Update of Original Wet Tropics of Queensland Nomination Dossier

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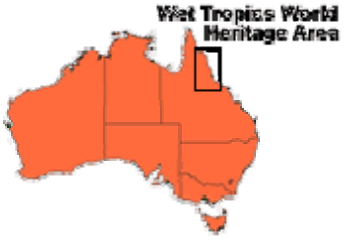
Description and Inventory



Australia's *Wet Tropics of Queensland World Heritage Area* covers 894,420ha. It is located in the north-east coastal region of the State of Queensland, where it extends from just south of Cooktown to just north of Townsville. The World Heritage Area comprises a large proportion of the 1,849,725 ha Wet Tropics biogeographic region (Thackway & Cresswell 1995; Goosem *et al* 1999).

The rainforests of the Wet Tropics of Queensland are a relict of a vegetation type which was once much more widespread. Fossil pollen records have indicated that much of Australia was covered by closed forests some 50 to 100 million years ago. Australian rainforests are currently restricted to a series of discontinuous pockets extending for more than 6,000 km across northern Australia and along the east coast to Tasmania. Representatives of the sub-tropical and temperate rainforests are included in the *Central Eastern Rainforests Reserve World Heritage Area* in New South Wales and south-east Queensland and the cool temperate rainforests are included in the *Tasmanian Wilderness World Heritage Area*.

Australia has a total native forest area of almost 156 million hectares (National Land & Water Resources Audit 2001). With a land area of almost 769 million hectares, only about 20 per cent of the Australian continent is forested. It is estimated that rainforests currently cover just over 3.0 million hectares of Australia (National Land & Water Resources Audit 2001). The largest area of remaining rainforest in Australia is located in the Wet Tropics region of Queensland (27.6%) where most of the larger contiguous blocks are contained within the boundaries of the Wet Tropics of Queensland World Heritage Area (the Property) (**Table 1**). Due to its landscape diversity and latitudinal position, the Property supports a range of tropical, subtropical, temperate and monsoonal rainforest types found elsewhere in Australia, but nowhere else is the full range of these broad climatic rainforest types represented.

Table 1. Distribution of rainforest in Australia (km^2) [1]

ACT	SA	Vic	WA	NSW	NT	Tas	Qld	Australia	Wet Tropics[2]	Property[2]
0	0	407	16	2218	977	7055	19558	30231	8340	6690
0	0	1.3%	0.1%	7.3%	3.2%	23.3%	64.7%	100%	27.6%	22.1%

Source: [1] National Land & Water Resources Audit 2001, [2] Authority GIS

(i) Climate and hydrology

Many of the distinctive features of the region relate to the high rainfall and diverse terrain. The mean annual rainfall ranges from about 1,200 to over 8,000 millimetres (Nix 1991). Even in the wettest areas between Tully and Cairns there is a distinctly seasonal precipitation regime with over 60 per cent falling in the summer months (December to March) followed by a relatively dry season in mid-year. Tropical low pressure cells and cyclones that develop in the monsoonal trough commonly produce more than 250 millimetres of rain in a day during the wet season. Mt Bellenden Ker has recorded 1,140 millimetres of rain in a 24-hour period.

By comparison with other tropical rainforest areas in the world, the wetter parts of the region lie at the 'wet' to 'extremely wet' end of the hydrological spectrum. During the wet season when soil profiles are often saturated, high intensity rainfall may not be absorbed by the soil, and widespread overland flow can occur even on relatively steep slopes. The common occurrence of widespread overland flow, as distinct

from highly localised saturation overland flow in valley bottoms, channel margins and stream head locations, appears to be rare in other wet tropical rainforests of the world; indeed its absence has been regarded as characteristic. In this respect, the rainforests of the Wet Tropics appear to be exceptional (Walsh 1980).

On the coast, mean daily temperatures range from a maximum of 31°C to a minimum of 23°C. During winter the mean daily maximum and minimum temperature are about 5˚C lower. The tablelands and uplands are cooler, with mean daily summer temperatures ranging from a maximum of 28˚C to a minimum of 17˚C. During winter, the mean daily maximum and minimum temperatures are 22˚C and 9˚C respectively. Temperatures on mountain summits may fall to 5˚C and in the lowlands may be as high as 35˚C (Nix 1991). Coastal humidity during the summer months is on average 78 per cent, but there are numerous days when it reaches into the high nineties.

(ii) Geology and geomorphology

The Property straddles three major geomorphic regions:
- tablelands of the Great Divide;
- coastal lowlands; and
- intermediate Great Escarpment.

The undulating tablelands are remnants of an elevated and warped landscape. The highlands rise to altitudes of 900 m with isolated peaks up to 1,622 m. To the east, the Great Escarpment marks the limit of headwards erosion into these tablelands from the coastal plain. It is a zone of rugged topography, rapid geomorphic processes and diverse environments. The escarpment is deeply incised by many gorges, and there are numerous waterfalls.

The geological history can be divided into three parts:
- formation of a relatively rigid and impermeable continental basement in the Palaeozoic;
- initiation of a north-west drainage in the Mesozoic; and
- intensified doming to the east in the late-Mesozoic-Cainozoic, culminating in continental rifting, ocean formation, partial foundering of the new continental margin with the coast retreating to its present position in the late Tertiary.

The bulk of the underlying rocks are marine Silurian, Devonian and Carboniferous sediments of the Hodgkinson Basin and Broken River Embayment. The greatest concentrations of volcanics and granite occur at the southern end of the Basin at its intersection with the trend of the Broken River Embayment.

Many of the granites were exposed by the end of the Palaeozoic and the beginning of the Mesozoic. Uplift of the tablelands shed drainage north-west during the Jurassic to the Tertiary period. Climatic change and geomorphic processes during the Quaternary led to repeated coastal retreat and marine submergence. These events influenced the reversal of stream flow to the east.

Stepwise coastal retreat and formation of the present juvenile upland coast has led to stream reversal and slope failure. One of the most striking elements of the landscape is the Great Escarpment, which has retreated to its present position as a result of catastrophic erosion and slope failure. Only where basalt flows run down valleys have the gradients of the Escarpment been locally reduced. In the Johnstone River valley system the escarpment is breached by a basalt ramp of moderate slope. The vulcanism of the Atherton Tablelands and adjacent volcanic provinces is characterised by scoria cones, lava cones and maars. Lakes Eacham and Barrine occupy the youngest maars. The tablelands and some coastal areas were greatly disturbed by basalt flows throughout the Pliocene-Pleistocene. However, the high nutrient status of the developing basalt soils may have proved advantageous to the rainforest in resisting stresses during the fluctuating climatic conditions associated with the Pleistocene glacial cycles.

(iii) Fringing reefs

Fringing reefs are extensively developed between the Daintree and Bloomfield rivers. The association between coastal rainforest and fringing coral reef to the extent that is manifest off Cape Tribulation appears to be undocumented elsewhere in the world and is thought to be a unique feature. The reefs are part of the Great Barrier Reef World Heritage Site.

(iv) Vegetation types

The major vegetation type in the Property is tropical rainforest but this is fringed and to some extent dissected by sclerophyll forests and woodlands, mangroves and swamps. The broad vegetation types represented within the Property are described below.

Rainforests

The rainforests of the Wet Tropics of Queensland occur across a diverse range of rainfall, soil type, drainage, altitude and evolutionary history. As a result there is a spectrum of rainforest plant communities and habitats recognised as being floristically and structurally the most diverse in Australia (Tracey 1982).

The rainforests of the wet tropics were classified into 13 major structural types including two which have sclerophyll (*Eucalyptus* and *Acacia*) components. The major types have further been classified into 27 broad communities correlating with climatic zones and soil parent material (Tracey & Webb 1975; Tracey 1982). All these communities occur in the Property and are listed in Appendix 3 of the original nomination document.

On the slopes and summits of the higher peaks where there is frequent cloud cover and strong winds there exist the wet submontane forests known as simply microphyll vine-fern forests and thickets. There is a high regional endemism of species in the floristic composition of these upland areas. Above 1,500 m on the Bellenden Ker Range the canopy, sometimes with the endemic *Leptospermum wooroonooran* dominant, is often low and dense and shows the streamlining effects of strong winds. On the summits there are many narrowly restricted species including *Dracophyllum sayeri, Cinnamomum propinquum, Rhododendron lochae, Flindersia oppositifolia, Orites fragrans* and *Uromyrtus metrosideros,*

The montane forests of the Mt Lewis and Mt Spurgeon area are also classified as simple microphyll vine-fern forests. However these forests, having many of their own endemics, differ floristically from those of the Bellenden Ker area. These include in the family Proteaceae, *Helicia recurva* and *Austromuellera trinervia*; *Prumnopitys ladei* in the family Podocarpaceae; the striking pink-flowered *Aceratium ferrugineum* in the family Elaeocarpaceae and the Mt Lewis palm *Archontophoenix purpurea*.

Floristically, the upland simple microphyll vine-fern forests and thickets are very different to the other rainforest types in the Wet Tropics, but they show a floristic affinity with the Australian temperate rainforests at higher latitudes and with montane rainforests of New Guinea and Indonesia. Shared genera with southern Australia include *Trochocarpa* and *Eucryphia. Rhododendron* and *Agapetes*, which are each represented in the Wet Tropics by a single species, are shared with New Guinea and Indonesia.

The most highly developed Australian rainforests occur on the wet lowlands. These complex mesophyll vine forests on colluvial footslopes and alluvial soils are represented in the Wet Tropics by small patches between Innisfail and Cape Tribulation. Characteristic trees include *Acmena graveolens, Backhousia bancroftii, Argyrodendron peralatum* and *Ristantia pachysperma*. Local endemism and disjunctions are common and are exemplified by *Storkiella australiensis* and *Idiospermum australiense*.

One of the most striking rainforest types is that dominated by the endemic Fan Palm, *Licuala ramsayi.* The type is restricted to small patches on poorly drained soils on the lowlands. Most has been cleared for sugar-cane farming and only 780 ha remain. Small patches (totalling 420 ha) of these palm forests are included in the World Heritage Area near Cowley Beach, Mission Beach, Yarrabah and north of the Daintree River.

Complex notophyll vine forests on the basalt soils of the Atherton Tablelands have by now been mostly cleared. What remains includes restricted and disjunct species such as *Athertonia diversifolia, Austromuellera trinervia* and *Austrobaileya scandens*. The drier remnant of the type is conserved in the World Heritage Area at the Curtain Fig (State Forest 452) and Severin Creek (State Forest 185) with the wetter type at Mt Hypipamee - The Crater National Park. The overlap of the wet and dry types is conserved in National Parks at Lake Barrine and Lake Eacham.

Complex mesophyll vine forest on very wet lowlands on beach sands is now extremely rare. The major occurrences at Kurrimine Beach and near the mouth of the Daintree River and at Noah Creek near Cape Tribulation are all represented in the World Heritage Area. Palms found in this type include *Arenga appendiculata, Archontophoenix alexandrae, Hydriostele wendlandiana, Licuala ramsayi, Ptychosperma elegans* and in the Noah Creek area the narrowly restricted endemic *Normanbya normanbyi.* Conspicuous trees in the type include *Calophyllum inophyllum* on the beachfront; *Calophyllum sil, Syzygium forte, Acmena hemilampra* and *Podocarpus grayi* on the dunes; and in the wetter swales *Dillenia alata, Syzygium angophoroides* and *Randia fitzalani*. *Backhousia hughesii* is common in the community at Noah Creek.

In addition to these rarer forest types the World Heritage Area contains outstanding and extensive occurrences of mesophyll vine forests and simple notophyll vine forests found on the moist uplands and highlands.

Non-rainforest components

The inclusion of various non-rainforest types within the Property represent the drier end of the rainforest spectrum and because of the influence of fire, act as a transition between rainforest and non-rainforest vegetation. These transitional zones are dynamic and important in terms of long-term management, climate change, and for certain rainforest fauna that use sclerophyll forests on a seasonal basis. These ecotones are important not only for their intrinsic interest but as additional insurance of integrity under fluctuating climates. Their inclusion also adds substantially to the overall biodiversity values of the Property.

Tall Open Forests

Adjacent to the rainforest on the western margin of the-World Heritage Area are tall open forests (wet sclerophyll forests) dominated by *Eucalyptus grandis* (Rose Gum), *E. resinifera* (Red Stringybark), *E. acmenioides* (White Stringybark), *Corymbia intermedia* (Pink Bloodwood), *Lophostemon confertus* (Brush Box) and *Syncarpia glomulifera* (Turpentine). Variation in species composition and concentration within these forests correlate with soil type, rainfall and fire frequency; as well these factors are reflected in understoreys of different compositions ranging from well developed rainforest elements to dense grass.

There is a striking contrast in the structure of the adjoining rainforest and wet sclerophyll forests of the Wet Tropics. This ecological situation is very different from rainforests and “campos cerrados” of Brazil and the moist evergreen-dry deciduous forests of India (Webb and Tracey 1981).

The narrow strip of tall open forest where it occurs adjacent to rainforest is important for the conservation of one of the mammals restricted to the World Heritage Area, the endangered *Bettongia tropica* (northern bettong) and the northern population of two other species of mammals restricted to this forest type - *Petaurus australis* (fluffy or yellow-bellied glider), and *Rattus lutreolus* (swamp rat).

Medium and Low Woodlands

Areas of medium and low eucalypt woodlands are also included in the World Heritage Area. These are examples of widespread vegetation types found today over most of tropical Australia. Their inclusion preserves the ecotones between rainforest and sclerophyll elements. The species compositions of both canopy and understorey differ in response to rainfall, soil type, fire frequency and vegetation history.

