1. INTRODUCTION

1.1 Background

The subject of this report is work carried out by the authors between 15 October 1992 and 1 August 1994. One of us, David Fell, was dedicated entirely to the project during that time with heavy responsibilities for data collection and processing of data and botanical material collected on field trips, among other duties. Peter Stanton took responsibility for design of the project and supervision and participated in the majority of the field trips; although heavily involved for much of the time in unrelated work. The project was, however, flexible in design and practice, so that the nature of each stage depended heavily on experience and observation to that point. This iterative process, and the nature of our work relationship, has ensured that this final report is, intellectually, the product of both of us to equal degree.

The National Rainforest Conservation Strategy of the Commonwealth Government largely funded the work, with matching contributions by the Queensland Government. It was however, a significant contributor to the vegetation mapping and description carried out by V. J. Neldner and J. R. Clarkson within Stage 1 of the Cape York Peninsula Land Use Strategy (CYPLUS)[2]. Site data were initially analysed by P. J. Lethbridge as part of a Queensland Environmental Protection Agency report on the CYPLUS work and have contributed to an analysis of National Estate values of Cape York Peninsula by the Australian Heritage Commission[3].

In the sense that the data from the work have now been (a) entered into the appropriate data bases; (b) contributed to the production of a vegetation map of Cape York Peninsula; and (c) used for analyses of the conservation status and management of the various plant communities of the Peninsula; it is considered that the original scientific imperatives of the work have largely been fulfilled.

In acknowledging that, given the extent of the data set, there are obvious opportunities to examine in greater detail certain aspects of the ecology of the rainforest ecosystems on Cape York Peninsula, there are other imperatives that guided the production of this report. The work has expanded knowledge of the rainforests of Cape York Peninsula from rudimentary to extensive and, in being the first systematic study of that important vegetation formation in a region containing about one quarter of the remaining rainforests in Australia, it is a significant pioneering work.

It is therefore considered important that the person should also have access to the findings and observations of the original study, with a description of the types of forest and their distribution that neither the raw data nor the analyses of those data, without the overview of the field experience, can adequately provide. It is also considered necessary that the experience of the work should contribute to an understanding of the processes that are now shaping the evolution of these forests, and of management requirements. This report is written with all these purposes in mind.

Accompanying the report on CD-ROM (Appendix 2) is a detailed description of each sampling site. The original files are lodged with the Queensland Herbarium and provide an accessible permanent photographic record of the work.

[2] Stage 1 of CYPLUS entitled the *Natural Resource Assessment Program*, undertook to carry out a comprehensive inventory and analysis of the regions natural environment. The Neldner and Clarkson (Project NR01) work mapped the Peninsula's vegetation north of sixteen degrees latitude at 1:250,000 scale.

[3] Abrahams *et al.* 1995

Unfortunately, circumstances beyond the control of the authors dictated that fieldwork ceased while there was still funding for several months' further work. As a result, a further fifteen sites for which work was planned was never completed. This has left some significant gaps in the work and is a situation that is regretted by the authors. These gaps, however, can be precisely identified in geographical terms, and from the aerial photograph record and overflights by helicopter, the likely nature of the forests involved can be deduced. Future investigation within them would no doubt provide invaluable structural and floristic information and would include potential new and interesting botanical records. Another significant gap in the work is related to its essentially broad scale nature. This gap includes the lack of adequate documentation of the narrow riparian zones that exist in every rainforest area and every landscape type. Only the most significant of these in terms of area have been described.

What must also be left for the future is an adequate publication that might make use of the slides of leaf and bark features of over one hundred species of rainforest tree. Selected prints from these slides are appended to the original report.

1.2 Definitions

In this report, we have followed the precedent of Baur (1965) spelling *rainforest* as one word. This would seem an appropriate usage considering it is edaphic and historical factors, and not rainfall, that separates rainforest from other vegetation formations in any particular locality, and that the formation occurs across a wide range of rainfall zones. The term is used in this report only to denote a broad formation type of vegetation.

Where a structural nomenclature is used, the terms *vine forest* and *vine thicket* are applied. The word *rainforest* encompasses both these terms. The term *vine thicket* is used here for the more stunted vegetation with canopy closure at three to twelve metres, sometimes with emergents.

During the study, determination of what was rainforest was made on canopy characteristics. No sites were included where the canopy was dominated almost entirely or completely by sclerophyll species. Neither were sites included where the rainforest occurred as a closed layer or understorey to a woodland or forest of sclerophyll species. Where, however, the sclerophylls occurred as scattered canopy trees, or emergents, such communities were considered to be rainforest. In all cases, to be accepted as rainforest, the community had to have a closed canopy (plus seventy percent projective foliage cover). Very few non-sclerophyll communities were excluded on the latter basis, which eliminated only some woodlands of widely scattered trees, or shrubs, on foredunes.

