 1981).

All species recorded from the plot at the time of establishment are listed in life form groups in Appendix 2 Table 17 and are typical of the type in this geomorphic setting. The four most abundant canopy tree species on the plot (listed above) are also common on the rocky alluvial deposits and regularly disturbed alluvial fans adjacent to Noah, Oliver and Cooper Creeks. The plot notes suggest that the floristic composition of the plot differs from that of the forest closer to, and along the banks of, Oliver Creek. The 1977 understorey was described by Stocker (1983) as "rather poorly developed" and "sparse consisting of tree seedlings (especially *L. racemoides* and *I. australiense*), a few shrubs and vines (especially *Calamus* spp.)." Depending on seeding and weather patterns (see below), dense carpets of *I. australiense* can be a notable characteristic of the plot.

On this plot, the number of recorded life forms is moderate (8) and species richness ranks as moderate to low (121), while tree species richness is also moderate to low (85). The percentage of tree species is moderate (70%) with shrubs contributing 11% and vines 12% of the plot flora (Table 13).

Disturbance History and Stand Structure

Plot records and observations are based on 11 measurements over 25 years. Prior to the passage of severe Tropical Cyclone *Rona* on 12 February 1999, no major disturbances had been recorded at this site (Table 6). At establishment, "the plot appeared to be free from past human interference and although there was plenty of evidence of cyclone damage in the vicinity, it did not seem to have been affected by cyclones for a long time" (Stocker, 1983). Minor disturbance of the groundstorey from walking tracks was recorded in 1985.

Cyclone Disturbance

Following Cyclone *Rona*, an inspection of the general Daintree area and Plot 17 (EP41) was carried out on 25 February 1999 (K.D. Sanderson, Plot 17 (EP41) file report). Throughout the Daintree River to Cape Tribulation region, damage was localised and associated with westerly winds. Areas of heavy damage were often associated with topographic wind-funnelling effects (e.g. along the lower Noah Creek valley) or exposure adjacent to cleared land (e.g. east of the clearing at Mason's Store adjacent to Myall Creek). Localised heavy damage was evident in both open and closed sclerophyll communities, and in rainforests including Notophyll Vine Forest adjacent to beaches, Complex Mesophyll Vine Forest on the coastal plain, and Mesophyll Vine Forest on the footslopes and ridges. Most shoreline vegetation was largely untouched. Where fan palm forests (Mesophyll Vine Forests dominated by *Licuala ramsayi)* were impacted, the damage appeared limited to the upper canopy or emergent trees and the palms were largely unaffected. Further accounts of the effects of this cyclone on the forests of the region have been given by Grove *et al.* (2000), Turton (1999) and and Turton and Siegenthaler (2004).

In the valley of Oliver Creek, the effects of Cyclone *Rona* were rated as *Damage Category 3, Moderate Canopy Disturbance* in terms of the cyclone damage criteria developed by Unwin *et al.* (1988), i.e. most stems remained erect, some treefalls occurred, and structural injury was mostly branch and foliage loss. In the vicinity of the plot, the most intense structural damage was largely limited to Subplots A and B (see summary data in the electronic archive) and the buffer area adjacent to Subplots A and B. Many of the seven trees that broke appeared to have weaknesses due to trunk rot either at the base or above.

Significant structural crown damage was recorded for 13 trees across the plot varying from loss of more than half the crown to only a few damaged branches (see summary data in the electronic archive). Many small branches with dead leaves hung in the understorey and their high visual impact gave a false over-estimate of both the extent and intensity of serious structural damage. However, leaf loss was extensive, and some trees with only light structural damage were virtually leafless. As a result, in late February 1999, the projective foliage cover appeared quite low with an estimated reduction of approximately 60% due to leaf loss from defoliation and minor crown damage.

On about one quarter of the plot, the groundstorey is extensively disturbed by water flow and gravel movement during occurrences of intense rainfall. During the intense rainfall associated with Cyclone *Rona*, the ephemeral creek again distributed coarse gravel and cobbles across much of Subplots A, B, E and F (Figure 42). In July 2000 the groundstorey of this area remained conspicuously sparse in contrast to the remainder of the plot, which featured a dense carpet of well-established *L. racemoides* seedlings.