Paperbark Swamps

Melaleuca spp. (paperbarks) occur as the dominant tree species in poorly drained lowland coastal areas where the water table is near to or above ground level for most of the year. They usually occur as components of vegetation mosaics reflecting specific habitats including the *Melaleuca leucodendra* and *M. dealbata* complex in freshwater and brackish swales in old beach ridge systems; *M. quinquenervia* dominant in fresh water swamps; and *M. viridiflora* on solodic and saline sand plains. The *Melaleuca* communities often have distinct species including the epiphytes *Dischidia, Hydrophytum* and the Tea Tree Orchid, *Dendrobium canaliculatum*.

Mangroves

A high degree of species diversity of mangroves trees and shrubs (c. 30 species) occurs in the Wet Tropics, comparable to the diversity of those of New Guinea and Southeast Asia which are acclaimed as some of the richest mangrove areas in the world. Major areas include the Hinchinbrook Channel, the north bank of the Daintree River and Alexandra Bay north of the Daintree River.

Rainforests intergrade with the mangroves, sharing many species at the interface including *Diospyros littorea*, a species found only on the landward side of the mangroves.

The mangrove zone has a rich and varied epiphytic flora including ferns of the genus *Drynaria* and orchids of the genus *Dendrobium* and the Ant Plant, *Myrmecodia beccarii*. The ant *Iridomyrmex cordatus* that inhabits the *Myrmecodia* tends the larvae of the endangered butterfly *Hypochrysops apollo*.

(v) Flora

Within the Property there are over 2840 recorded species of vascular plants, representing 1164 genera and 210 families. Of the genera, 75 are endemic to Australia and 43 are restricted to Queensland's Wet Tropics. More than 700 species, or 25 per cent of the total, are found only in this area.

The Wet Tropics of Queensland World Heritage Area plays a vital role in the conservation of the Australian members of the Southern Hemisphere family Proteaceae. At least 29 genera (some of which are still to be described) out of a world total of 76 occur in the Wet Tropics and over 40 species are restricted to the Property. The rainforest members of the Proteaceae, living or extinct, are claimed (Johnson and Briggs 1975) to be the ancestors of the sclerophyll species such as *Grevillea* and *Persoonia* that today form such an important part of the Australian vegetation. *Placospermum coriaceum*, one of the most primitive plants of the Proteaceae, occurs only in the- Wet Tropics.

Many examples of isolated populations of tree species occur throughout the rainforests of the- World Heritage Area, both on the lowlands and in the uplands. Species included on the lowlands are *Storkiella australiensis* and *Noahdendron nicholasii* which are restricted to near Cape Tribulation; *Idiospermum australiense* and *Lindsayomyrtus brachyandrus* have a disjunct distribution between the Cape Tribulation area and the Harveys Creek–Russell River area south of Cairns, both very wet humid tropical lowland areas. On the uplands *Sphalmium racemosum* and *Stenocarpus davalloides* have populations restricted to the Mt Carbine Tableland in the northern section of the-World Heritage Area, whereas *Lomatia fraxinifolia*, *Darlingia darlingiana* and *Cardwellia sublimis* are widespread. Much is yet unknown of the species distribution patterns in the tropical rainforests of the Wet Tropics.

The Property has a rich orchid flora. Of some 150 species present, about 59 have a restricted distribution with 43 having an extremely small range. *Dendrobium fleckeri, D. adae, D. carrii* with its creeping rhizome, *Bulbophyllum boonjie* and *Saccolabiopsis rectifolia* are a few examples of the restricted epiphytic orchids. Terrestrial orchids are also represented in the Property. The endemic Jewel Orchid, *Anoectochilus yatesiae*, is only found in the darkest, dense upland rainforests of this region.

The Property is also the home of one of the world's largest cycads, as well as one of the smallest. *Lepidozamia hopei* may grow to a height of about 20m. Its population today is scattered and disjunct. The small fern-like cycad, *Bowenia spectabilis*, is common in the understorey of rainforest-associated communities.

The richest concentrations of ferns and fern allies in Australia are found in the Wet Tropics. Of more than 250 species occurring in these rainforests, 46 are entirely restricted to the Property. Some 17 species have extremely restricted distributions within the Property. Of the five Australian endemic fern genera (Page and Clifford 1981), four occur in the Wet Tropics (*Coveniella*, *Neurosoria*, *Pteridoblechnum* and *Platyzoma*). *Pteridoblechnum* is the only endemic fern genus restricted to the tropical area of northeast Australia and is represented by *P. acuminatum* at Mt Spurgeon and Mossman Gorge and the widely distributed *P. neglectum*.

(vi) Fauna

In comparison with other regions in Australia, the Wet Tropics is extraordinarily rich in vertebrate and invertebrate species. Although the highest species densities occur at lower elevations, the proportion of species restricted to the region increases very markedly with elevation. With the exception of two fish species, the Cairns rainbowfish (*Cairnsichthys rhombosomoides*) and the Roman-nosed goby (*Awaous crassilabrus*), the lizard *Lygisaurus laevis* and the frog *Cophixalus exiguus* and the mammal, the Mahogany glider (*Petaurus gracilis*), the remaining endemic vertebrate species are most frequently recorded above 400 m and often above 600 m (Nix 1991). Several species, however, may be found at lower than usual elevations only in those areas characterised by high annual mean rainfall and frequent cloud cover, where mountains and ridges drop steeply to the sea. These include Lumholtz's tree-kangaroo (*Dendrolagus lumholtzi*), the musky rat-kangaroo (*Hypsiprymnodon moschatus*), the chowchilla (*Orthonyx spaldingii*), Victoria's riflebird (*Ptiloris victoriae*), the northern red-throated skink (*Carlia rubrigularis*), Boyd's forest dragon (*Gonocephalus boydii*), the Palmerston frog (*Cophixalus infacetus*) and the ornate litter frog (*Cophixalus ornatus*). The occurrences of these species below their normal altitudinal limits on wet cloudy coastal mountains and isolated mountains is known as the 'massenerhebung' or 'mountain mass' effect – many explanations have been offered to explain this phenomenon but none have proved adequate (Nix 1991).

Nix (1991) describes the Wet Tropics as an archipelago of mesotherm islands that are separated by dry and/or warm barriers. Nix's climatic analysis of Wet Tropics endemic vertebrates produced five distinct groups that emphasised the importance of altitudinal zonation in describing patterns of endemism within the region.

Mammals

Spatial and altitudinal distributions of Wet Tropics mammals are relatively well established (Winter *et al* 1984; Winter 1988, 1991; Winter *et al* 1991; Van Dyck 1991; Nix & Switzer 1991). Two subregions of mammalian faunal assemblages have been proposed (Winter *et al* 1984).

Patterns in diversity have been largely attributed to altitudinal preference (uplands have higher diversity), dispersal from New Guinea and the fluctuations in the size of rainforest refugia over the last 25,000 years (Schodde & Calaby 1972; Winter 1988, 1991a). Endemic rainforest specialists are considered to be "relict species of a once more widespread community" which are now primarily restricted to upland, cooler rainforests (Winter 1988; Nix 1991).

Birds

Broad distributions and habitat preferences of most Wet Tropics rainforest birds have been well documented (Kikkawa 1968, 1974, 1976, 1982, 1988, 1991a, 1991b; Schodde & Calaby 1972; Crome & Nix 1991; Ingram & Raven 1991; Williams *et al* 1996).

There are high levels of regional endemism in birds from the upland areas of the Wet Tropics. Many of these upland endemic species are considered relicts of either an older connection with the upland fauna of New Guinea or from an older, cool temperate, Australian fauna (Kikkawa *et al* 1981). Present upland rainforests in the Wet Tropics is a refugium and an "epicentre of evolution for low vagility animals" (Kikkawa *et al* 1981). In contrast, the lowland rainforests birds have a higher affinity with the Cape York Peninsula rainforests of far northern Queensland, with dispersal from the north being a more important process than the vicariance inferred by a "pattern of overlap among closely related species" in upland bird assemblages (Kikkawa *et al* 1981). Genetic studies (Joseph & Moritz 1994) suggests that vicariant evolution in historical rainforest refugia has been an important influence on the bird fauna, although the effects of this history have been more complex than previously thought, resulting in different patterns in different species. Genetic analysis also suggests that the time of important vicariant events is variable between species and much longer ago than the late Pleistocene contractions (Joseph & Moritz 1994).

Reptiles

The Wet Tropics is part of the Torresian biogeographic zone and has many representatives of recent reptile species invasions from the north (Cogger & Heatwole 1981). The Wet Tropics consists of a mixture of old endemics (Gondwanan origin) and recent invaders from New Guinea (Cogger & Heatwole 1981; Kikkawa *et al* 1981). Covacevich and Couper (1994) found that the areas of highest reptile diversity in the region are (in descending order) the Bellenden Ker Range/southern Lamb Range, Bloomfield, Mt Lewis/Mt Spurgeon/Windsor Tableland, Ravenshoe/Tully Falls, Kuranda, Paluma and Cardwell.

Frogs

The Wet Tropics contains the most diverse rainforest frog assemblage in Australia with very high levels of regional endemism (McDonald 1992). The Atherton Uplands, Carbine Uplands and Thornton Uplands are the core areas of high rainforest frog diversity (McDonald 1992). High diversity areas are characterised by high rainfall, granite parent rock and high altitude. In general the highest diversity areas are above 600 m with particularly important areas found above 1,000 m (Williams *et al* 1996). The highest lowland frog diversity area is found in the northern coastal section of the Wet Tropics – the Cape Tribulation Lowlands.

McDonald (1992) presents a comprehensive review on the patterns of distribution and diversity of Wet Tropics rainforest frogs. Since that report was published there have been dramatic declines in abundance in a number of species (Richards *et al* 1993). Four species (*Litoria nyakalensis, L. lorica, Taudactylus acutirostris, T. rheophilus*) cannot presently be found despite intense survey work. At least three other species (*Litoria nannotis, L. rheocola, Nyctimystes dayi*) have severely declined in upland areas (above 300 m) throughout their previous ranges.

Freshwater fish

The Wet Tropics sustains a very high diversity of freshwater fish relative to other Australian regions, parallel to that seen among the terrestrial vertebrates. The Wet Tropics supports 45% of Australia's freshwater fish species, 70% of genera and 70% of families (Pusey 2001) – this is exceptional continental diversity for a small strip of land less than 70 km wide that passes through only 5 degrees of latitude.

Two of the endemic fish species, *Guyu wujalwujalensis* and *Cairnsichthys rhombosomoides* are very old paleoendemics. With the exception of *G. wujalwujalensis,* all the endemic fish species are found in either or both the Russell/Mulgrave and Johnstone rivers which form the core of freshwater fish diversity and endemism in the region (Pusey 2001). These three river systems encompass the wettest parts of the Wet Tropics and their catchments contain the region's highest mountains, Mt Bartle Frere and Mt Bellenden Ker. These mountains are likely to have exerted a powerful influence on the distribution of rainfall in the area throughout the Pleistocene.

Most of the endemic species are found predominantly in the smaller tributary streams and not in the main stream channels. Most of the endemic species occur in riffle and rapid habitats, whereas elsewhere in Australia, species found in riffles and rapids are a very minor component of the freshwater fish fauna (Pusey 2001).

Invertebrates

Like other faunal groups, gross change takes place in the qualitative composition of invertebrate fauna along altitudinal gradients in the Wet Tropics. For example, the insects of the lowlands are very different from those that occur on nearby mountain slopes and summits. This has been particularly demonstrated by altitudinal transect surveys of insect fauna from sea level to the summits of three major mountain massifs in the region – the Bellenden Ker Range, Mossman Bluff and the Mt Sorrow Tableland. On Bellenden Ker there is only a 3% similarity between the insect fauna of the summit and that of the lowlands at the base of the mountain. A major transition in the insect fauna appears to take place at about 500-600 m altitude, which appears to coincide with the lower limit of regular fog precipitation. The lowland insect fauna is consistently more diverse (Monteith 1996).

High altitude insect surveys by Monteith (1994, 1996) has revealed a distinctive faunal component of insects with Gondwanan affinities and has established the Wet Tropics as a temperate refugial area of significance as great as that of Tasmania, New Zealand and the Border Ranges (Monteith 1996). Examples of these relict taxa include the primitive leafhopper genus Myerslopella (5 species) with its nearest relatives in Madagascar; the moss bug family Peloridiidae (3 species) with relatives in Chile and New Zealand; the barkbug genus Kumaressa (1 species) whose nearest relative is in New Zealand; the arboreal carabid genus Philipis (33 species) which is the only member of its tribe outside South America; the stag beetle genus Sphaenognathus (1 species) otherwise restricted to Andean South America; the darkling beetle tribe Adeliini has 45 genera found in Chile, Australia, New Caledonia and New Zealand with six of these genera confined to the Wet Tropics (Monteith 1996) These ancient, relict insects of temperate affinity occur mostly above 800-900 m altitude. Many of the relict species are very localised and some are restricted to a single mountain peak.

Justification

Cultural property

(note: the Wet Tropics of Queensland was only listed as a natural property)

Natural property

The Wet Tropics of Queensland fulfils all four criteria described for inclusion of properties on the World Heritage List as a 'natural heritage' as defined under the World Heritage Convention.

(1) *Outstanding examples representing the major stages of the earth's evolutionary history*

The Australian wet tropics region conserves in its biota elements that relate to 8 major stages in the earth's evolutionary history: (a) The Age of the Pteridophytes, (b) The Age of the Conifers and Cycads, (c) The Age of the Angiosperms, (d) the final break-up of Gondwana, (e) the origins of the Australian sclerophyll flora and marsupial fauna, (6) the origin and radiation of the songbirds, (7) the mixing of the continental biota of the Australian and Asian continental plates and (8) the extreme effects of the Pleistocene glacial periods on tropical rainforest vegetation. It contains the most complete and diverse living record of the major stages in the evolutionary history of land plants (from the very first plants on land to the higher plants, the Gymnosperms and the Angiosperms), as well as one of the most important living records of the history of the marsupials and the world's songbirds.