2.0 THE RAINFOREST RESOURCE AND ITS SETTING

2.1 Distribution and Description

At the completion of the field survey and initial analysis and reporting the only accurate representation of the distribution of the rainforests of Cape York Peninsula was found in the Department of Forestry 1:500,000 map (O'Neill, Betts and Stanton 1988).

By adopting 16° S as its southern boundary, the CYPLUS study included a significant part of the Wet Tropics biogeographic region. The inclusion of Wet Tropics rainforest in this study was not considered a useful exercise and was rejected. Apart from the obvious difficulties it presented in terms of a proper comparative analysis of any data collected, it was considered a serious impediment to the collection of information over a greater Cape York Peninsula region where only basic survey work had been previously carried out. Work in the Wet Tropics section of the study area would have consumed a large part of the field time available to the project with a relatively small return in terms of new information. Even this remote northern section of the Wet Tropics region had been far better researched, with a much more comprehensive data base, than any of the forests north of Cooktown.

Most of the rainforests of Cape York Peninsula are to be found north of about the latitude of Moreton (12° 30'S) and east of the Peninsula Development road southwards to latitude 14° S, with scattered pockets south of Bathurst Bay and north, northwest of Cooktown. Outside these areas, the only significant concentrations are of vine thickets on clay soils in the middle areas of the Archer and Wenlock catchments. There are also ribbon-like occurrences of rainforest along some of the major rivers, most notably the Normanby and Archer, but these are relatively insignificant in terms of area.

The sclerophyll-vine thicket complexes along the west coast of the Peninsula, south of Aurukun, were not studied on the basis that, being woodlands or dominated by sclerophylls in the canopy, they did not fit the definition of rainforest being used in this study.

The most significant area of rainforest on the Peninsula, in terms of area, floristic and habitat diversity and altitudinal range, stretches between the Pascoe River in the north and Massy Creek and the southern end of the McIlwraith Range in the south, a distance of 155 kilometres. In that distance, it achieves a maximum unbroken east to west extent of twenty kilometres.

Most of the biological exploration of rainforest on the Peninsula has been carried out in this area and with good reason as it has proven to be remarkably rich in most aspects. The total effort, however, has been relatively minuscule in terms of the proportion of the area covered. It has largely been confined to its northern and southern extremities, adjacent to access routes to Portland Roads and Lockhart River, and to the southern McIlwraith Range and adjacent coastal area. There are undoubtedly significant discoveries still to be made, even in the best-known areas.

The biological significance of this area is related to the wide range of basic geology encompassing granites, acid volcanics, and metamorphics; the greatest altitudinal range on the Peninsula (reaching 824 metres at the headwaters of the Archer River catchment); and high rainfall (plus 2,000 millimetres per annum). Here is found the largest surviving lowland (minus 300 metres altitude) rainforest in Australia, and the only significant areas surviving in tropical Queensland, of tall, species-rich riverain forest. It is also notable for the context in which the rainforest is found, that is, as part of a complex pattern with other habitats ranging from grassland through to tropical heathlands, shrublands and woodlands dominated by *Eucalyptus/Corymbia* and *Melaleuca* species.

Part of the reason for the concentration of past attention on the Iron Range-McIlwraith Range, and perhaps the Bamaga area, has been through the fact that these forests have been more accessible, and a possible lack of awareness of the existence and extent of other rainforest areas on Cape York Peninsula.

The ‘Lockerbie Scrub’ near Bamaga is a well known and important type locality for much rainforest flora and fauna. Its location was made known last century because of proximity to a main shipping route and the historic settlement of Somerset. Many of the type localities were made known through the biological exploration undertaken by the Archbold Expedition in 1940s. The Lockerbie Scrub is the name given to what is considered the northernmost rainforest massif in Australia. It extends for about thirty kilometres along the northernmost continental vestige of the Great Dividing Range, and is continuous with some small areas of rainforest on aeolian dunes bordering Newcastle Bay. It is remarkable for not only its aesthetic appeal but for the ferruginous sandstone substrate on which it occurs. Nowhere else in Australia is rainforest of such great height development and structural and floristic complexity found on such an infertile substrate. There are relatively few other rainforests in Australia which, almost uniformly throughout their occurrence, have a comparable aesthetic appeal derived from great canopy height (up to fifty metres), the presence of buttressed trees, gentle topography, and a very open nature free of understorey development. Botanically it is very significant for a number of tree species found nowhere else in Australia (although some are shared with Papua New Guinea).