Structural Characteristics

On the Oliver Creek plot, the basal area (45.6 m^2 ha^{-1}) is low to moderate while stem density (792 stems ≥10 cm ha^{-1}) is moderate to high in comparison with data recorded from the other 19 CSIRO plots (Table 11, maximum values). These values probably reflect past disturbances associated with cyclones, intense rainfalls and extreme stream discharges across the alluvial fan. Similar situations and disturbance regimes are quite common in much of the lowland rainforest in north Queensland.

Soil Profile and Characteristics

Using selected chemical analysis data from the preliminary survey (Table 12) the soil at this site was assessed as oligotrophic (Figure 4). The brief soil profile description (Appendix 1 Table 72) is based on field records from a soil pit located adjacent to the plot although the exact position is not known. This profile was not formally referred to a Great Soil Group in the file records, but was described as a colluvial soil by Stocker (1983). Soil chemical data (second series) are presented in Appendix 1 Table 73. Limited soil particle size data from the preliminary soil survey are given in Appendix 1 Table 74.

Plot 18 (EP42) Iron Range

Location, Landform and Climate

The Iron Range plot is the most northerly in the series of 20 plots, lying about 550 km north - northwest of Cairns on the east coast of Cape York (Figure 1). The plot is located on the south bank of the West Claudie River, 6 km east-northeast of Mount Tozer, and 10 km northwest of the Lockhart River settlement (Table 1, Figure 44). This site lies in Iron Range National Park and is accessible by walking 550 m upstream from the last causeway crossing the Claudie River, approximately 12 km before the Lochhart River settlement. The plot was established in November 1977 but no plot establishment proposal or report is on file.

The site lies on an active riverine plain landform (Figure 45) at about 60 m elevation. The landform elements represented on the plot include: an actively eroding streambank (now in Subplots I and M, about 9 m high above the streambed), a scroll (an alluvial sediment rise centred on Subplots F, G, J and K), a gully (seasonal overflow channel, possibly a partially infilled meander channel, along the eastern, northern and western plot margins) and small areas of footslope (Subplots D and P, leading up to the higher sections of the alluvial plain). The 100 m axis of the plot lies at 220°, tangential to the bend of the Claudie River. The commencement corner (Subplot A) is located in the northern corner of the plot and the subplot layout is as represented in Figure 3. The buffer zone has always been incomplete on the western corner of the plot, around Subplot M, where the 1977 position of the riverbank lay only a few metres from the plot corner peg. (For further details, see disturbance description below.) About one-third of the plot (along and adjacent to the overflow channel) is subject to inundation almost every wet season, January-April (Figure 45).

The site has a deep sandy alluvial loam soil (Stocker 1983) typical of the riverine plain. Extrapolation of the climatic zones of Tracey and Webb (1975) suggests the site is moist (Table 9) though with “severe drought conditions prevailing through October-December” (plot notes). Although no model climatic data are available, the estimated rainfall lies in the mid-range of the CSIRO plots (Table 5) but the relative seasonality of precipitation is probably higher than for any other site in the series. Assessment of the soil moisture availability at this site must consider the augmentation of the rainfall by groundwater and soil moisture recharge from flooding.

Forest Structure, Type and Floristics

Structurally, the rainforest on the plot is a variably tall to extremely tall closed forest, the upper canopy being irregular and very uneven (Figure 46). The tallest trees have characteristically broad crowns with *Antiaris toxicaria* var. *macrophylla* and *Tetrameles nudiflora* both attaining heights of 41 m. Between the large trees, the canopy height drops to as low as 10 to 15 m. There are no large gaps in the canopy but in the channel from Subplot M to Subplot P, the trees are relatively widely spaced. Across the plot, the understorey density varies inversely with the duration of flooding. The bed of the overflow channel is almost devoid of small tree and understorey growth whereas the higher ground towards the centre of the plot (on the scroll deposit) has a dense understorey of seedlings and shrubs (plot notes). This forest contains a number of facultative and obligate deciduous species and is a typical Semi-Deciduous Mesophyll Vine Forest, i.e. type 4 of Tracey and Webb (1975) and Tracey (1982).