(a) The Age of the Pteridophytes

One of the most significant evolutionary events on this planet was the adaptation in the Palaeozoic (or Ancient) Era of plants to life on the land (White 1986). The earliest known (plant) forms were from the Silurian Period more than 400 million years ago. These were spore-producing plants that reached their greatest development 100 million years later during the Carboniferous Period. This stage of the earth's evolutionary history, involving the proliferation of club mosses (lycopods) and ferns, is commonly described as the Age of the Pteridophytes. The range of primitive relict genera representative of the major and most ancient evolutionary groups of pteridophytes occurring in the Wet Tropics is equalled only in the more extensive New Guinea rainforests that were once continuous with those of the Property (Clifford and Constantine 1980; Jones and Clemesha 1980).

These include all but one of the surviving genera of the ancient Classes of Psilotopsida (*Psilotum, Tmesipteris*) and Lycopsida (Lycopodiaceae, Selaginellaceae and Isoetaceae) that represent the earliest living ancestors of the two main branches of land plants. *Huperzia squarrosum*, the most primitive living lycopod most closely resembles *Baragwanathia longifolia*, the 415-million-year-old Silurian fossil lycopod from the famous Baragwanathia Flora at Yea in Victoria (Sporne 1975; White 1986). The Wet Tropics is a major centre of endemism and diversity for lycopods and the Selaginellaceae in Australia. Most *Huperzia* species in the Wet Tropics are now endangered or vulnerable to extinction.

The majority of today's ferns do not appear in the fossil record before the angiosperms (Kramer 1993). Only seven families of true ferns from the world's existing flora of about 36 families can be traced back to the earliest fossil record in the Early Carboniferous when most land lay in the tropical and subtropical zones within the one continent, Pangaea (Scott *et al.* 1985, Galtier and Scott 1985). The greatest evolutionary diversity for these seven ancient families (Lycopodiaceae, Selaginellaceae, Ophioglossaceae, Marattiaceae, Osmundaceae, Schizaeaceae and Gleicheniaceae) occurs in the Wet Tropics. Eighteen out of the 27 genera from all seven families are represented in the region by 41 species. These include the most primitive members of ancestral or ancient orders of ferns (Class Pteropsida) such as the Marattiales (*Angiopteris*, Marattia), Ophioglossales (*Botrychium, Helminthostachys, Ophioglossum*) and Osmundales (*Leptopteris, Todea*). The Osmundales is the sole survivor of the two true fern orders first detectable in the fossil record and is considered to have originated in the Australian portion of Pangaea (Dettman and Clifford 1991). This extremely ancient order which occupies an isolated position among the ferns (Sporne 1975, Clifford and Constantine 1980) has survived relatively unchanged to the present day. Two of the three genera in the order are restricted to the Southern Hemisphere. *Leptopteris* comprises seven species restricted to western Pacific countries originally part of Gondwanan Australia or its Pacific terranes (Polynesia, New Zealand, New Guinea and eastern Australia). The single Australian species, *L. fraseri* (Filmy King Fern) is restricted to the summit of Mt Bellenden Ker in the Wet Tropics and isolated warm temperate rainforests in New South Wales and Victoria.

The homosporous Ophioglossaceae are considered by some scientists to be living pro-gymnosperms and part of an evolutionary line leading to flowering plants via the gymnosperms (Kato 1988, 1990, 1991). Three of the four surviving genera occur in the Wet Tropics. The Ophioglossaceae appear in the Australian fossil record in the Late Tertiary (Dettman and Clifford 1991).

The Schizaeaceae and Gleicheniaceae are the oldest and most primitive families of the largest group of pteridophytes, the Filicales. All four genera of the Gleicheniaceae and three of the four genera of the Schizaeaceae occur in the Wet Tropics. *Actinostachys* is the most primitive genus in the Schizaeaceae and has a relict distribution in the Wet Tropics of Australia and Madagascar as well as occurring in tropical Asia. It first appears in the Australian fossil record in the Late Cretaceous. The Gleicheniaceae appears earlier in the Australian fossil record in the Middle Triassic (Dettman and Clifford 1991).

The Wet Tropics has the highest diversity of ferns in Australia and one of the highest levels of genetic diversity in the world. Thirty-one (86 per cent) of the 36 known families and 111 of the 364 described genera (30 per cent) of pteridophytes occur in the Wet Tropics. The Wet Tropics contains 64 per cent of species and 88 per cent of the genera of ferns occurring in Australia.

The level of diversity and endemism among East Gondwanan fern taxa is exceptional. East Gondwanan fern genera include the monotypic endemic genus *Coveniella*, *Lastreopis*, *Polystichum* (Aspleniaceae), the monotypic endemic genera *Pteridoblechnum* and *Steenisioblechnum* (Blechnaceae), *Oenotrichia* (Dennstaedtiaceae), *Leptopteris*, *Todea* (Osmundaceae), *Tmesipteris* (Tmesipteridaceae/Psilotaceae), and the Australian endemics *Lycopodiella* and *Huperzia* (Lycopodiaceae). The Wet Tropics is the major centre of endemism for *Huperzia* with 9 of the 12 known species occurring there. Seven of these are either endangered or vulnerable to extinction, with the Wet Tropics being the only known location for *H. lockyeri* and *H. marsupiiformis*.

The Wet Tropics of Queensland is therefore one of the most significant centres of evolutionary diversity and survival for the most primitive and relict members of ancestral or ancient orders of spore-producing plants. As such the fern assemblages contribute the earliest chapter to one of the most complete living records of the evolution of land plants.

(b) The Age of the Conifers and Cycads

The origin of seed plants over 320 million years ago (Farjon *et al.* 1993) was one of the most significant events in the evolution of terrestrial vegetation, an adaptive breakthrough that allowed colonization of habitats that were inhospitable to spore-producing plants and triggered a Lower Carboniferous diversification of vascular plants. This event also significantly facilitated the evolutionary radiation of other terrestrial organisms (Rothwell and Erwin 1987). The cone-bearing Cycads and Southern Conifers are the most ancient of living seed plants, little changed from ancestors that flourished in the Jurassic Period, termed the 'Age of the Conifers and Cycads' between 136 and 195 million years ago (White 1986; Norstog 1987). The flora of this Period was a cosmopolitan flora of conifers, cycads, ferns, seed-ferns, ginkgos, herbaceous lycopods and horsetails. Jurassic fossils from the Talbragar Fish Beds near Gulgong in New South Wales reveal forests comprising *Agathis* and *Podocarpus* conifers with an understorey of the Cycadophyte, *Pentoxylon australica*. The closest modern counterpart of these forests occurs in the World Heritage area with a rare assemblage of *Agathis robusta*, *Podocarpus grayi* and *Lepidozamia hopei*.

The World Heritage area is a major centre of survival for the cycads. Ten genera and 121 species in four families of cycads are all that remain of a group that has been in existence relatively unchanged for at least 200 million years with the majority of species now considered as rare and threatened (Norstog 1987, Jones 1993).

Cycads as a group are thought to have originated in the East Gondwanan sector of Pangaea prior to its break-up. The cycads contain more primitive features than any other living group of gymnosperms. Cycads are the only gymnosperm known to fix nitrogen from the atmosphere which is achieved through a symbiotic relationship with blue-green algae in specialized root structure called corraloid roots (Jones 1993). The production of motile sperm cells is unique to cycads and one other gymnosperm, *Gingko biloba*. The discovery of this feature in 1896 was hailed as one of the most exciting botanical discoveries of all time, since it provided the missing link between gymnosperms and the ferns and fern allies (Jones 1993). The pollination syndrome of cycads involving primitive groups of insect vectors is believed to represent the most primitive pollination system known and the earliest examples of insect–plant symbiosis. The insect vectors involve ancestral beetle families such as Curculionidae (weevils) and Tenebriondae (tenebrionid beetles), Languriidae, Anthribidae (mortar and carpenter bees), Boganiidae and Nitidulidae (Jones 1993). *Native bees from the genus Trigona pollinate Cycas media*. This genus is the oldest known bee with fossil records from the Cretaceous Period preceding the origin of flowering plants.

Three of the four cycad families (Boweniaceae, Cycadaceae, Zamiaceae) and three genera (*Bowenia, Cycas and Lepidozamia*) occur in the World Heritage area representing the highest diversity of cycad genera in Australia and the greatest diversity of major cycad groups anywhere in the world.

The genus *Cycas* is the most primitive of all the known cycads (Chase *et al.* 1993) with earliest fossils dated from the Lower Permian. It separated very early from other cycad genera as a distinct and isolated line of evolution. Australia has the highest diversity of *Cycas* species in the world with about 20 of the world's total of 30 species occurring there (Hill 1992). The most species rich area is along the east coast of Queensland north from Rockhampton. About 10 species occur in China and with single species in Malesia, Japan and south-east Asia, and in Polynesia, Madagascar and East Africa (Hill 1992). Most *Cycas* species are geographically isolated. All but two of the 9 *Cycas* species occurring in Queensland are rare (2) or vulnerable to extinction (5). One species occur within the Wet Tropics World Heritage area (*C. media*). Warm humid environments are thought to be the ancestral habitat of *Cycas*. Seasonally dry habitats are regarded as more recent.

The palm-like *Lepidozamia hopei*, restricted to the- World Heritage area, is the tallest of all living cycads growing to heights of 20 metres (Johnston 1959; Clifford and Constantine 1980). A rare assemblage of *Lepidozamia hopei*, podocarp (*Podocarpus grayi*) and the araucarian, *Agathis robusta* in the World Heritage area represents the closest living counterpart of Jurassic forests fossilised remains of which are found in the Talbragar Fish Beds of New South Wales (White 1986). The Southern Cassowary, believed to have evolved in the Early Tertiary, is known to be significant for long distance dispersal of *Lepidozamia hopei*.

The fauna associated with these modern-day Jurassic forest analogues are equally ancient mostly dating from the same era. Larvae of the very "primitive' south-west Pacific moth family Agathiphagidae (kauri moths), the only surviving family within the entire suborder Aglossata, feed only on the seeds of *Agathis* (Robinson and Tuck 1976). Only two species survive - *A. queenslandicus* restricted to eastern Queensland, and *A. vitiensis* in the south-west Pacific. An endemic Australian subfamily of cynipoid wasps (Austrocynipinae) is associated with the seeds of *Araucaria*. A group of 'primitive' southern hemisphere weevils (Nemonychidae: Rhinorhynchinae) feed on the pollen of Araucariaceae and Podoarpaceae (Kuschel 1983, 1994). This family, the most primitive of the weevils, is now relict after having been the dominant group amongst all phytophagous beetles in the Upper Jurassic some 200 million years ago. The rainforests of the Wet Tropics and those of south-east Queensland contain the greatest known evolutionary diversity within this group. Members of the Tribe Rhinorhynchini within the subfamily Rhinorhynchinae resemble almost unchanged their fossil counterparts of the Upper Jurassic (Kuschel 1994).

Beetles of the subfamily Paracucujinae (family Boganiidae) are restricted to the Cycadaceae, feeding on pollen as both larvae and adults.

One of the smallest cycads in the world, restricted to rainforest and wet sclerophyll forests in the World Heritage area and McIlwraith Range on Cape York, is the fern-like *Bowenia spectabilis*. Fossil species of both *Bowenia* and *Lepidozamia* have only been recorded from Eocene deposits at Anglesea, Victoria (*B. oecenica* resembling *B. spectabilis*), Bacchus Marsh, Victoria (*L. hopeites* resembling *L. hopei*) and at Nerriga in New South Wales (*B. papillosa, L. foveolata*). *Bowenia* is the only known cycad with bipinnate leaves which, from the fossil record, appear not to have changed over 45 million years (Jones 1993). The family is endemic to Australia.

Forests containing the gymnosperm group, the araucarians, are of immense interest to science for they are among the most ancient and primitive of the world's surviving conifers. The Australian sector of Gondwana is considered to have been the site of origin of these austral or southern conifers. Both the Araucariaceae and Podocarpaceae dominate the Australian pre-Tertiary fossil record with a great diversity of species in the Jurassic and Cretaceous (Dettman 1994). They are regarded as the ancestral core of present-day perhumid rainforests that arose though progressive addition of angiosperms throughout the Cretaceous and Early Tertiary (Dettmann 1994).

Only two araucarian genera survive today. The greatest diversity of surviving evolutionary lineages of *Araucaria* and *Agathis* occur in the Property. Two species of *Agathis* endemic to the World Heritage area are rare. This area is also the most significant centre of survival for the major genetic lineages of

Prumnopitys and *Podocarpus*, the most dominant and closely related relict genera of the Podocarpaceae. At least 50 per cent of species in these two genera worldwide are now rare or at serious risk of extinction. The three endemic species of Prumnopitys and Podocarpus in the Wet Tropics area are considered rare with very small ranges and at therefore at risk (Farjon and Page 1993).

(c) The Age of the Angiosperms

The emergence of the angiosperms some 200 million years after the first appearance of the gymnosperms marked the beginning of one of the most fundamental changes in biological diversity on this planet. By late Cretaceous gymnosperms had largely been replaced by angiosperms, although the beginnings of the modern flora did not emerge until the Tertiary. The current estimates of 235 000 species of flowering plants represents 88.7 per cent of all plant species on earth (Raven 1987). The majority of flowering plants are dicotyledons (class Magnoliopside), with 180000 species in six subclasses — the Magnoliidae, Hamamelidae, Caryophyllidae, Dilleniidae, Rosidae and Asteridae (Cronquist 1988). According to the classification of Cronquist dicotyledons are organised into 321 families in 64 orders and the 55 000 species of monocotyledons (class Liliopside) are arranged within five subclasses containing about 66 families in 19 orders (Cronquist 1988) although the actual organisation of many families between the subclasses is still in a state of flux (Liden 1992).