The extensive forests of the Jardine River catchment to the south separated by a gap of only twenty-five kilometres, however, were not even acknowledged in the scientific literature until around 1967, when development of the area now known as Heathlands by the Comalco Pastoral Company began. The forests of this unique area were first described and mapped by Lavarack and Stanton in 1975. Even lesser known have been the scattered forests of the Laura Basin and adjacent coastal areas from Cape Melville south towards the Endeavour River. Though very isolated they are quite significant in total area. Their great ecological and botanical interest was only revealed for the first time as a result of this study.

It is also the only rainforest on Cape York Peninsula that has been significantly impacted by Europeans. A sawmill existed for many years near the Lockerbie homestead site, and in the early 1970s the then Department of Aboriginal Affairs initiated an abortive pastoral development ‘experiment’ which saw ten percent of the forest cleared.

The twenty-five kilometres of open forest, woodland and shrubland which separate the Lockerbie Scrub from the rainforests of the Jardine River catchment and adjacent coastal areas may as well be the Torres Strait in terms of the great structural and species differences between the separate forests developed on different sandstones. The Jardine River forests are generally much lower in height, with buttressed trees rarely present, and a dense understorey, which often extends to almost impenetrable tangles of *Calamus* species. Although the basic geology and topography of the two areas is similar, the change from ferruginous to quartzitic sandstones has obviously allowed the development of significantly different soil conditions. In the Jardine catchment these soil conditions have imposed a remarkable uniformity on the forests and a relatively small sampling intensity was found adequate to sample them for the purposes of this study. There was, however, a difference between the forests of sandstone ‘uplands’, and those of the colluvial and alluvial coastal plain. In the undulating more elevated areas west of the Great Dividing Range escarpment (the Jardine River catchment) rainforest is confined to the crests of the broad ridges, whilst on the coastal plain it is found in all drainage situations.

South of the Jardine River forests (which extend a little south of that catchment) there is a break of fifty kilometres before rainforests again appear on the Olive River-Shelburne Bay sandmass. They are also present on dunes and sandstone headlands and broad rises between the Olive River and the southern limits of Temple Bay. These forests are the equivalents of those on the narrow coastal plain east of the Jardine River area. Very different, however, are those of the sandstone gullies and escarpments along the southern headwaters of the Olive River and those in the granite hills just north of the mouth of the Pascoe River. The former were not examined, and are limited in extent, but structurally and in their topographic situation, do not have equivalents further north. The latter, although physically separated, on geological grounds belong with the forests of the Iron Range-McIlwraith Range area.

From about the latitude of Moreton, northwards, largely west of the main road and separate from the forests of the Jardine River catchment and Lockerbie Scrub already described, are numerous scattered patches of rainforest. From aerial photographic evidence, they appear to be structurally similar forests with similar topographic and soil characteristics. The few sample points we have indicate that floristically they are also a convenient grouping. There is evidence that many of them were much greater in areal extent at some pre-European stage and have shrunk under the onslaught of fire over time. There is also evidence that many of them have now begun to expand again or at least had static boundaries.

Deciduous vine-thickets are concentrated in the central Peninsula, mainly in the Archer River catchment but extending into the adjacent catchment of the Watson River as well as a small part of the Wenlock River upper catchment. They are almost entirely within the pastoral holdings of York Downs (Merluna) and Coen River (Merapah) with minor occurrences in Sudley, Batavia Downs, and the Mungkan-Kaanju National Park. These thickets occur in drainage depressions on clays from Cretaceous sediments and are quite different in structure from most other rainforests of the Peninsula. They are the far-northern equivalents of a variety of vine-thickets formerly found in the Brigalow Belt bioregion, but now largely exterminated.

The greatest gap in the Peninsula's rainforest distribution occurs between the southern limits of the forests of the Iron Range-McIlwraith Range area and forests adjacent to the mouth of the Normanby River. There are numerous patch forests scattered east and southeast from there to Cape Melville and Cooktown. During this study, the first detailed description of these forests was undertaken, finding new species, major extensions of range, and identifying evidence towards the definition of a distinct botanical province. The geological substrate of these forests is more varied than that of the forests of any other areas described above. In relation to the total area of the forests, fieldwork in this area was the most intensive undertaken. This was a reflection of the fact that most of the forest is found in small patches, some of them well isolated from each other, with a high degree of floristic variation among patches. It was also a reflection of the nature of the work which progressively revealed the unsuspected distinctiveness of many of the individual forest patches, a distinctiveness that could not at the beginning have been predicted from the high-level aerial photographs used, and which thus required continual revision of proposed sampling intensity.

The most distinctive and unique part of the area, and indeed the whole study region, was the Melville Range. Evidence collected during the study indicates that the elevated granites of this range, which experiences significantly higher rainfall than the surrounding district, may have acted as a refugium for rainforest flora in past times. Further research effort into this aspect of rainforest ecology would be a valuable extension to the preliminary work carried out in this study.