All species recorded from the plot at the time of establishment are listed in life form groups in Appendix 2 Table 18. Representative species that support the structural/ environmental classification are *Ailanthus integrifolia* ssp. *intregrifolia*, *Neolamarckia cadamba*, *Barringtonia calyptrata*, *Beilschmiedia obtusifolia*, *Myristica insipida*, *Nauclea orientalis*, *Palaquium galactoxylum, Sterculia shillinglawii*, *Tetrameles nudiflora* and *Rhyticaryum longifolium.* All the recorded species are typical of the type in this area. Stocker (1983) observed that the floristic composition of this plot "suggested … greater affinity with the rainforests of parts of southern New Guinea than with those ... in the Cooktown to Townsville region".

In terms of stem densities, the plot is dominated by *Pisonia umbelliflora* (11.5% of stems) followed by *Beilschmiedia obtusifolia* (7%) and *Cleistanthus apodus* (6%). The greatest basal area contributions are from *Castanospermum australe*(19%), *Nauclea orientalis* (14%) and *Beilschmiedia obtusifolia* (9%).

At 111, the total species richness value for this plot is the third lowest of the series, exceeding only the successional Plot 1 (EP2) Downfall Creek, and biogeographically remote Plot 14 (EP37) Eungella (Table 13). This low species richness is, at least in part, due to the relatively small numbers of herbaceous, epiphytic and hemi-epiphytic species recorded. (The paucity of herbaceous species may reflect both the disturbance of the site by pigs and, possibly, the timing of the sampling in the late dry season.) The tree-species richness lies in the lower mid-range at 89 (comparable to Plot 17 (EP41) Oliver Creek or Plot 11 (EP33) Curtain Fig), but the surprisingly, the percentage of tree species (76%) is the joint highest of the series equalled only by biogeographically and climatically dissimilar Plot 2 (EP3) Mount Haig. The life forms count (7) is moderate to low, but is comparable to that of the other northern Plot 10 (EP32) McIlwraith Range.

Disturbance History and Stand Structure

Timber Removal and Feral Animals

Being remote from population centres, this site showed little human disturbance at establishment (plot notes). Based on the evidence from a cut stump, the location of which was not specified, Stocker (1983) suggested that one *C. australe* was "probably removed to provide a bridge girder when the access road was constructed in the early 1940s". In common with many rainforest areas, this plot was subject to extensive pig disturbance at least between 1977 and 1983 (Stocker 1983).

Cyclone Disturbance and River Bank Erosion

Stocker (1983) reported that, during 1979, a cyclone passed across this locality but did little direct damage to the vegetation. His observations that "most if not all of the … canopy level species regenerated either periodically or under different conditions to those recently occurring" may reflect the influence of earlier cyclones on the floristic composition of the plot. He also noted that the high river levels associated with the 1979 event caused erosion of the stream bank and consequential tree falls in Subplot M. This erosion has continued unabated (file records, Figure 45) with the riverbank cutting back up to 25 m in a northeast direction by 1998. There has been no evidence of structural damage from other types of natural events during the 9 measurements spanning a 25-year record to 2002 (Table 6).

The structure of this plot appears typical of type 4, SDMVF with a low basal area (43 m^2 ha^{-1}) and the maximum recorded stem density is low at 554 stems ≥10 cm ha^{-1} (Table 11, maximum values). The only comparable dataset available is the basal area of 41.3 m^2 ha^{-1} and c. 560 stems ≥10 cm ha^{-1} recorded from Long Scrub, Bamaga (Webb and Tracey, unpublished "18 sites" data). The Iron Range plot basal area value is similar to the cyclone disturbed forests of Plot 9 (EP31) Woopen Creek or Plot 4 (EP4) Little Pine Creek. Stocker (1983) suggested that more stems occurred in the larger size classes than might be expected and the Webb and Tracey Long Scrub data show a similar trend, suggesting this may be a characteristic of the type.

Soil Profile and Characteristics

Using selected chemical analysis data from the preliminary survey (Table 12) the alluvial soil at this site was assessed as mesotrophic (Figure 4). The detailed soil profile description (Appendix 1 Table 75) is based on field records from a soil pit at an unknown location adjacent to the plot. The Principal Profile Form Uc6.14 has affinities with the earthy sand Great Soil Group, being developed on unspecified unconsolidated material (soil database records). Soil chemical data (second series) are presented in Appendix 1 Table 76. Soil particle size data are shown in Appendix 1 Table 77.