The origin of these flowering plants is one of the major unsolved questions of botany. East Gondwanan countries are known to contain the greatest concentration of archaic and relict taxa relating to the origins of flowering plants (Takhtajan 1987). The distribution of relict taxa in the individual continents reflects the timing of origin and spread of the different plant groups in relation to the rifting and drifting of continents once part of Gondwana.

The radiation of floras, as recorded in the fossil record, has occurred in discrete waves. The Australian wet tropics region contains outstanding examples representing 5 major elements in the history of the angiosperms.

Australia was once part of the southern supercontinent Gondwana. Other parts of that landmass were made up of the continents now known as Africa and South America (West Gondwana) and Antarctica, the subcontinent of India and the now island fragments including New Zealand, New Caledonia, New Guinea and Madagascar. Australia, New Zealand and New Guinea were part of East Gondwana.

A West Gondwanan origin has been proposed for the angiosperms (Raven and Axelrod 1974). Evidence suggests that diversification occurred quite rapidly and that a significant number of taxa had arisen before the break-up of Gondwana began about 120 million years ago. By this stage, angiosperms had appeared in the northern hemisphere and in South America and Southeast Gondwana (Antarctica and Australasia) and were apparently spreading in two essentially separate, diversifying streams (Schuster 1972, 1976). A significant part of the southern stream became essentially isolated in Australia when, about 50 million years ago, it finally broke away from Antarctica and rafted towards the tropics.

However, distributed throughout the Indo-Pacific regions are numerous fragments, or terranes, derived from the northern margin of the Australian section of Gondwana (Audley-Charles 1987, 1988 1991; Hutchison 1989; Burrett *et al.* 1991; Harbury *et al* 1990; Metcalfe 1990; Veevers 1991a, 1991b). These fragments now form parts of South-east Asia, Indonesia and some pacific islands. Audley-Charles (1987) has suggested that those terranes that rifted during the Cretaceous when angiosperms first evolved, acted as ‘Noah’s Arks’, carrying with them an evolving Gondwanan angiosperm flora.

(i) *The richest assemblage of families of primitive flowering plants*

The first recognizable angiosperm pollen was *Clavatipollenites hughesii* described from the late Barremian and Aptian (Early Cretaceous) of southern England (Couper 1958) and has been found in southern Australia from the same time period at Koonwarra (Dettman 1986). It closely resembles that of the living New Caledonian genus *Ascarina* of the Chloranthaceae (Walker and Walker 1984) and

Austrobaileya of the Austrobaileyaceae, a monotypic family found only in the Wet Tropics (Endress and Honegger 1980). The most primitive and ancient orders of living flowering plants are the Magnoliales and Laurales. Of the 19 angiosperm families described as the most primitive (Walker 1976), 12 occur in the Wet Tropics, giving it the highest concentration of such families on earth. These families are: Annonaceae, Austrobaileyaceae, Eupomatiaceae, Himantandraceae, Myristicaceae and Winteraceae of the order Magnoliales; Atherospermataceae, Gyrocarpaceae, Hernandiaceae, Idiospermaceae, Lauraceae and Monimiaceae of the order Laurales.

(ii) *Species belonging to small, relict primitive angiosperm families*

The Australian Wet Tropics has the highest concentration of small, relict and virtually extinct, primitive angiosperm families in the world (Endress 1983). These are Austrobaileyaceae, Eupomatiaceae, Idiospermaceae and Himantandraceae. Two of these, the monospecific Austrobaileyaceae and Idiospermaceae are restricted to the region. The ditypic Eupomatiaceae and Himantandraceae extend outside of Australia, only to New Guinea and East Malesia (the Moluccas) respectively. They are probably the last few remnants of an ancient assemblage that have survived the attrition of rainforest during dry cycles of the last ice ages in the Pleistocene. *Eupomatia* fossils derive from the Cretaceous and have been discovered in America indicating a much larger former range.

(iii) *Orders occupying nodal positions in the evolution of the angiosperms*

Higher dicotyledonous angiosperms form five major groups accounting for 70 per cent of all living flowering plants (Cronquist 1981). The initial major radiation of these groups occurred in the Cretaceous with ancient members of the sub-classes Hamamelidae and Rosidae being especially important (Crane *et al.* 1986). The orders Hamamelidales, Rosales, Euphorbiales, Dilleniales, Violales, Theales, Celastrales and Gentianales, are considered to occupy major nodal positions in the evolution of the angiosperms (Takhtajan 1980; Cronquist 1981). Within these orders, key families with a relict distribution are of considerable importance. Those represented in the Wet Tropics are: Hamamelidales - Hamamelidaceae; Rosales - Alseuosmiaceae, Cunoniaceae, Davidsoniaceae, Escalloniaceae, Eucryphiaceae, Pittosporaceae; Celastrales - Aquifoliaceae, Icacinaceae, Celastraceae; Euphorbiales - Euphorbiaceae; Dilleniales - Dilleniaceae; Violales - Flacourtiaceae; Theales - Ochnaceae; Gentianales - Apocynaceae.

(iv) *Gondwanan angiosperm families of Cretaceous origin*

One of the most sudden and significant transformations of terrestrial plant life occurred in the Mid-Cretaceous leading to a vast and rapid spread of flowering plants throughout the world. Catastrophic events around the Cretaceous–Tertiary boundary led to major extinctions of angiosperm taxa. An estimated 75 per cent of all living species were lost, particularly in the northern hemisphere (Crowley and North 1991; Collinson 1990). However, East Gondwana in the southern hemisphere was relatively unaffected (Muller 1984), and consequently the highest concentrations of Cretaceous angiosperm families survived in that region, many of which were still present on the Australian landmass when it finally broke away from Antarctica. Today, the highest concentration of relict taxa from Cretaceous angiosperm families survive in the Australian Wet Tropics. Cretaceous families include the Cunoniaceae, Proteaceae, Winteraceae, Myrtaceae, Monimiaceae (Raven and Axelrod 1974), Rutaceae, Platanaceae, Sapindaceae, Aquifoliaceae, Callitrichaceae, Chloranthaceae, Gunneraceae, Trimeniaceae, Epacridaceae, Olacaceae and Loranthaceae (Dettman 1994).

Pollen similar to that of *Syzygium* and *Eugenia* (Myrtaceae) occurs in Campanian and Maastrichtian sediments on the Antarctic Peninsula (Dettman 1989) and the Paleocene of Australia (Dettman 1994). Eugenia is now represented in Australia by a single species endemic to the Wet Tropics. It is the largest genus in the Myrtaceae (~1000 species), concentrated today in tropical America, and the only genus shared between the Old World and New World. *Syzygium*, the second largest genus (~500 species), on the other hand occurs exclusively in the Old World with 55 species still remaining in Australia. The Wet Tropics is the most significant centre of survival in Australia with 31 species, 16 being endemic to the Property. Australia is also the outstanding centre of diversity and endemism for the entire family (73 of the world's 140 genera and 1361 out of the world's total of 3350 species. The Myrtaceae family are now

represented in the Wet Tropics by 41 genera and 124 species. Four mono- or ditypic genera are endemic to the wet tropics — *Barongia* (1sp.), *Sphaerantia* (2 spp.) and two undescribed monotypic genera.

(v) *East Gondwanan families or genera*

East Gondwana which included Australia, New Guinea, New Zealand and New Caledonia was a key area for the early radiations of flowering plants. Significant numbers of taxa believed to have originated in East Gondwana still survive in rainforests within these areas. The Australian wet tropics has a special position as the area with the longest continuous history as part of the parent landmass.

Angiosperm taxa recorded from the Wet Tropics and believed to have originated in East Gondwana includes 153 genera in 43 families.

(d) The Final Break-up of Gondwana

The final stage in the break-up of Gondwana had a profound effect on global climates and consequently on the evolution of all subsequent life forms (Kemp 1978). When Australia was still attached to Antarctica, warm equatorial currents reaching polewards ensured a generally more equably wet and warm climate. The detachment and northward drift of the Australian continent allowed the development of circumpolar currents. Temperature gradients between the equator and the poles increased dramatically and the Antarctic ice cap began to form. Forest types once mixed or closely juxtaposed now mostly became geographically separated and extensive regional extinctions of species occurred. However, the effects of global cooling and accompanying aridity were maximally compensated for in the Australian wet tropics region by the northward drift of Australia towards the tropics. As a consequence of this and a wide range of available altitudinal gradients, the Wet Tropics of Queensland is the only large part of the entire Australasian region where rainforests have persisted continuously since Gondwanan times (Barlow & Hyland 1988), preserving in the living flora the closest modern-day counterpart of the Gondwanan forests (Christophel, Collinson 1992).

Several groups regarded as likely relicts or early descendents of the Gondwanan fauna at the time of the final break-up are represented in the Wet Tropics. [Note that the flora that fall into this category have been included in parts (c) or (d).]

Of Australia's four families of frogs, the Myobatrachidae and Hylidae are believed to have had Gondwanan origins (Duellman and Trueb 1986; Tyler 1989; Roberts and Watson 1993). Close relatives are found in South America. Fossils from both families are found in Oligo-Miocene deposits at Riversleigh in north-western Queensland.

Molecular studies suggest that the major generic-level splits in the Australian frog fauna are very old (Roberts and Maxson 1985). Among the oldest lineages are *Mixophyes* and *Taudactylus* (Heyer and Liem 1976).

Of the six species in the genus *Taudactylus*, one of the most primitive groups of frogs in Australia, two are restricted to the Wet Tropics. *T. rheophilus* had been recorded only from the Bellenden Ker Range, Lamb Range, Carbine Tableland and Thornton Peak, all recognised refugial areas but has suffered massive declines over its entire former range. Prior to 1988, *T. acutirostris* occurred in upland streams throughout the World Heritage Area. However, it has since suffered a dramatic decline in numbers and its status is considered critical (Ingram and McDonald 1993)[See below, Criterion (iv).]. The catastrophic amphibian declines that have occurred in the Wet Tropics have recently been attributed to an amphibian fungal disease caused by *Batrachochytrium dendrobatidis. Mixophyes* is represented in the Wet Tropics by *M. schevilli*, the Northern Barred Frog. Molecular studies have shown *M shevilli* to represent three species, each well differentiated (Donnellan *et al.* 1993).

Among the Australian reptile fauna, the geckoes of the subfamily Diplodactylinae and the endemic family of legless lizards (Pygopodidae) are generally accepted as having Gondwanan origins. Within the Wet

Tropics, the diplodactyline geckoes are represented by *Carphodactylus*, *Diplodactylus*, *Nephrurus*, *Oedura*, *Phyllurus* and *Saltuarius. Carphodactylus laevis*, the Chameleon Gecko, is the only member of the genus and is restricted to the Wet Tropics.

Fossils from the Riversleigh deposits show that dragons were present in Australia at least 15–20 million years ago (Covacevich *et al.* 1990). Australian dragons form two groups, one adapted to more mesic environments on the eastern coast and including *Hypsilurus* and *Physignathus*, and the other adapted to drier conditions including arid inland environments. Molecular studies suggest that the split between these two groups probably occurred between 15 and 20 million years ago with Australian *Hypsilurus* and *Physignathus* diverging at about the same time (Baverstock and Donnellan 1990). The fossil evidence shows that extant *P. lesueurii* has changed little from forms living in the rainforests of the Riversleigh area about 20 million years ago (Covacevich *et al.* 1990). *P. lesueurii*, the Eastern Water Dragon, occurs along the eastern Australian coast and is recorded from many locations in the Wet Tropics.

Hypsilurus, of which Australian species were formerly considered to belong to the predominantly Asian genus, *Gonocephalus*, and *Physignathus* are among the Australian dragons considered to have had an Asian origin. However, immunological studies of plasma albumin suggest that Australasian *Hypsilurus* are more closely related to other Australian dragons than to Asian *Gonocephalus* (Baverstock and Donnellan 1990). When considered together with the evidence from Riversleigh fossils, these data provide support for an Australian origin for *Hypsilurus* and *Physignathus* from a Gondwanan ancestor. There are just two species of *Hypsilurus* in Australia: Boyd's Forest Dragon, *H. boydii*, is confined to the Wet Tropics and the Southern Angle-headed Dragon, *H. spinipes*, is endemic to the rainforests of the central Australian coastal region. Other species occur in New Guinea, Moluccas and Solomon Islands.

Australian skinks fall into three groups, the *Sphenomorphus* group, *Egernia* group and *Eugongylus* group. All three groups are represented in the Oligo-Miocene fossil fauna of Riversleigh, and some taxa are practically indistinguishable from living forms (Hutchinson 1992). The Riversleigh fossils indicate that the Australian skink fauna has arisen from evolution within Australia rather from a series of invasions as has been previously proposed. The fossil evidence, together with that from serum albumin studies (Baverstock and Donnellan 1990), suggests that the three major groups of skinks arose in the early Tertiary, around 60 million years ago. The *Egernia* and *Eugongylus* groups, which are almost entirely confined to the Australian region, may have arisen in Australian Gondwana (Hutchinson and Donnellan 1993). Hutchinson (1992) has compared the Riversleigh skink fauna with those of the rainforests of north-eastern and south-eastern Queensland. All three faunas are dominated by the *Sphenomorphus* group with the *Egernia* group present as a minor component. Of interest is the presence of the slender *Sphenomorphus* type at Riversleigh. Living members of this type have been placed in the genus *Glaphyromorphus* and, with one exception, they are confined to northern coastal Australia. Seven of the fourteen species occur in the Wet Tropics region and two species, *G. fuscicaudis* and *G. mjobergi*, are endemic to the World Heritage area. The similarity of the Riversleigh fossil of this type with *G. mjobergi* has been noted (Hutchinson 1992).

Of the birds occurring in the rainforests of the Wet Tropics, those with accepted Gondwanan origins include the Southern Cassowary (one of the world's few surviving giant flightless birds, the ratites) and the megapodes (mound-builders). Fossil records show that cassowaries were once much more widespread across Australia, but they are now restricted to north-east Australia and New Guinea. Of the three megapodes in Australia, two are found in the rainforests of the Wet Tropics - the Orange-footed Scrubfowl (*Megapodius reinwardt*) and the Australian Brush-turkey (*Alectura lathami*).