In the southeast of the area a complex pattern of rainforest distribution occurs on more elevated country from Cooktown to Mt. Stuckey near the head of the Starcke River. It is highly significant, not only in the range of geology covered but in that here is found the entire extent of Peninsula rainforest developed on basalt. Further south, on Hope Vale Aboriginal Lands, are some significant swamp forests within the upper catchment of the Endeavour River, while elsewhere, rainforest is confined to numerous patches in rugged sandstone ranges, and minor occurrences on metamorphics, granites, and river and coastal alluvium.

2.2 Climate

Only those factors of climate that would play a significant role in the development and survival of rainforest are dealt with here. Throughout the Peninsula, temperature and humidity are not likely to be limiting factors. Only rainfall and its distribution take that role, both seasonally and between localities. Wind has an influence on structure in exposed situations along ridges and escarpments as well as coastal foredunes, and repetitive cyclones can have a dramatic and seemingly very long-term effect on isolated areas.

There are fewer than a dozen official meteorological stations on Cape York Peninsula, and not all have long-term records. The latest official figures show long-term annual rainfall averages varying from 935.1 millimetres (1897-1993) at Laura, to 2,073.8 millimetres (1956-1993) at Iron Range airstrip. Intermediate figures are 1,172.6 millimetres at Coen (1887-1993), and 1,720.1 millimetres at Weipa (1914-1993).

It is obvious from field work at all times of year, that rainfall figures at official recording stations do not give a useful picture of any aspect of climatic conditions within the main areas of rainforest distribution. In the more mountainous areas of the east coast there are obviously very significant differences in total annual rainfall over very short distances, and these are determined by local topography. There are also large areas along the coast and ranges north of Silver Plains where low average rainfall in the dry period of July to October is considerably ameliorated by prolonged periods of cloud and intermittent drizzling rain.

By the appearance of their plant communities and comparison with coastal areas of the Wet Tropics bioregion, it would appear likely that many east coast rainforest areas experience much wetter environments than would be experienced from the highest official long-term rainfall figure of 2,073 millimetres at Iron Range Airstrip. Even in the relatively very dry areas in and adjacent to the Laura Basin it is obvious that the eastern side of the elevated Melville Range is anomalously wet with regular showers to as late as July or beyond.

The only general conclusion that can be drawn from available data is that virtually all rainforest areas of the Peninsula are found in the plus 1,000 millimetres annual rainfall zone.

2.3 Geology, Soils and Their Relationship to Rainforest Distribution

2.3.1 Geology

Geology by its dominant influence on the range of soils that may be developed from a particular rock type is important to the most basic understanding of rainforest and its distribution. Because of that, and the fact that it could generally be precisely determined from aerial photograph interpretation, there was considerable stratification by geology in the process of selection of sampling sites. The existing geological maps, at a scale of 1:250,000, were not precise enough for this purpose and could not replace the aerial photographs. It was readily observable however, and expected, that there was a much higher level of correlation between vegetation and soil types.

2.3.2 Soils

Because there were no soil maps adequate for the selection of sampling sites, and soil information at an adequate level of precision could not be deduced from aerial photographs, a potentially useful tool for stratification of areas at the site selection stage could not be used. Neither was the usefulness of soil data as an aid in defining rainforest types fully exploited during the study because of the difficulty of carrying a soil auger to remote sites in often dense vegetation and the time involved in undertaking full soil descriptions. Where soil descriptions were taken they involved, at a minimum, texture and colour of surface horizons up to a metre in depth, or deeper where use could be made of profiles exposed by erosion.

Whilst most authors acknowledge the importance of soil in determining the distribution and structure of rainforest, there is less agreement on what are the precise determinant factors within the soil profile. A particular item where there is a conflict of opinion is the nutrient status of the soil. While there is clear evidence from sub-tropical Australia of the importance of this factor (Floyd, 1990 and Tracey, 1969) that does not appear to be so in more equatorial parts of the world. Whitmore (1975), in writing of the ‘Far East’ rainforests including forests from Southeast Asia to the New Guinea area, emphasises the importance of soil. He states that, next to climate, soil conditions are the "most important controlling factor in the distribution of plants," and then goes on to say "the nutrient content of soils is unlikely to play an important role in the differentiation of forest communities". In his opinion, "a deep strongly weathered soil mantle minimises the effect of parent materials on the nutrient content of surface soils and plants”. Paijmans (1976), in writing of the vegetation of the lowland alluvial plains and fans of New Guinea, notes that "soil mainly influences the structure, and differences in amount and distribution of the rainfall are reflected most markedly in species composition."