Plot 19 (EP43) Mount Baldy

Location, Landform and Climate

The Mount Baldy plot is located 7 km southwest of Atherton near the crest of the Great Dividing Range (Table 1, Figure 47). This site lies in the Herberton Range State Forest (previously referred to as Scrubby Logging Area, State Forest 194) and is not in the World Heritage Area. It is most easily accessed by a c. 1.5 km near level walk along an abandoned logging track leading off the Mount Baldy Forestry Road from the major intersection at Atherton 1:50,0000 AGD 1966 332600 8086450, GDA 1994 332715 8086626. The plot was established in June 1978 but no plot establishment proposal or report is on file.

The plot lies at 1120 m centered on the midslope of a major spur running southeast from the range crest. The 100 m axis (bearing 305° 30') runs across the upper slope landform element parallel to the ridgeline, and the 50 m axis (bearing 215° 30') runs down a steep slope (12°, soil database) to the lowerslope landform element. Subplot A is located in the eastern corner of the plot and the layout is as represented on Figure 3 with a complete buffer zone.

The soil parent material is Late Carboniferous to Early Permian rhyolite (Bain and Haipola 1997) and surface boulders are common, particularly in the lower sections of the plot. In terms of the climatic and altitudinal zones of Tracey and Webb (1975) this is a cloudy moist highland site (Table 9). From the modelled data, the rainfall pattern appears moderately seasonal (Table 5) but at this elevation, the 1655 mm of direct rainfall is undoubtedly augmented by cloud interception.

Forest Structure, Type and Floristics

Structurally, the rainforest on the plot is a very tall to extremely tall closed forest with an uneven canopy ranging mostly from 25 to 42 m, across the plot (Figure 48). The tallest trees have high, broad crowns that structurally dominate the uppermost canopy, e.g. *Galbulimima baccata* 42 m, *Cinnamomum laubatii* 40 m and 38 m, *Flindersia brayleyana* 40 m, *Xanthostemon whitei* 37 m, *Flindersia pimenteliana* 37 m and *Carwellia sublimis* 36 m. In terms of both frequency and basal area contribution, *Franciscodendron laurifolium* dominated the plot for stems ≥10 cm dbh (29% of stems, 24% of basal area). Except in recent gaps and older treefall areas, the understorey was sparse, being mostly composed of small trees. All species recorded from the plot at the time of establishment are listed in life form groups in Appendix 2 Table 19. This forest appears typical of Simple Microphyll Vine-Fern Forest (SMiVFF), type 9 of Tracey and Webb (1975) and Tracey (1982). The group of species that confirms the structural/ environmental classification includes *Acronychia crassipetala*, *Balanops australiana*, *Bobea myrtoides*, *Canarium australasicum*, *Halfordia kendack, Steganthera macooraia, Syzygium endophloium* and *Sarcotoechia* sp. (Mount Carbine GJM 995). All the recorded species are typical of the type in this area.

At 157, the total species richness value ranks as moderate to high, being fourth highest of the plot series (Table 13), exceeded only in Plot 4 (EP9) Robson (189), at Plot 5 (EP18) Mount Lewis (183) and from the heavily disturbed Plot 3 (EP4) Little Pine Creek (160). The tree-species richness is also moderate to high, being exceeded only in the two relatively undisturbed plots listed above. The percentage of tree species also is high (75%) as appears characteristic of structurally simple forests from cloudy sites in highland settings. The life forms count (8) is only moderate with treeferns, pandans and palm forms being conspicuous absences.

Disturbance History and Stand Structure

Establishment Condition and Effects of Tropical Cyclone Winifred

At establishment, the plot "appeared not to have been logged and contained no evidence of cyclone damage" (Stocker 1983). File notes from the 1986 remeasurement record minimal damage to the plot canopy or understorey during the passage of Tropical Cyclone *Winifred* on 2 February 1986. In the vicinity, some large trees were blown over or uprooted, but only a few trees were lost within the plot. Numerous small branches were lost from canopy trees but these were recovering by the August census. No other significant disturbances were noted during the 24 years of observations spanning 10 measurements (Table 6).

Stand Characteristics

This plot has a high basal area of 66.2 m^2 ha^{-1} (Table 11, maximum value) ranking third highest in the series below Plot 11(EP33) Curtain Fig (69.8 m^2 ha^{-1}) and Plot 2 (EP3) Mount Haig (67 m^2 ha^{-1}). The stem density of 784 stems ≥10 cm ha^{-1} (Table 11, maximum value) ranks as moderate, and is the sixth lowest in the series. Together with the imposing height of the uppermost canopy trees and the relatively clear understorey, these structural characteristics combine to make a visually appealing forest.