Songbirds of the Wet Tropics belonging to groups of likely Gondwanan origin are considered under (f) below.

Many primitive insects have been conserved in the Wet Tropics as relicts of the Gondwanan fauna, mainly in the upland areas. The moss bug, *Hackeriella taylori*, belongs to a small family found only in eastern Australia, New Zealand, New Caledonia and South America. The wingless water bug, *Austrovelia queenslandica*, is known only from Mt Sorrow–Mt Pieter Botte. The only other species in the genus is in

New Caledonia (Malipatil and Monteith 1983). The relict wingless genus of bark bugs, *Kumaressa*, which belongs to the small primitive subfamily Chinamyersiinae, is confined to Australia. *K. storeyi* occurs on Mt Bellenden Ker, Mt Bartle Frere and Mt Carbine Tableland. Two other species occur in the rainforests of central eastern Australia. The nearest relatives are in New Zealand. An ancient origin for the large stag beetle, *Sphaenognathus queenslandicus*, found only on Mt Lewis and Mt Windsor Tableland, is indicated by the occurrence of its closest relatives in South America. The flightless leafhopper genus, *Myerslopella*, known only from a few mountaintops in the Wet Tropics, belongs to a tribe otherwise known only from Madagascar, New Zealand and Juan Fernandez (Evans 1977). The small cockroach genus, *Tryonicus*, is represented in the Wet Tropics by the endemic species, *T. mackerrasae* and *T. montheithi*. *T. parvus* is found in the central eastern rainforests of Australia and the only other members of the genus are in New Caledonia.

The present-day distribution of most of these insects suggest their origins pre-date the separation of Australia and New Caledonia and New Zealand about 80 million years ago.

Even more ancient origins are indicated for a water beetle, *Terradessus caecus*, found only on Mt Sorrow and Thornton Peak and adapted for a terrestrial life (Watts 1982). The only other recorded occurrences of similarly adapted water beetles are in the highland forests of the Southern Himalayas and in the montane moss forests of New Caledonia (Brancucci 1985).

The presence of these ancient, relict insect taxa demonstrates the great antiquity of uninterrupted rainforest habitat in the Wet Tropics (Kikkawa *et al.* 1981).

The spider fauna of the Wet Tropics also includes many relict Gondwanan taxa. Australian spiders belong to two infra-orders, the Mygalomorphae ('trapdoor' spiders) and Araneomorphae ('true' spiders). Apart from one group now restricted to southeast Asia, the mygalomorphs are considered to be the most ancient and primitive group of spiders (Platnick and Sedgwick 1984). Of the 55 or so genera of 'trapdoor' spiders in Australia, more than 35 inhabit rainforest. Seventeen are recorded from the Wet Tropics. They include *Sason, Trittame, Cethegus, Masteria, Namirea, Cataxia, Homogona, Aname, Ixamatus, Namea, Xamiatus, Idioctis, Idiommata, Zophorame* and the newly described genera (Raven 1994), *Mandjelia, Moruga* and *Ozicrypta*.

Among the most primitive of the 'true' spiders (Araneomorphae) are members of the family Gradungulidae that is known only from New Zealand and Australia (Forster *et al.* 1987). The nearest relatives occur in South America. Of the twelve species in the family, three are restricted to the Wet Tropics. *Tarlina daviesae* is known only from Mt Finnigan at more than 1000 metres. *T. simipes* has been found at a few elevated sites between Cairns and Ravenshoe. The monotypic *Macrogradungula* is known only from Boulder Creek on the Walter Hill Range (*M. moonya*).

Another relict genus of 'true' spiders of likely Gondwanan origin is *Otira*. Six species occur in New Zealand, one in Tasmania and two (*O. summa* and *O. aquilonaria*) are recorded only from Bellenden Ker Range above 1000 m altitude (Davies 1986).

The Wet Tropics land snail fauna contains remarkably high numbers of the Gondwanan family Charopidae which occurs in south-eastern Australia, New Zealand and some subantarctic islands (Stanisic 1990). There are 86 species in the Wet Tropics (77 are undescribed), mainly in the cool uplands and especially on the mountain tops (Stanisic 1994). The refugial role of upland sites in the Property is indicated by a number of major disjunctions among relict taxa. The genus *Lenwebbia* contains just two species, one from the Bulburin area in south-eastern Queensland and the recently described *L. paluma* known only from the type locality in Mt Spec National Park in the Wet Tropics. Of the three species in the genus *Hedleyoconcha, H. ailaketoae* is recorded from Mt Bellenden Ker, while *H. delta* occurs at a number of sites from the central New South Wales coast to the Bunya Mountains and *H. addita* is found only on Lord Howe Island (Stanisic 1990).

(e) Biological evolution and radiation during 35 million years of isolated rafting of the Australian continental plate

Australia was an isolated landmass during several million critical years when the extant flora was being shaped (Truswell 1993). Climate change was a major influencing factor. After separation of the Australian landmass from Antarctica and during its isolated drift towards the equator, there was a general increase in aridity. At this time, major evolutionary radiations took place within the flora, particularly in the plant families Proteaceae, Myrtaceae, Casuarinaceae, Epacridaceae and Rutaceae, and within the marsupials. The wet tropics region contains the highest concentration of the surviving remnants of the ancestral stock from which evolved the sclerophyll flora and marsupial fauna that now dominate the Australian landscape. The rainforests of the region also contain a number of bird species that may represent the ancestral forms from which certain dry-adapted taxa have evolved (the Tumbunan avifauna)(Schodde 1982). [The passerine avifauna is considered in Section (f).]

Whilst sclerophylly *per se* originated from rainforest stock during the early Tertiary as an adaptation to infertile soils (Barlow 1981) evolution of features related to aridity and fire did not appear in the fossil record until the Middle to Late Miocene (Martin 1994).

Primitive genera of the Proteaceae, the remnants of ancient Gondwanan origins, are found in the Wet Tropics. In this family that now comprises a very important component of Australia's sclerophyll flora, ~~12~~ seven of the genera are restricted to the wet tropics. At least three of these, *Placospermum, Sphalmium* and *Carnarvonia* are considered primitive. *Placospermum coriaceum* has the greatest array of primitive features of any living Proteaceous genus.

The important Casuarinaceae family that has its centre of diversity in Australia occupies habitats ranging from beaches to arid regions, with one genus occurring in rainforest. Fossil evidence indicates that the ancestral form was the East Gondwanan rainforest genus *Gymnostoma*, which was widespread in Australia during the early Tertiary (Hill 1987). *Gymnostoma* now has a relict distribution in Australia with just one species that is restricted to the Roaring Meg–Alexandra and Noah Creek valleys in the Wet Tropics. The earliest evidence of sclerophyll communities involving Casuarinaceae date from the Early–Middle Miocene (Macphail *et al.* 1994).

Most of the primitive members of the large Rutaceae family (150 genera, 1800 species) occur in rainforests (Stace *et al.* 1993). The family is considered to have originated in Gondwana (Armstrong 1983) before the Tertiary (Smith-White 1954, 1959). The Tribe Zanthoxyleae of the Rutaceae family is considered to have given rise to the Tribe Boronieae, a long isolated group of 20 genera occurring in Australia and New Caledonia (Waterman and Grundon 1983). There are 245 Australian species in the Boronieae which now so characterise this continent's sclerophyllous heathlands (Morley and Toelken 1983). Five species of the small genus *Euodia* together with the endemic genus *Medicosma* (5 species) occurring in the Wet Tropics from within the Zanthoxyleae Tribe have close~~st~~ affinities to the ancestors of *Boronia* the largest and most widespread genus in the tribe Boronieae all 15 members of which have radiated out into open forest and heathland communities around Australia (Waterman and Grundon 1983, Stace *et al.* 1993).

The most primitive of the Australian marsupials are the dasyuroids, a basically carnivorous group that, probably, are preceded in the evolutionary history of the marsupials only by the didelphoids of South America. Immunological studies of abumins suggest that this group diverged from the diprotodont marsupials about 40 million years ago (Baverstock *et al.* 1990). Nine species of dasyuroids are found in the Wet Tropics including one restricted species, the Atherton Antechinus (*Antechinus godmani*), which is considered a relict species (Van Dyck 1982).

It has been proposed that the earliest marsupials evolved in ‘rainforests’ on the basis that extant rainforest-dependent species are among the most primitive of their respective groups (Schodde and Calaby 1972). This is now generally accepted and the Oligo-Miocene rainforests have been described as the “Green Cradle” for Australia’s dry-adapted marsupials (Archer *et al.* 1989). The Riversleigh deposits

are rich in marsupial fossils including taxa closely related to those living in the rainforests of the Wet Tropics. Indeed, the rainforests of the Wet Tropics represent the best surviving equivalent of the Oligo-Miocene rainforests of Riversleigh. They share several mammalian genera with the Oligo-Miocene Upper Site of Riversleigh, including *Hypsiprymnodon*, *Cercatetus*, *Pseudochirops* and *Trichosurus* (Archer *et al.* 1989).

The Musky Rat-kangaroo, *Hypsiprymnodon moschatus*, which is restricted to the World Heritage Area, is the most primitive of the kangaroos and the only living member of the group that has retained the mobile first toe on the hind foot, a characteristic of possums. It is unique in representing an early stage of evolution of macropods from an arboreal possum-like stock (Johnson and Strahan 1982).

The Wet Tropics area is particularly significant for the ringtail possums. Of the six species in Australia, five occur in the Wet Tropics World Heritage Area and the four rainforest-dependent species are all found only there. The Lemuroid Ringtail, *Hemibelideus lemuroides*, the only member of the genus, forms a single lineage with the Greater Glider, *Petauroides volans*, sharing a common ancestor with the remainder of the ringtails, *Pseudocheirus* and *Pseudochirops* species (Baverstock *et al.* 1990).

Birds confined to upland forests of eastern Australia and New Guinea (the Tumbunan fauna) are considered to include forms ancestral to dry-adapted species. Such ancestral forms occurring in the Wet Tropics include the Southern Cassowary, Australian Brush-turkey, Emerald Dove and Australian King-Parrot (Schodde 1982).

(f) The origin and radiation of the songbirds (oscine passerines)

On the basis of protein electrophoretic studies, Christidis and Schodde (1991) speculate that the passerines may have originated in Gondwana where the order diverged in two major radiations, the suboscines in west Gondwana (South America) and the oscines in east Gondwana (Australasia).

DNA–DNA hybridisation studies by researchers at Yale University have led to a new classification that divides the oscine passerines into two major groups (parvorders), Corvida and Passerida. The studies suggest that the two groups diverged about 60 million years ago, when Australia was still part of Gondwana, and that the Corvida probably originated in that part of Gondwana that is now Australia (Sibley and Ahlquist 1985). As discussed earlier, the vegetation of Australasian Gondwana was then dominated by rainforest.

The Corvida includes 40 per cent of the world's songbird families. Most of the living members are confined to Australia and New Guinea. However, groups such as crows, jays, shrikes and cuckoo-shrikes have radiated to Eurasia and the Americas.

The Wet Tropics of Queensland is the most important area for several lineages of Australo-Papuan songbirds, eg the bowerbirds and the scrubwrens, thornbills and gerygones.

Bowerbirds, which are confined to Australia and New Guinea, are the only birds known to decorate their courting grounds (Slater 1974). There are about twenty species of bowerbirds, eight of which are endemic to Australia, ten to New Guinea and two shared. Five species are found in the Wet Tropics giving the region the highest diversity for the bowerbirds of any area in Australia. Two species, the Golden Bowerbird (*Prionodura newtoniana*) and Tooth-billed Bowerbird (*Ailuroedus dentirostris*), are endemic to higher altitude areas in the Wet Tropics. *Ailuroedus* may be the most ancient genus; the DNA-DNA hybridisation data suggest that *Ailuroedus* diverged from *Ptilonorhynchus* and *Chlamydia* more than 20 million years ago, although no data was provided for the other genera (Sibley and Ahlquist 1985).

The scrubwrens, mouse-warblers, gerygones and thornbills have generally been placed in the family Acanthizidae, but Sibley and Moore (1990) place them in the Pardalotidae (subfamily Acanthizinae). There are about 60 species, most being confined to Australia. Kikkawa (1991) lists 16 species as inhabiting closed forests. Ten of these occur in the Wet Tropics which is more than twice the number

found in any other area in Australia. Three are endemic to uplands of the Property: the Fernwren (*Oreoscopus gutteralis*), Atherton Scrubwren (*Sericornis keri*) and Mountain Thornbill (*Acanthiza katherina*).

A likely relict species endemic to the Wet Tropics is the Chowchilla or Northern Logrunner, *Orthonyx spaldingii*. The only other species in the genus, *O. temminckii*, is found only in the rainforests of Central Eastern Australia and the highlands of New Guinea. On the basis of DNA-DNA hybridisation studies, *Orthonyx* has been placed in a separate family (Sibley and Ahlquist 1990, Sibley and Monroe 1990). Fossils of *Orthonyx* have been found in late Oligocene deposits (~25 million years) at Riversleigh in north-west Queensland (Boles 1993).

The Wet Tropics of Queensland is also of major importance in understanding the origins of the diverse bird fauna of New Guinea. Many genera are shared between the two areas. In at least some cases, this would appear to be the result of relatively ancient connections. One example is *Orthonyx* as discussed above. Another is the robin genus, *Heteromyias. H. cinereifrons* is endemic to the uplands of the Wet Tropics, whereas the only other species in the genus, *H. albispecularis*, is restricted to the highlands of New Guinea.