The reason for conflicting observations on the importance of the nutrient status of soil undoubtedly lies in its interaction with other factors. As these become limiting then nutrient status becomes a determinant factor. Hence the importance of basalt soils in attenuating the occurrence of rainforest as temperature drops (higher latitude and altitude) or rainfall decreases (more inland) becomes significant. In the warm, relatively high rainfall environment of Cape York Peninsula, it does seem that the observations of Whitmore and Paijmans in more equatorial climates may still be relevant. This can be seen in the markedly similar structure and some notable floristic similarities between forests on deep structured red earth soils derived from such different substrates as ferruginous sandstone in the far north at Lockerbie Scrub, metamorphics in the northeast at Iron Range, and basalts in the southeast of the study area at Mt. Webb.

There is, however, a possible way in which nutrient status could be responsible in part for the similarities observed in the above sites. Webb (1965) refers to an observation by Richards (1952) that "some soil enrichment may have been inherited from basic soil parent materials which are no longer apparent and preserved in the closed nutrient cycle." This could explain the remarkable forest development on nutrient poor parent material of sandstone at Lockerbie Scrub. In the absence of any analyses of nutrients within relevant soil profiles, or any visible evidence of a soil origin from anything but sandstone, this possibility must remain extremely speculative.

The strongest correlation between soil characteristics and vegetation type may be seen at the extremes of development of those characteristics. This is seen in the deciduous vine thickets of heavy clay soils in the central Peninsula, the characteristic swamp forests where drainage is permanently poor, and the vine forests and thickets of deep infertile quartz sands which share some prominent characteristics whether developed on aeolian dunes, alluvial sand sheets, or inland.

Throughout the Peninsula where rainfall is greater than about 1,500 millimetres per annum, it is common to observe rainforest species invading sclerophyll communities. There is clear evidence that this is related to a recent reduced incidence of fire. It is also clear that on some soils rainforest will not invade no matter how long fire is absent and a study of these would provide insight into precise soil conditions that are required for the persistence and development of rainforest in the climatic conditions of the higher rainfall parts of Cape York Peninsula. Such detailed research has not been attempted here, but it was observed that most rainforest types required soils of good internal drainage and adequate depth (plus two metres), as well as favourable moisture relationships throughout the year. They do not appear to survive on soils that are seasonally dry, except where there is root access to a permanent watertable as is common in the deeper sands that could normally be considered a hostile soil environment. In the absence of access to a watertable to neutralise the effects of seasonal drought, the moisture-holding capacity of the soil becomes critical, and rainforest favours the deep loams and clay loams.

For this reason tall rainforest can persist on the steep slopes of metamorphic ranges in the apparent absence of a waterable access, whilst on the lighter soils of sandstone origin such as in the Jardine River catchment, the presence of a permanent watertable at least several metres below the surface appears to be critical. In this latter area, rainforest is restricted to the higher parts of broad low rises. As one proceeds downhill, sclerophyll communities of decreasing stature, changing to low heath where the watertable intersects the surface, replace the rainforest. It would be reasonable from the available observational evidence to assume that the changes are related to the depth of the permanent watertable, which determines effective soil depth. The watertable, in a subdued way, is a reflection of surface topography intersecting it in drainage lines and being at greatest depth below the surface at the higher levels. It is at those higher levels that rainforest survives, occupying, apparently, the soils of greatest effective depth, while retaining the advantage of root access to the watertable.

As rainfall decreases below about 1,500 millimetres per annum, soil conditions are still a critical determinant of rainforest survival, and although there is no research work on plant-soil relationships to point to here, observational data would suggest that the presence of a watertable within rooting depth becomes even more critical. Rainforest would appear to survive away from such root access only in run-on situations where the most moisture retentive well-drained soils exist. These are structured clays and clay-loams such as those that support deciduous vine-thickets of the Archer River catchment and adjacent areas. Elsewhere it survives where surface rock or topography create fire-exclusive situations, or on coastal dunes and riverine situations. Whilst we have no direct evidence that watertables of appropriate depth were present in any of these situations they could be expected in coastal dunes and riverine levee banks, or in breakaway situations on sandstone plateaux or basaltic hills where rainforests most commonly occur.

An exception to soil requirements for rainforest growth described above would appear to be the various types of swamp forest described in this report. The exception is rather a matter of degree, however, than an absolute one. These forests contain relatively few species, most of which are adapted to waterlogged soils and have relatively uncritical requirements in relation to soil texture. They will not, however, survive where watertables remain permanently at or near the surface, nor where they may seasonally become so low that the surface profile becomes dry. Commonly hummock (mound and depression) formations are found in which the trees maximise root aeration by growing on the mounds.