Present Forest Context and Pre-European Fire History

While there is no sclerophyll vegetation along the ridge immediately uphill from the plot, *Eucalyptus grandis* occurs along the ridge crest about 200m to the east, marking the uphill boundary of the widespread tall open forests along the eastern flank of the range. At this location, the oldest eucalypts along the ecotone are moribund and now stand in developing rainforest. The ridge carries an old logging and mining road and was probably an important Aboriginal foot track prior to the full establishment of European development in the district. Fire has long been an important part of management along Aboriginal access routes, both in rainforest and sclerophyll forests (Ernie Grant, Tully, personal communication).

Charcoal fragments were found at a depth of 0.05 m to 0.2 m in two of six soil cores taken from this site during 2000 (Table 7). The radiocarbon age of a single charcoal fragment from hole 5 was 2020 ± 40 years BP (CSIRO sample L53 H5.3, ANSTO code OZF177). The corresponding calendar year intervals, together with the interval probabilities, are 39 BC - 27

AD (77.7%); 40 AD - 51 AD (22.3%). Due to the small fragment sizes, no taxonomic determination was possible.

Because of the limited extent and small size of the charcoal (Table 7), it is not possible to recognise or distinguish between the most probable sources of the charcoal, i.e. burning of a pre-existing *Eucalyptus* open forest now replaced by rainforest, burning of rainforest debris following a major storm or cyclone, or aboriginal activities along the ridgetop. The age of the burnt wood (Table 8) suggests that it is unlikely that the firing was of European origin.

Soil Profile and Characteristics

Using selected chemical analysis data from the preliminary survey (Table 12) the soil derived from the rhyolite at this site was assessed as oligotrophic (Figure 4). The detailed soil profile description (Appendix 1 Table 78) is based on field records from a soil pit located adjacent to the plot although the exact position is not known. This profile, more than 2 m deep, was documented as having a Principal Profile Form Gn3.71 and affinities with the xanthozem Great Soil Group, being described by Stocker (1983) as a “red loamy soil”. The soil chemical data (second series) are presented in Appendix 1 Table 79. Soil bulk density and moisture retention data are given in Appendix 1 Table 80 while soil hydraulic parameters are presented in Appendix 1 Table 81. Soil particle size data are given in Appendix 1 Table 82.

Plot 20 (EP44) Fantail Logging Area

Location, Landform and Climate

The Fantail Logging Area plot is located in the central section of the Windsor Tableland (Table 1, Figure 49) in the Mount Windsor National Park (previously Fantail Logging Area of State Forest Reserve 144) inside the Wet Tropics World Heritage Area. The site lies 31 km west-northwest of Daintree Village on the Daintree River, or 47 km southwest of Cape Tribulation. Access is from the Mount Windsor Forestry Road system. There is no record of the specific purpose for which this plot was established. It was first enumerated on 5 November 1980. Details of this plot were not included in Stocker (1983) or other published literature to date.

The plot locality lies on the Great Dividing Range in the mid-western section of the Bargoo Creek catchment above the Daintree River. The site is at 910 m elevation along the northwestern side of a major ridge that rises to 950 m on a rolling low hills landscape that is a dissected plateau remnant. The plot is located on an extensive midslope landform element that is not traversed by any gullies or drainage lines. Bargoo Creek is about 100 m to the north of the plot while a local ridgeline lies about 60 m to the south. The 100 m axis of the plot lies along a bearing of 248°, roughly parallel to the ridgeline. The short axis bears 158° and runs down slope. The commencement corner (Subplot A) is located in the northeastern corner of the plot, and the subplot layout is as represented on Figure 3. The now abandoned major logging road is about 100 m to the east of the plot and the buffer zone is intact. There is no longer any direct access by vehicle to this plot and a 3 hour walk now is required. Although there is no outcrop evident on the plot, the soil parent material is Late Carboniferous to Early Permian granite (Bain and Haipola 1997). The rainfall seasonality is moderate to low (Table 5) and, in terms of the climatic zones of Tracey and Webb (1975), this highland site is cloudy wet (Table 9).