(g) The mixing of the continental biota of the Australian and Asian plates after 80 million years of separation

The Wet Tropics contains a unique record of a mixing of two continental floras and faunas that has no known parallel. This mixing occurred following the collision of the Australian and Asian continental plates about 15 million years ago. This collision was a unique event in that it mixed two evolutionary streams (both flora and fauna), in some cases of common origin, which had been largely separated for at least 80 million years. Whereas other continental collisions that led to a mixing of the biota have occurred, e.g., that of North and South America, none of those continents had such a long period of separation prior to collision.

Unlike New Guinea, parts of the Australian wet tropics represent a stable fragment of Gondwana in which rainforest has existed continuously and whose extant flora, together with fossil pollen deposits of unparalleled continuity and resolution, provide a unique record of the mixing of long separated floras. Genera considered to have been of Gondwanan or Laurasian descent but to have entered Australia following the collision of the Australian and Asian continental plates and occurring in the Wet Tropics include Alangium, Allophylus, Althoffia, Alyxia, Anthocephalus, Barringtonia, Berrya, Bombax, Bulbophyllum, Calophyllum, Canthium, Celtis, Cordia, Epipogium, Garcinia, Gardinia, Leea, Lethedon, Melia, Oreodendron, Phaleria, Securinega, Trema.

Among the fauna, two families of frogs provide outstanding examples of the impact on the biota of the collision of the Australian and Asian plates. These are the Microhylidae and Ranidae.

The microhylids occur in South America, Madagascar, southern Asia and New Guinea with just two genera occurring in Australia. Views are divided on the origins of the Australian microhylids. Savage (1973) proposed a Gondwanan origin with radiation in Australia and subsequent invasion of Asia via New Guinea, followed by extinction in Australia and a Pliocene reinvasion of northern Australia from New Guinea. Tyler (1979) proposed an Asian origin and entry into Australia via New Guinea. Australian microhylids are from two genera, *Cophixalus* and *Sphenophryne.* Not surprisingly, fifteen of the sixteen species are confined to north-eastern Australia with one species in the Northern Territory. Twelve species are endemic to the Wet Tropics region, although one (*C. mcdonaldi*) is restricted to Mt Elliott which lies just to the south of the World Heritage Area. All but one are rainforest species, the exception being *Cophixalus saxatilus* that lives among the boulder piles of the Black Trevethan Range.

The only Australian member of the cosmopolitan family Ranidae is *Rana daemeli* that is restricted to Cape York Peninsula and eastern Arnhem Land and occurs throughout lower altitude areas in the Wet Tropics.

Recent reassessments *of the origins of Australia's native birds suggest* that only a few groups (other than migratory birds) have entered from Asia. Those belonging to this category are the Yellow-bellied Sunbird, Singing Bushlark, Mistletoe Bird, Metallic Starling, Silvereye, Pale White-eye, Yellow White-eye and White's Thrush (Schodde 1986; Schodde and Christidis 1987). With the exception of the Pale White-eye that occurs on islands of the Torres Strait, all are recorded from the Wet Tropics.

Of the Australian mammals, the rodents and bats are considered to have entered since connections with the Asian plate were established. Sixty per cent of Australia's bat species are found in the Wet Tropics. Several of the Australian rodent genera, including *Hydromys*, *Pogonomys*, *Uromys* and *Melomys*, have their centres of diversity in New Guinea and have entered Australia relatively recently. They represent a second wave of the "Old Endemics" among the rodents. *Melomys* has four species in Australia although one of these, found only on Bramble Cay in Torres Strait, may only be a variant of the Cape York Melomys that occurs only around the tip of Cape York Peninsula. The other two species occur in the Wet Tropics. *Pogonomys* and *Uromys* have only one and two species respectively in Australia. The Giant White-tailed Rat, *U. caudimaculatus*, occurs on the eastern side of Cape York Peninsula including the Wet Tropics. The Prehensile-tailed Rat, *P. mollipilosis*, occurs as two disjunct populations, one in the Iron Range area on Cape York Peninsula and the other in the Wet Tropics.

(h) The extreme effects of the Pleistocene glacial periods on tropical rainforest vegetation

Even though marked changes in global climates had occurred during the Tertiary, it was not until about 2.5 million years ago, that a series of dramatic changes of climate, the Pleistocene ice ages, began, which changed the face of the earth, causing extinctions, speciations and profound distributions of plants and animals (Livingstone and van der Hammen 1978). Fossil-based data from Southern Hemisphere continents suggest that the effects of Pleistocene glacial periods were greatest in Australia (Kershaw 1984). Fossil pollen records going back over 200 000 years, of unparalleled continuity and resolution for this period, from three sites within the Wet Tropics region**,** Butcher's Creek, Lynch's Crater and Lake Euramoo, indicate that the rainforest underwent severe contractions during the Pleistocene glacial periods. Uniquely among tropical rainforest areas, there were many extinctions and near extinctions within the Wet Tropics (*Nothofagus* c.f. *brassii*, *Phyllocladus* spp., and *Dacrydium* spp. - all large, long-lived trees). Outstanding examples of ancient taxa that survived and persist as relicts within the Wet Tropics of Queensland World Heritage Area today include the Araucariaceae (5 species) and Podocarpaceae (7 species) and Casuarinaceae (1 species, *Gymnostoma*).

The peak of glaciation occurred at 18 000 BP, sea levels were at their lowest for the past 150 000 years (Kershaw 1989).

(2) Outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial ecosystems and communities of plants

Geological history involving the separation and drifting of continents, vulcanism, mountain building and erosion has profoundly influenced the evolutionary history of life on earth. The tropical rainforests, in particular, are one of the most significant biomes harbouring the majority of the earth's genetic diversity (Raven 1983, Walker 1986).

Processes resulting in areas of exceptional species richness or of high endemism are of outstanding scientific interest.

Much of the world's humid tropics is of 'recent origin', the newly expanding environments generating areas of exceptional species richness such as in the equably wet, lowland humid regions of peninsular Malaysia, New Guinea, the African Cameroons and the north-western and eastern foothills of the Andes (Ashton 1981). Endemism in these areas of species richness is surprisingly low.

However, the long-isolated ancient floras of New Caledonia, Madagascar and the Australian wet tropics have exceptionally high levels of endemism. These centres of endemism are not only historically important but also significant as diverse pools of unique genetic material retaining elements over the widest evolutionary time span and of potential significance in new radiations in a world of changing global climates and ongoing continental drift.

The Australian wet tropics centre of endemism is unique as part of an ancient continental as opposed to island landscape, uplifted more than 100 million years ago and tectonically stable for the greater part of the period of angiosperm evolution.

The level of endemicity within the rainforest flora of the Australian wet tropics (43 genera and 500 species 7 000 square kilometres of rainforest)(White 1983). The Australian wet tropics is second only to New Caledonia in the number of endemic genera conserved per unit area (Webb and Tracey 1981, Morat *et al.* 1986, 1993). The former suffered the greater degree of Pleistocene extinctions which was exacerbated by the Aboriginal use of fire (Kershaw 1984). Of the surviving endemic genera 75 per cent are monotypic and none contain more than a few species.

Many of the endemic species and genera are narrowly restricted within the Wet Tropics and several local centres of endemism have been identified (Keto 1986). All encompass altitudinal gradients within the most equably wet climatic zones allowing for mobility of refugia and survival of relict taxa during climatic fluctuations on geological time scales (Nix 1980).

The rapid and ongoing ecological, biological and geological processes occurring in the Australian wet tropics region have left many species restricted to upland areas and divided by altitudinal barriers into two or more disjunct allopatric populations. As allopatry is an important mechanism of speciation, these species may be regarded as potential examples of ongoing evolution.

Among the plants, genera best exhibiting allopatric (occupying different areas) speciation include Haplosticanthus, Pseuduvaria, Elaeocarpus, Ceratopetalum, Polyosma, Endiandra, Uromyrtus, Pilidiostigma, Buckinghamia, Orites, Stenocarpus, Sarcotoechia, Bubbia, Planchonella and Symplocos. Some outstanding examples of disjunctions that may eventually lead to new species are *Denhamia viridissima* (Mts Lewis, Bellenden Ker and Bartle Frere), *Elaeocarpus linsmithii* (Mts Lewis and Bartle Frere), *E. thelmae* (Alexandra Creek and Mt Windsor Tableland), *Trochocarpa bellendenkerensis* (Thornton Peak, Mts Bellenden Ker and Bartle Frere), *Glochidion pruinosum* (Thornton Peak and Mt Bellenden Ker), *Flindersia oppositifolia* (Thornton Peak and Mt Bellenden Ker), *Endiandra* sp. 'Boonjie' (Mt Lewis and the Boonjie area), *Litsea* sp. 'Mt Lewis' (Thornton Peak and Carbine Tableland), *Orites fragrans* (Thornton Peak, Mts Lewis, Bellenden Ker and Bartle Frere, and Boonjie), *Triuna montana* (Mts Spurgeon, Lewis, Bellenden Ker and Bartle Frere), *Wendlandia connata* (Mts Hemmant and Spurgeon), *W. urceolata* (Thornton Peak, Mts Spurgeon and Bartle Frere), *Bubbia queenslandica* subspecies *queenslandica* (Noah Creek, Mts Spurgeon and Lewis) and *Symplocos ampulliformis* (Mt Hemmant, Mt Windsor Tableland and Mts Spurgeon and Lewis).

Several species of fauna restricted to the Wet Tropics also occur as two or more disjunct populations: the Mountain Mistfrog, *Litoria nyakalensis*, has been recorded from a number of localities between the McDowall Range and Kirrama Range, all at altitudes above about 400 metres; the Northern Tinkerfrog, *Taudactylus rheophilus*, occurs as four allopatric populations on Thornton Peak, Carbine Tableland, Lamb Range and Bellenden Ker Range, all at altitudes above 900 metres (*L. nyakalensis* and *T. rheophilus* were not found at any site during a survey in 1991–92.); the Lemuroid Ringtail Possum (*Hemibelideus lemuroides*) occurs on the Atherton Uplands and Mt Carbine Tableland and differences between these isolated populations have been noted (Trenerry and Werren 1993); Lumholtz's Tree-kangaroo (*Dendrolagus lumholtzi*) also occurs on the Atherton Uplands and at Mt Carbine Tableland; the Thornton Peak Melomys (*Melomys hadrourus*) occurs at Thornton Peak and Mt Carbine Tableland.

Species with disjunct populations outside the wet tropics similarly have potential for allopatric speciation. There are numerous examples among the plants including , *Maytenus bilocularis, Cassia marksiana,*

Pseudoweinmannia lachnocarpa, Pollia crispata, Dysoxylum fraseranum, Premna lignum-vitae, Ixora beckleri, Euodia micrococca, Ripogonum discolor, R. elseyanum and Phaleria chermsideana. Among the animals the following species occur in the Wet Tropics as populations isolated by ecological barriers and many of which are recognised as subspecies:

- Brown Antechinus (*Antechinus stuartii adustus*)
- Yellow-footed Antechinus (*Antechinus flavipes rubeculus*)
- Common Dunnart (*Sminthopsis murina tatei*)
- Red-cheeked Dunnart (*Sminthopsis virginiae virginiae*)
- White-footed Dunnart (*Sminthopsis leucopus*)
- Spotted-tailed Quoll (*Dasyrurus maculatus gracilis*)
- Koala (*Phascolarctus cinereus adustus*)
- Fluffy Glider (*Petaurus australis reginae*)
- Long-tailed Pygmy-possum (*Cercatetus caudatus macrurus*)
- Red-legged Pademelon (*Thylogale stigmata*)
- Little Cave Bat [*Vespadelus* (*Eptesicus*) *pumilus*]
- Golden-tipped Bat (*Kerivoula papuensis*)
- Bush Rat (*Rattus fuscipes coracius*)
- Cape York Rat (*Rattus leucopus cooktownensis*)
- Swamp Rat (*Rattus lutreolus lacus*)
- Australian King Parrot (*Alisterus scapularis minor*)
- Double-eyed Fig-Parrot (*Cyclopsitta diophthalma macleayana*)
- Pale-yellow Robin (*Tregellasia capito nana*)
- Yellow-breasted Boatbill (*Machaerirhynchus flaviventer secundus*)
- Brown Gerygone (*Gerygone mouki mouki*)
- Grey Fantail (*Rhipidura fuliginosa frerei*)
- Eastern Whipbird (*Psophodes olivaceus lateralis*)
- Spotted Catbird (*Ailuroedus melanotis maculosus*)
- Satin Bowerbird (*Ptilonorhynchus violaceus minor*)

Recent studies have shown a surprising level of genetic diversity within the Prickly Forest Skink, *Gnypetoscincus queenslandiae*. The studies were directed at determining the level of variation within mitochondrial DNA and a range of enzymes from specimens collected at seven different sites throughout the species range of 275 kilometres. The results show a major genetic break, clearly separating it into northern (Cape Tribulation to Mt Lewis) and southern (Mt Bartle Frere to Mt Sullivan) populations (Moritz *et al*. 1993). The authors conclude that the northern and southern populations "appear to represent very distinct evolutionary lineages that should be considered separately in any analyses of ecology, biogeography and conservation status". The magnitude of the genetic difference between the two populations is of such an order that geographic separation probably occurred more than 5 million years ago (Moritz *et al.* 1993). There is every reason from a management point of view to consider the two populations as separate species.

Also conserved in Wet Tropics are communities of forests considered to be early segregates from rainforests. The Tall Open Forests on the drier western margins of the rainforest are significant as part of an evolutionary continuum of rainforest and sclerophyll forests. Eucalypts that now dominate the Australian landscape are considered to have evolved from rainforest stock and radiated into drier environments from the margins of closed forests (Gill *et al.* 1985). The first appearance of these wet sclerophyll forests in the fossil record was by the late Miocene (Truswell 1993).

Within the listed area, especially at the Cowley–Kurrimine Beach area and the mouth of the Murray River, active geological processes including coastline progradation have produced dynamic mosaics of rainforests, melaleuca and mangrove forests, and sandridge and swale communities. These complexes contain some of the oldest extant roots of an evolutionary continuum that originated from ancestral rainforests.