These swamp forests may be considered to exist on the brink of survival, as a slight change in the nature of the watertable may favour the development of *Melaleuca* (paperbark) woodlands and forests, or even open sedge swamps. On the less fertile soils, such as sands, they tend to occupy the vicinity of streams, or seepage areas, with Melaleucas replacing them elsewhere. Where they are replaced by paperbark, the sites with the highest and seasonally most prolonged watertables will favour communities dominated by *M. quinquenervia*, while sites with more seasonally dry surface profiles will favour communities dominated by *M. viridiflora*, or less commonly *M. leucadendra.*

Although again, there are no data to support our observations, there is a clear relationship in Peninsula rainforests between soil and the deciduous nature of the canopy. Average rainfall on the Peninsula is nowhere high enough, nor its seasonal spread even enough, to exclude deciduous species from the canopy, yet in all rainfall zones there are some situations where deciduous species are uncommon or absent. These are invariably on the poorest, most siliceous soils, and/or the driest sites. Further, in the highest rainfall zones, the canopies with most deciduous species present belong to the tall forests on riverain alluvium, where growth conditions, in terms of soil moisture and nutrient status, are optimal. While there is speculation in the literature as to why this is so (e.g. Lamb, 1991), it appears obvious that deciduous trees with large leaves and fast rates of crown recovery after losing those leaves, are able to best exploit optimum growing conditions while avoiding seasonal drought.

While discussion in this section has focused on the importance of soil characteristics, which could not be anticipated from geology beyond a broad range, the geology maps provided a useful guide to the probable sampling intensity needed to gain a useful basic classification of the Peninsula's rainforests. Where a uniform geological formation covered large areas with relatively subdued and repetitive variations in topography, it was found that a low intensity of sampling, providing it was chosen to cover (with a few repetitions) the variations in canopy characteristics observed from aerial photographs, was adequate for descriptive purposes. Areas that fitted into this category were the Lockerbie Scrub (ferruginous sandstone or laterite above sandstone), the Jardine River catchment (dominantly quartzitic sandstone with some laterite) and the high plateau-like areas of the McIlwraith Range (adamellite - granite).

In the Laura Basin and adjacent coastal areas, a much different situation was found. Here the rainforest occurred in a large number of relatively small areas. This combined with complex geology and topography necessitated a much more intensive sampling pattern than in the areas referred to in the paragraph above.

In the Iron Range area, and in the eastern foothills of the McIlwraith Range and hills and plains between them and the coastline, the large unbroken areas of rainforest were also found to have a variation that warranted a more intensive sampling strategy. As in the Laura Basin this was related to complex topography and geology. An additional factor would appear to be the high rainfall, the highest on the Peninsula, and the opportunity for diversification of vegetation structural forms and species that presents in combination with landscape variety.

The sampling strategy adopted in this study, which relied heavily upon the use of aerial photographs to identify a range of canopy signatures which were presumed to represent structural differences in the vegetation, was intended to allow the description of as full a range of rainforest types as possible with minimum field sampling.

This method was validated at every stage of the study, but nowhere more dramatically than in the forests of the Jardine River area. Here, the most complex forests of the greatest botanical interest were found in small valleys below the Dividing Range escarpment. These represented much less than one percent of the total rainforest in the area. Without the aerial photographs only recognition of the importance of topographical variety in shaping vegetation differences in an area such as this, with uniform geology and uniform vegetation structure and floristics over a large area, would have allowed the identification of such significant parts of the area's biodiversity.

2.4 Land Tenure in Relation to Rainforest Distribution

The production of a vegetation map of Cape York Peninsula, now concluded, enables a determination of the area of rainforest found within various contemporary land tenures. Although no attempt to use the available data has been made for the purposes of this report, some approximations have been made toward a broad overview.

It is clear that only a small part of the rainforest estate, possibly less than ten percent, is within existing National Parks, and it is also clear that what is in the parks is only poorly representative of the range of rainforest types identified in this study.

At the time of the survey, it was estimated that about one third of the rainforests of the Peninsula were found on lands under Aboriginal tenure (i.e. Aboriginal Land Trust, Aboriginal Leasehold and Deed of Grant in Trust), with the remainder, in decreasing order of distribution, being on Timber Reserve, Pastoral Holding, Unallocated State Land, Occupation Licence, Departmental and Official Purposes Reserve, non-Aboriginal Freehold, and Mining Lease.

The transfer of tenures in the Silver Plains and McIlwraith Range areas has increased the extent of rainforests within Indigenous land ownership and management.