Forest Structure, Type and Floristics

This rainforest is a very tall to extremely tall closed forest with the upper canopy ranging between 30 m and 39 m. In the transect diagram (Figure 50), the apparently open nature of the canopy is an artifact resulting from occurrences of small trees along the plot margin beneath adjacent larger stems. The tallest trees are *Elaeocarpus ruminatus* (39 m), *Ceratopetalum succirubrum* (38 m), *Galbulimina baccata* (38 m), *Cardwellia sublimis* (36 m) and *Syzygium wesa* (36 m). In terms of overall stem frequency *Medicosma fareana* was most common (22%) followed closely by *Fransiscodendron laurifolium* (19%). The basal area contributions are clearly dominated by *F. laurifolium* (20%) followed by *Syzygium wesa* (7.1%) and *Neorites kevediana* (6.8%). The plot has a relatively low value for all-species richness (119) being similar to Plot 13 (EP35) Whyanbeel with 121 species and Plot 16 (EP40) Agapetes Scientific Area with 118 species (Table 13). Tree species richness is moderate to low (89) and the number of life forms is the joint lowest in the series (6) along with Plot 11 (EP33) Curtain Fig and Plot 16 (EP40) Fantail Logging Area (Table 13). The proportion of tree species (73%) falls in the high range (75%) that appears typical of high altitude, wet and infertile sites.

This forest appears typical of Simple Notophyll Vine Forest (SNVF), type 8 of Tracey and Webb (1975) and Tracey (1982). All species recorded from the plot at the time of establishment are listed in life form groups in Appendix 2 Table 20. When considered in combination, species that confirm the structural/ environmental classification are *Archidendron vaillantii*, *Beilschmiedia collina*, *Cryptocarya saccharata*, *Eleaocarpus elliffii*, *Litsea connorsii* and *Steganthera macooraia*. The recorded species are typical of the type in this area.

Disturbance History and Stand Structure

At the time of plot establishment, logging activities had not reached the vicinity of the plot and subsequently did not affect the buffer zone or plot area. At establishment, there was no evidence of recent disturbance from natural events and no significant disturbances have been recorded during the seven remeasurements, a total record of 24 years (Table 6).

On this plot, the basal area value of 59.4 m^2 ha^{-1} (Table 11, maximum value) is typical of the well developed forests on wet, upland to highland sites such as Plot 15 (EP38) The Crater, Plot 5 (EP18) Mount Lewis, Plot 16 (EP40) Agapetes Scientific Area and Plot 4 (EP9) Robson Logging Area. The stem density (890 stems ≥10 cm ha^{-1}) falls in the mid-range recorded from the 20 CSIRO plots (Table 11, maximum value) and is most similar to 5 (EP18) Mount Lewis (908 stems ≥10 cm ha^{-1}), 10 (EP32) McIlwraith Ra. (894 stems ≥10 cm ha^{-1}) and 14 (EP37) Eungella (880 stems ≥10 cm ha^{-1}).

Soil Profile and Characteristics

Although no soil chemical analysis data for this plot are available from the preliminary survey (as presented for other plots in Table 12) the soil at this granitic site was assessed as oligotrophic by comparison with the nearby Plot 8 (EP30) Agapetes Logging Area and Plot 16 (EP40) Agapetes Scientific Area. The detailed soil profile description (Appendix 1 Table 83) is based on records from a soil pit, the location of which is not known. As the landform element of the plot is quite extensive, concerns about variability in soil characteristics across the plot may be minimal. In the soil data base records the profile was described as having a Principal Profile Form Gn3.14 and affinities with the red podzolic Great Soil Group. Soil chemical analyses, based on multiple bulked samples taken at various depths from random locations, are presented in Appendix 1 Table 84. Soil bulk density and moisture retention data are given in Appendix 1 Table 85 while soil hydraulic parameters are presented in

Appendix 1 Table 86. Soil particle size data from the preliminary soil survey are presented in Appendix 1 Table 87. Soil particle density data are given on Appendix 1 Table 88.

Fragments of relict soil charcoal of Late Quaternary age are relatively abundant in soil profiles in the section of the Windsor Tableland a little to the north of this plot (Hopkins *et al.* 1993). However, because of its age, this material reported by Hopkins' team reflects past regional vegetation changes that have no immediate bearing on interpretation of the structure and dynamics of the plot.