The Wet Tropics of Queensland includes variations in elevation above sea level and changes in topography and soil types and thus conserves the full diversity and complexity of the rainforest and associated communities present.

(3) *Superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance*

The Wet Tropics of Queensland World Heritage Area is one of the most significant regional ecosystems in the world. Despite its relatively small size, the exceptionally high genetic diversity and endemism make it a superlative example of tropical rainforest It has been described as a key to the origins and ancient habitats of primitive flowering plants; as a key to the processes of past climatic sifting of taxa and community types; and as a biological link with temperate and other tropical zones (Webb 1984).

Northern Australia has been postulated as a major centre of evolution of rainforest flora (Kershaw *et al.* 1984). The living history of this evolution is best conserved in the listed area.

Apart from the diverse tropical rainforests that present a complex array of life forms, there are outstanding features of natural beauty and magnificent sweeping landscapes.

Between the Daintree River and Cedar Bay there is exceptional coastal scenery that combines tropical rainforest, white sandy beaches and fringing reefs just offshore. Considering the extent of the fringing reef, adjacent as it is to a rainforested continental coastline, this rainforest–reef association is probably unique in the world.

Rugged mountain peaks and gorges are among the dominating superlative features of the landscape. The stark peak of Mt Pieter Botte with its massive granite outcrops provides extensive vistas of undisturbed forest and the valley of the magnificent Roaring Meg Creek which in its lower reaches descends rapidly through a series of spectacular waterfalls and cascades. The region between the Bellenden Ker Range and the Atherton Uplands including the Walter Hill Range contains superb gorge scenery with swiftly flowing rivers. The Russell, Mulgrave and Johnstone Rivers are wild rivers and have become popular with canoeists.

In this area of high rainfall and rugged topography, spectacular waterfalls abound. Wallaman Falls on Stony Creek, dropping 278 metres into a deep canyon, has the longest single drop of any waterfall in Australia.

The winding channels of the Hinchinbrook Channel contain the most extensive mangroves in the region, providing a rich visual mosaic of rainforest and mangroves. The view to the east from this part of the Wet Tropics is backed by the magnificent scenery of Hinchinbrook Island, part of the Great Barrier Reef World Heritage Area.

(4) *The most important and significant habitats for* **in situ** *conservation of biological diversity, including those containing threatened species of plants and animals of outstanding universal value from the point of view of science and conservation*

The Wet Tropics is a major centre of biological diversity and provides the only habitat for numerous threatened species. Although accounting for only 0.26 percent of the Australian continent, the Wet Tropics conserves much of Australia's biodiversity (**Table 2**).

Table 2. Importance of the Wet Tropics to Australia's biodiversity

Taxonomic group	Percentage of Australia's total
Plants	
fern species	65
cycad species	21
conifer species	37
orchid species	30
vascular plant species	26
Animals	
mammal species including:	35
• marsupials	30
• bats	58
• rodents	25
bird species	40
frog species	29
reptile species	20
freshwater fish species	42
butterfly species	58
dung beetle species	42
barkbug species	46
weta species	50

Plant diversity

Within the Property there are over 2800 recorded species of vascular plants (**Table 3**), representing at least 1037 genera and 221 families. The outstanding significance of the Property is that it contains many taxa representing long, distinct lineages preserving a greater degree of evolutionary heritage than places with a similar number of species but containing a succession of closely allied forms. This is reflected in the very high plant diversity at the higher taxonomic levels such as numbers of plant genera and families represented in the Wet Tropics. Seventy-five genera are endemic to Australia and 43 are restricted to the Wet Tropics. Over 700 species are restricted to the Property.

Table 3. Plant diversity recorded within the Property

Class	**Number**		
	families	**genera**	**species**
Fork ferns	2	2	4
Tassel ferns	2	4	12
True ferns	29	86	251
Cycads	3	3	8
Conifers	3	6	15
Monocots	42	220	541
Dicots	140	716	2014
Total	221	1037	2845

Of the 19 angiosperm families described as the most primitive (Takhtajan 1969), 12 occur in the Wet Tropics, giving it the highest concentration of primitive plant families on earth (**Table 4**). Several of these (eg. Austrobaileyaceae, Eupomatiaceae, Idiospermaceae and Himantandraceae) are now small, relict and virtually extinct families. Two of these, the monospecific Austrobaileyaceae and Idiospermaceae are restricted Wet Tropics endemic families. The ditypic Eupomatiaceae and Himantandraceae extend outside of Australia, only to New Guinea and East Malesia respectively. These relict primitive families represent the last few remnants of an ancient assemblage that have survived the attrition of rainforest during the extreme climatic fluctuations of the past.

Table 4. Primitive angiosperm families found in the Wet Tropics.

Family	Number present in Wet Tropics genera	species	Number present worldwide[1] genera	species
Magnoliales				
• Annonaceae	12	30	130	2300
• Austrobaileyaceae	1	1	1	1
• Eupomatiaceae	1	2	1	2
• Himantandraceae	1	1	1	1
• Myristicaceae	1	2	15	300
• Winteraceae	2	7	9	100
Laurales				
• Hernandiaceae (including Gyrocarpaceae)	2	2	4	60
• Idiospermaceae	1	1	1	1
• Lauraceae	8	83	50	3000
• Monimiaceae (including Atherospermataceae)	14	27	30	450

[1]Hyland & Whiffen (1993)

Endemism is particularly high in 33 angiosperm and six gymnosperm and fern families, most of which are old, primitive or relict and with a high proportion of species that are geographically rare. The majority of plants in the rainforests of the Wet Tropics have a restricted distribution either as isolated or disjunct populations. High concentrations of monotypic genera reflecting the refugial nature of the rainforests are found at several locations. Of the 49 monotypic genera in the Property (represented by a single surviving species), 19 are considered rare.

Animal diversity

Although the Wet Tropics of Queensland World Heritage Area represents only about 0.1 per cent of the land surface of the continent, it has a large and diverse share of the Australian continent's fauna (**Table 5**), including more rainforest dependent endemic vertebrates than any other area in Australia. Most of these endemics are confined to the cooler, upland rainforests and are considered to be relicts from formerly widespread temperate environments (Switzer 1991). At least 663 terrestrial vertebrate species have been recorded in the bioregion (DASETT, 1987; Williams *et al* 1996; Williams pers com) which represents 32% of Australia's terrestrial vertebrate fauna (**Table 5**). Of this total, 259 are rainforest species (**Table 6**). The wet sclerophyll forest that forms a narrow band on the western edge of the rainforest is very rich in vertebrate species with at least 227 species in only 72,000 ha. This high diversity (but low regional endemism) is due to this habitat being an overlap zone between rainforest and dry sclerophyll forests and woodlands. There are only five species of vertebrates that are confined to the wet sclerophyll forest in the Wet Tropics and of these only one is a regional endemic.

Within the Property occur 35 per cent of Australia's mammal species (including 30 per cent of the marsupial species, 58 per cent of the bat species and 25 per cent of the rodent species), 40 per cent of the bird species, 29 per cent of the frog species, 20 per cent of the reptile species, 42 per cent of the freshwater fish species and about 58 per cent of the butterfly species of Australia. There are at least 70 species of vertebrate animals unique to the Wet Tropics. In addition, there are numerous invertebrate species endemic to the Property. In terms of species diversity and endemicity, no area in Australia appears to have greater biological significance than the tropical rainforest of north Queensland (Switzer 1991, Williams *et al* 1996, WTMA 2001).

Table 5. Comparative Wet Tropics vertebrate diversity

Vertebrate Group	No. of Wet Tropics species	% of Australian total	No of endemic species	Level of regional endemism
Mammals	110	35%	13	12%
Birds	314	40%	13	4%
Reptiles	151	20%	27	21%
Frogs	58	28%	24	40%
Freshwater fish	80	42%	8	10%
Total	741	33%	85	11%
Terrestrial Total	663	32%	77	12%

Source: Williams *et al.* (1996), DASETT (1987), Pusey & Kennard (1994), EPA (1999), Williams unpublished data (2002), Burrows (2002)

A breakdown of the region's terrestrial vertebrate fauna by broad habitat preference and regional endemism is presented in **Table 6**. The apparent higher totals presented in this table compared to **Table 5** recognises the fact that some species utilise more than one broad habitat type. Although the dry sclerophyll forests contain the highest overall diversity of vertebrate species, there is low proportional regional endemism (4%). In contrast, the rainforest fauna includes 66 species that are found only in the Wet Tropics or 25% of the rainforest terrestrial vertebrate species are endemic to the region (Williams *et al* 1996).

Table 6. Number of Wet Tropics terrestrial faunal species by broad habitat preference.

	rain forest	wet sclerophyll	dry sclerophyll	grassland	rocky outcrops	caves	freshwater	mangroves
mammals	51	43	71	13	8	9	3	8
birds	112	107	174	48	3	-	73	63
reptiles	65	61	108	24	27	1	16	14
frogs	31	16	35	20	1	-	30	2
total	259	227	388	105	39	10	124	87
% regional endemism	25%	7%	4%	0%	21%	0%	4%	2%

Source: Williams *et al.* 1996.

Mammals

The mammal fauna includes 2 monotremes, 41 marsupials, 15 rodents and 36 bats. The Wet Tropics has a range of rainforest-specialist mammals, in contrast with south-eastern Australia where there are none, indicating a long continuous history of rainforest in the region (Winter 1988, 1991). Of the thirteen endemic species, only the Mahogany Glider and Tropical Bettong are not rainforest dependent. In addition to the endemic species, there are at least eight subspecies of mammals restricted to the area. Most of the rainforest-dependent endemics are restricted to the uplands and, as a consequence, they occur as a number of isolated populations (Winter 1991). One example is the Lemuroid Ringtail Possum that occurs only above 550 m with the larger population in the Atherton Uplands and a smaller population on Mt Carbine Tableland, the two being separated by the Black Mountain Corridor. The Mt Carbine Tableland population of the Lemuroid Ringtail Possum occurs only above about 1000 m and is characterised by a much higher proportion of pale-furred individuals ('white' lemuroids)(Trenerry and Werren 1993). The endemic species include one antechinus (Atherton Antechinus, *Antechinus godmani*), four ringtail possums (Lemuroid Ringtail Possum, *Hemibelideus lemuroides*; Green Ringtail Possum, *Pseudochirops archeri*; Herbert River Ringtail Possum, *Pseudocheirus herbertensis*; Daintree River Ringtail Possum, *P. cinereus*), one glider (Mahogany Glider, *Petaurus gracilis*), one rat-kangaroo (Musky Rat-kangaroo, *Hypsiprymnodon moschatus*), Australia's only two tree-kangaroos (Lumholtz's Tree-kangaroo, *Dendrolagus lumholtzi*; Bennett's Tree-kangaroo, *D. benettianus*), one bettong (Northern Bettong, *Bettongia tropica*) and one rodent (Masked white-tailed Rat, *Uromys hadrourus*). Only the tree-kangaroos, the musky rat-kangaroo and the long-tailed pigmy-possum are found from sea level to mountaintops.

Winter *et al.* (1984) defined two distinct sub-regions for the distribution of the endemic rainforest mammals of The Wet Tropics, the southern one centred on the Atherton Uplands and the northern one on

Thornton Peak, with Mt Carbine Tableland representing an overlap area. The Atherton Antechinus occurs only in the southern sub-region, as does the Herbert River Ringtail Possum, though the latter also has an isolated population on the Seaview Range towards the southern end of the World Heritage Area. The Daintree River Ringtail Possum occurs in the northern sub-region and on Mt Carbine and Mt Windsor Tablelands. The distributions of the two tree-kangaroos do not overlap. *Dendrolagus lumholtzi* occurs in the southern sub-region and on Mt Carbine Tableland, while *D. bennettianus* occurs in the northern sub-region and on Mt Windsor Tableland.

The Musky Rat-kangaroo is of particular interest. It is the smallest and, in many respects, the most primitive of the kangaroo group, and represents an early stage in the evolution of kangaroos from an arboreal possum-like stock.

The endangered Mahogany Glider (*Petaurus gracilis*) was rediscovered in 1989 after having been essentially forgotten for more than a century (Van Dyck 1993). It has been found only at a few localities in lowland woodland between Ingham and Tully. Over 80% of its habitat had been cleared for sugar cane, plantation pine, bananas and cattle. There are estimated to be only 2000 – 3000 Mahogany Gliders left in the wild (http://www.qmuseum.qld.gov.au/features/endangered/animals/mag_glider.asp)

The endangered Northern Bettong (*Bettongia tropica)* was once widely distributed in a range of tall and medium sclerophyll habitats in the uplands of the Wet Tropics region (Hilbert *et al* 2001) but are known to currently occur at only three locations: Mt Carbine Tableland (a very small, restricted and low density population), Lamb Range (including the Davies Creek, Emu Creek and Tinaroo sub-populations which are genetically distinct but geographically close)(Pope *et al* 2000) and Coane Range (a recently discovered small disjunct population in the southern section of the region. A total north-south spread of 340km.

In addition to the endemic species, there are at least eight subspecies of mammals restricted to the region (Werren 1993). These include the Yellow-footed Antechinus, *Antechinus flavipes rubeculus*, Brown Antechinus, *A. stuartii adustus*, Common Dunnart, *Sminthopsis murina tatei*, Godman's Rock-wallaby, *Petrogale godmani godmani*, Swamp Wallaby, *Wallabia bicolor mastersii*, Bush Rat, *Rattus fuscipes coracius*, Cape York Rat, *Rattus leucopus cooktownensis* and Swamp Rat, *Rattus lutreolus lacus.* In addition, a subspecies of the Long-tailed Pygmy-possum, *Cercartetus caudatus macrurus,* a tiny marsupial with a head and body length of about 10 cm, is restricted to the Wet Tropics with another subspecies occurring in New Guinea (Atherton and Haffenden 1991).