3. THE RAINFOREST TYPES AND THEIR DETERMINATION

3.1 Methods of Study

The objective of the study was to identify, as completely as possible in the time available, the range of rainforest types to be found on Cape York Peninsula and their distribution. Because the state of knowledge of the rainforests of Cape York Peninsula, in these terms, was rudimentary, it was felt that the greatest imperative was to devote maximum time to the gathering of field data, and to interpret these data in a most basic manner.

In hoping to fulfil the aims of CYPLUS, the study also contributed to the vegetation mapping project carried out by the Queensland Herbarium. It was not, however, considered an appropriate use of time to be involved in the mechanics of a detailed mapping project. Within the scale (1:250,000) of the Neldner-Clarkson project, the data collected were more than adequate for the definition of broad rainforest types. At a detailed level, however, it was felt that the 1:80,000 aerial photography would not be adequate for precise definition, and that the mechanics of the exercise would be far too time-consuming.

The Peninsula was initially stratified by broad geographical zones. Within the zones, sites were chosen using stereoscopic vision of 1:80,000 black and white aerial photographs to represent the full range of canopy patterns that could be determined within areas of the same geology and topographical situation.

In selecting sites that were subsequently examined in the field, questions of accessibility were given secondary importance although, of course, within any particular canopy pattern, the sites chosen for examination were those nearest to roads and tracks. Much time, however, was spent in gaining access to the sites, which severely limited the number that could be fully documented during the two year period. It also limited the amount of duplication that could be permitted in the sampling process.

Once selected the sites were sampled using a plot-less 32 nearest neighbour point centred methodology. A canopy tree was selected to identify the centre of the plot and four quadrats were marked out using compass bearings. Within each quadrat, eight trees whose crowns was determined to be part of the canopy layer were surveyed and identified with heights, diameter at breast height, leaf size and deciduousness recorded on a standard proforma. Plot areas were calculated using the radii of the the furthest canopy tree within each of the quadrats. All subcanopy, understorey and groundcovers were recorded within the area of the 32 canopy trees. Specimens were collected in the field and submitted to the Queensland Herbarium with duplicates provided to various herbaria, most prominently the CSIRO Herbarium at Atherton.

All effort was directed at ensuring that the perceived differences in the aerial photograph patterns did correspond to significant differences observed in the field. A testimony to the precision with which that was done is the fact that 72 different forest types were described from a total of 140 sampling sites. It should not be considered evidence that the forests are extremely complex or that the differences separating types are vanishingly small. What did become clear towards the end of the fieldwork was that (apart from the fifteen or so sites chosen for examination which were not examined), with further work the ratio between sites examined and rainforest types described would very rapidly grow larger.

It is necessary to emphasise that the definition of forest types was an integral part of the field process. This provides explanation and justification for the way in which the results have been presented in this report. The process used was one in which the conduct of the work at every stage was largely determined by experience and findings to that point. Each field trip gained knowledge, which was used to improve interpretation of the aerial photograph patterns and thus the sampling efficiency of future sites. It also provided a constant check that no significant types were being omitted from the sampling process, and that there was no unnecessary duplication of observation. In travelling to many sites on foot there were effectively a large number of traverses that provided cross-sections of forest communities. This aspect of the work proved extremely valuable in terms of relating site information to overall patterns and in gaining insight into plant-soil interactions and other basic ecological processes.

The number of sites varied according to the complexity of types examined. Types that were very rich floristically were examined at a number of locations to gain an understanding of the range of that floristic variation. Some types with apparently relatively little variation over a large area were repeatedly examined at widely separated locations to gain confidence that they were indeed unvarying.

The classification of forest types finally presented (see Section 3.2) is both a subjective and intuitive one. It is a classification based on the evidence of canopy features from aerial photographs, floristic and structural information gained at the sites and whilst gaining access to them, and the ecological insight gained while constantly working at the field level.

The 140 sites examined were placed into groups that were judged to have a significant correlation of structural and floristic features, as well as fitting within a range of soil features. The more salient features of sites within each group were then combined to give a description of a rainforest type.

There are significant problems with analysis of the data in any more essentially objective way. These are due to the fact that much sorting was done at the site selection stage and an attempt was made to ensure, in the interests of maximum information from an arduous field effort, that there was as little duplication in sampling as possible. Any attempt to analyse the data in a way that produced groups significantly fewer than those presented here, or which does not recognise the large sorting process that has already taken place, is bound to create problems. Nor can the data be analysed as part of a pool of data on Cape York Peninsula rainforests collected by all observers to date. Data was collected through use of a very different site selection process from that followed by other observers, and recorded by precise procedures. Other observers collected their data in different ways, and analyses would be more prone to highlight the differences between observers than to demonstrate essential site correlations.

Each site was precisely chosen on aerial photographs to represent average canopy conditions for what was judged a distinct rainforest type. Efforts were then made to get as close as possible on the ground to that chosen point. The critical importance of precisely identifying the chosen point on the ground was driven home on a number of occasions during the field work when even as little as fifty metres displacement from it resulted in the wrong types being sampled, or an atypical sample of the required type. A strictly objective sampling process, that ignored reality as revealed by the aerial photographs, would have failed to pick up much of the interest and variety of the forests. It is also doubtful that a process of random sampling within chosen canopy types would have been as effective at choosing typical conditions, with a minimum number of sites, as the process adopted here.

3.2 Classification and Description of Rainforest Types

The following classification has been adopted and rainforest types are described under these headings. As it is intended that this report should be useable by a wide range of people, a glossary of terms used in the following sections is inserted here, rather than as an appendix at the end of the report.

VINE FORESTS AND THICKETS OF STREAMS AND SWAMPS

All soil types

VINE FORESTS AND THICKETS OF WELL DRAINED SOILS

i. Of soils developed from detrital material:

- (a) *sand dunes and sand plains*
- (b) *alluvial fans and plains (other than sand plains), colluvial footslopes and deposits of mixed colluvial/alluvial origin*

ii. Of soils developed from erosional surfaces including ranges, undulating hills and residual plains:

- (a) *sandstones, metamorphics and granite*
- (b) *volcanics*

3.3 The Rainforest Types

As described in Section 3.1 above, 140 rainforest sites have been grouped according to significant correlations of structural, floristic, and soil features. Details of each site are provided in Appendix 1 *Brief Site Descriptions*, and a detailed photographic record within Appendix 2 *Full Site Descriptions* (CD-ROM). For each group, a description of a representative rainforest type has been formulated using a description that encompasses the main features of each site within the group. Thus in the descriptions that follow the forest type is a conceptual one based on:

(a) a structural and site definition that encompasses all sites of the group;

(b) an amalgamation of all species from each site that are listed as dominant, abundant, and frequent, so as to provide the common list of species from the canopy, sub-canopy, understorey, lianes and epiphytes, and groundcover;

(c) a description of the distribution of the type, its basic ecological features, and other pertinent features, based on site descriptions and field knowledge.

Where the type is based on one site only then the full description of that site is used to define it.

For each type, where a species is listed as occurring in a stratum, it is not listed for any lower strata that it may be present in. It is assumed that such species are transients in that stratum. Thus, for example, seedlings of canopy trees may largely occupy the groundcover, or the subcanopy may be largely composed of species in passage, when opportunity permits, to the canopy. In both situations the only species recorded are those considered permanent components of the stratum.

Similarly, species recorded for any stratum, even if not present in other strata, have been excluded from the type description if they are considered transients in the above sense.

Species listed with collection numbers, i.e. *Rapanea* sp. (DGF 3135), refer to material unable to be accurately identified at the time when the work was completed. All vouchers holding these numbers are housed with the Queensland Herbarium. It is acknowledged that many of these DGF series numbers may now be allocated to species level within the Herbarium collection.

A number of listings refer to species that were undescribed at the time of survey completion, e.g. *Flacourtia* sp. (Shipton's Flat, L. W. Jessup + GJD 3200). Where possible, these names have been revised to incorporate the current status.

3.4 Summary of Rainforest Types (by Type Numbers)

Vine Forests and Thickets of Streams and Swamps

- in dune swales and depressions
  → 1, 2
- with dominant feather palms
  → 3, 8, 9
- simple rainforests of riverain environments
  → 4, 5, 11, 12
- complex forests of riverain environments
  → 6, 7
- deciduous forests of clay loam and silty loam soils
  → 10, 13, 14, 15

Vine Forests and Thickets of Well-Drained Soils

i. Of soils developed from detrital material

- coastal sand dunes
  → 16, 17, 18, 19, 20, 21
- sand mantle over marine clays
  → 22
- sand mantle over laterite or bauxite
  → 23
- coastal plains - Sand and earth soils
  → 24, 27
- small alluvial fans and mixed alluvial/colluvial deposits at the base of hills and ranges
  → 25, 26, 29
- colluvial deposits
  → 28, 30, 32, 33
- podzol soils derived from mixed alluvial/colluvial deposits
  → 31

ii. Of soils derived from erosional surfaces

- metamorphics
  → 34, 35, 36, 37, 38, 39
- granites
  → 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54
- sandstones, laterite and bauxite
  → 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 67, 77
- rocky basalt hillslopes
  → 70
- acid volcanics
  → 71, 72
- structured red earth soils from basalt
  → 68, 69
- structured red earth soils from mixed parent materials other than basalt
  → 55

3.5 Individual Descriptions of Rainforest Types

The following section contains individual descriptions of the 72 rainforest types.