Diversity in the Australian bat fauna reaches its peak in The Wet Tropics (Richards 1991). At least 36 species have been recorded (Wiliams *et al* 1996), virtually all of which make use of rainforest for roosting or foraging or both (Richards 1991). Several species are considered endangered or vulnerable.

The White-footed Dunnart, Sminthopsis leucopus, which has been recorded from the Atherton Uplands, provides an outstanding example of disjunct occurrence. It is otherwise found only in south-eastern Australia and Tasmania.

Birds

The avifauna of the Wet Tropics is regarded as diverse. More than 314 species are either confined to, or have part or most of their range in the region (Williams *et al* 1996; Williams unpublished data 2002). Of these, more than 112 species principally inhabit rainforests in addition to other less rainforest-dependent species. Twenty-three species are either endemic to the region or have their Australian distributions largely confined to the region. Of the thirteen endemic species, nine are restricted to upland rainforests. These include the Tooth-billed Bowerbird (*Scenopoeetes dentirostris*), Golden Bowerbird (*Prionodura newtoniana*), Bridled Honeyeater (*Lichenostomus frenatus*), Fernwren (*Oreoscopus gutturalis*), Atherton Scrubwren (*Sericornis keri*), Mountain Thornbill (*Acanthiza katherina*), Grey-headed Robin (*Heteromyias albispecularis*), Northern Logrunner or Chowchilla (*Orthonyx spaldingii*) and Bower's

Shrike-thrush (*Colluricincla boweri*). All 13 endemic species have close relatives in the highlands of New Guinea.

Another four bird species that are restricted to the Wet Tropics but not confined to higher altitudes are the Lesser Sooty Owl (*Tyto multipunctata*), Macleay's Honeyeater (*Xanthotis macleayana*), Victoria's Riflebird (*Ptiloris victoriae*) and the Pied Monarch (*Arses kaupi*).

It has been noted that the number of bird species endemic to Wet Tropics belies the richness of the avifauna (Crome and Nix 1991). Many other species have most of their range within the Property and at least another ten birds have subspecies restricted to the Wet Tropics. These include the Australian King Parrot (*Alisterus scapularis minor*), Double-eyed Fig-Parrot (*Cyclopsitta diophthalma macleayana*), Pale-yellow Robin (*Tregellasia capito nana*), Yellow-breasted Boatbill (*Machaerirhynchus flaviventer secundus*), Grey Fantail (*Rhipidura fuliginosa frerei*), Eastern Whipbird (*Psophodes olivaceus lateralis*), Brown Gerygone (*Gerygone mouki mouki*), Spotted Catbird (*Ailuroedus melanotis maculosus*), Satin Bowerbird (*Ptilonorhynchus violaceus minor*) and Boobook Owl (*Ninox novaeseelandiae lurida*).

Included among the birds of the World Heritage Area is one of the largest birds in the world, the flightless *Casuarius casuarius johnsonii*, the Australian subspecies of the Southern Cassowary. Standing up to two metres in height, it is one of only three species of cassowary in the world, all of which occur in New Guinea. The majority of the Australian distribution is in the Wet Tropics with a lesser occurrence in Cape York Peninsula. The cassowary is an important 'keystone' species, being responsible for dispersal of many large-fruited rainforest plants (Crome and Moore 1988).

The Golden Bowerbird is the only Australian member of a small group of bowerbirds, otherwise restricted to New Guinea, that build 'maypole' bowers. The bower is based around two towers that may be up to three metres high and one metre apart with a display pole perched between them (Frith 1976).

Many of the birds of the Wet Tropics have close relatives in New Guinea. One such species is the Grey-headed Robin that is often considered to be conspecific with *Heteromyias* (*Poecilodryas*) *albispecularis*, the Ashy Robin of the central highlands of New Guinea (Sibley and Monroe 1990).

There are just two members of the logrunner family, Orthonychidae. *Orthonyx spaldingii* is restricted to the Wet Tropics while *O. temminckii* occurs in New Guinea and in central eastern Australia, the two sites being around 2500 kilometres apart. A similar pattern is seen in the case of the Lesser Sooty Owl, one of the Wet Tropics endemics, and the Sooty Owl (*Tyto tenebricosa*) that occurs in New Guinea and south-eastern Australia.

One species shared with New Guinea is the Buff-breasted Paradise-Kingfisher (*Tanysiptera sylvia*) that migrates in the wet season to breed in Australia, where it is largely restricted to the Wet Tropics and Cape York Peninsula.

Frogs

The Wet Tropics contains the most diverse rainforest frog assemblage in Australia with very levels of regional endemism (Covacevich and McDonald 1993). Upland areas between 600 and 1,000 metres are particularly important. There are 58 species of frog in the region, 24 of which are regional endemics. Twenty-one of the 31 rainforest dependent frogs are only found in the Wet Tropics (McDonald 1992).

All but two of the endemic species are rainforest-dependent; the exceptions are the Black Mountain Frog (*Cophixalus saxatilis)* and the Magnificent Brood Frog (*Pseudophryne covacevichae*). *Cophixalus saxatilis* inhabits the granite boulder areas of the Black Trevethan Range while *Pseudophryne covacevichae* has a very restricted distribution and is only found in seepage areas in eucalypt forest near Ravenshoe. Of the rainforest frogs found in the region, 76 per cent are endemic. Included among these are some very restricted species. One species of tree frog, *Litoria lorica*, has been recorded only from about 450 m altitude in the Thornton Peak area. One of the Narrow-mouthed Frogs, *Cophixalus neglectus*,

occurs only on the Bellenden Ker Range while *C. bombiens* is restricted to the Mt Windsor Tableland; *C. hosmeri* is restricted to the Carbine Tableland and *C. exiguus* to the Mt Finnigan area. Another rare frog *Taudactylus rheophilus* is found only on the Bellenden Ker Range, Lamb Range, Mt Carbine Tableland and Thornton Peak. Adding to the level of endemism, the myobatrachid frog *Mixophyes shevilli* has been shown to represent three species although the work has not yet been formally published.

Seven species of endemic, stream dwelling, rainforest dependent frog have suffered sudden, precipitous declines over their entire ranges in the last few years.

Reptiles

The Wet Tropics consists of a mixture of old endemics (Gondwanic) and recent invaders from New Guinea. There are about 151 species of reptiles within the Wet Tropics (Williams *et al* 1996; WTMA 2002). About 65 species of reptile have been recorded in rainforests. Of these, 29 are rainforest specialists of which 20 species are regional endemics, making the level of reptile endemism in the Wet Tropics the highest in Australian rainforests (Covacevich 1993). The skinks are a particularly diverse group within the Wet Tropics with sixteen locally endemic species (Covacevich & Couper, 1994).

Freshwater Fish

The Wet Tropics region has a greater diversity of freshwater fishes than any other in Australia (Trennery and Werren 1991). Of around 190 freshwater fish species in Australia, over 80 occur in streams of the Wet Tropics (Pusey 2001; WTMA 2002). To date, nine endemic species have been identified. The endemic species cover a wide range of taxa including: rainbowfish (*Cairnsichthys rhombosomoides, Melanotaenia eachamensis*), catfishes (*Tandanus* sp.), grunters (*Hephaestus tulliensis*), cod (*Guyu wujalwujalensis*), and gobies (Stiphodon allen, Glossogobius sp. and Schismatogobius sp.) Many species are yet to be formally described (Pusey 2001). The region contains two-thirds (48 genera) of the continent's fish genera and 25 (71%) of Australia's 35 freshwater fish families (Pusey & Kennard, 1994). This extraordinary diversity reflects the diversity of stream habitats and the highly variable but predictable seasonal flow rates.

Invertebrates

The Wet Tropics has the richest insect fauna in Australia (Monteith 1996). A transect of five sites along an altitudinal gradient on the Bellenden Ker Range found more than 4000 species (Monteith and Davies 1991). Of particular biogeographic interest is the fauna preserved in the upland rainforests of the Wet Tropics, where the climate is relatively cool and commonly moist. Many of the taxa occurring in these sites show links with southern hemisphere taxa that suggest Gondwanan origins. There are many primitive, relict species that are isolated from their nearest relatives by at least 1500 kilometres. One species, the large stag beetle, *Sphaenognathus queenslandicus*, which is found only on Mt Lewis and Mt Windsor Tableland, has its closest relatives in South America.

The highly diverse and numerous moth fauna of the Property includes many rainforest endemic species including the brilliantly coloured *Aenetus monabilis*, one of the largest moths with a wing span up to 18cm, and the very restricted *Douea xanthopygs* and *Polyeuta callimorpha* which are only known from several collections. The most spectacular of Australia's moths, the Hercules Moth (*Coscinocera hercules*), one of the largest moths in the world with a wing span up to 25 cm, occurs in the Wet Tropics and further north to Iron Range.

There are more than 230 species of butterflies recorded from the Wet Tropics, including many restricted species such as the evening flying Purple Brown Eye (*Chaetocneme porphyropis*) and the Australian Hedge Blue (*Udara tenella*). The Cairns Birdwing, *Troides priamus*, which occurs in the Wet Tropics, the mid-eastern coast of Queensland and on Cape York Peninsula, is the largest butterfly in Australia.

The insects show clearly a striking phenomenon of the montane biota of the Wet Tropics, namely, the restriction of many species to specific mountain massifs such that each mountaintop has its own unique

suite of species. Studies on the flightless carabid beetles have been particularly significant in identifying important mountain systems (Monteith 1994, 1996). The Bellenden Ker Range and the Mt Carbine Tableland have been identified as particularly significant (Monteith 1996).

The Wet Tropics is also an outstanding area for wetas or giant king crickets. Twenty-six species occur in the region which is half of the Australian total. Four of the nine genera found in the Wet Tropics, involving eight species, are endemic to the Property. All the known winged species, including the two most primitive in the world, occur in the Wet Tropics (Johns 1994).

The spider fauna of the Wet Tropics is also diverse. The transect of the Bellenden Ker Range referred to above found more than 300 species of spiders (Monteith and Davies 1991). The spiders show a similar distribution to that of the insects and other fauna with numerous species restricted to mountaintops. For example, species restricted to the Bellenden Ker Range include the 'trapdoor' spiders *Namea nebulosa*, *N. olympus* and *Ozicrypta wrightae*, a new species (and new genus) in the family Barychelidae (Raven 1994), and the 'true' spiders *Spinanapis ker*, *S. frere*, *Otira summa*, *O. aquilonaria*, *Manjala pallida*, *Bakala episinoides*, *Jacksonoides distinctus*, *Sondra variabilis*, *Tauala alveolatus*, *T. lepidus*, *Australomimetus andreae*, *Mimetus hannemanni*, *M. catulli* and *Tasmanoonops septentrionalis*.

Among the 'true' spiders of the Wet Tropics there are some particularly primitive species, including *Tarlia daviesae*, *T. simipes* and *Macrogradungula moonya*. Apart from some taxa in southeast Australia, the nearest relatives are in South America and New Zealand.

The invertebrate fauna of the freshwater streams of the Wet Tropics is not well known. Studies on crayfish show there are at least six species of crayfish restricted to cool, permanent streams above 800 m in the Property. *Eastacus fleckeri* is found only above 1000 m on Mt Carbine Tableland, *E. robertsi* above 1000 m on Mt Finnigan and Thornton Peak, *E. balanensis* on the Bellenden Ker Range and Lamb Range, and *E. yigara*, *Cherax parvus* and an undescribed species of *Macrobrachium* all in the upper Tully River on the Cardwell Range (Short and Davie 1993). Two Wet Tropics streams, Yuccabine Creek and Birthday Creek, have recorded the highest diversity of stream invertebrates in Australia (Pearson *et al* 1986) or anywhere on earth (Burrows 2002 citing R. Pearson pers. comm.).

Land snails form an extraordinarily diverse group within the fauna of the Wet Tropics. An analysis by the Queensland Museum identified 217 native species, of which 185 (85 per cent) are endemic to the region (Stanisic *et al.* 1994). More than half the species occur in the Atherton Uplands. Predictably, other centres of diversity include Mt Carbine Tableland and Thornton Peak, but also less predictably Malbon Thompson Range and Mt Bakers Blue.

Rare & threatened species

Many species in the Wet Tropics, particularly rainforest species, are naturally rare. Relative rarity is influenced by several factors that may influence a species total potential population size such as its geographic range, its local abundance, and its ubiquity of occurrence within its range. It is often the case that species with small geographic ranges also have low local abundance, and are often patchily distributed within their ranges. These characteristics, either independently or in combination, increase the potential for extinction and make such species sensitive to environmental change/disturbance.

In the tables that follow, the legal status of plants and animals are based on the lists contained within Queensland's wildlife legislation (*Nature Conservation (Wildlife) Regulation 1994*).

Rare & threatened plants

The Wet Tropics bioregion has a total of 351 officially listed rare or threatened plant species (**Table 7**, **Table 8**). Of the 29 recognised recent plant extinctions in Queensland, 17 were formally endemic to the Wet Tropics. The presumed extinct species, in general, have not been recorded for over 50 years. The high proportion of the State's presumed extinct, endangered and vulnerable plants coming from the Wet

Tropics highlights the vulnerability, small population size and restricted distribution of many of the bioregion's plants and the pattern and extent of past habitat clearing.

Table 7. Rare and threatened Wet Tropics plants[1].

Class	Extinct	Endangered	Vulnerable	Rare
Whisk ferns	1	0	0	0
Ferns	5	3	8	27
Club mosses	2	4	4	1
Cycads	0	0	1	0
Conifers	0	0	0	3
Dicots	6	19	29	170
Monocots	3	16	12	37
Total	*17*	*42*	*54*	*238*

[1]*Nature Conservation (Wildlife) Regulation 1994* (includes all amendments up to SL No. 354 of 2000)

Table 8. Percentage of total known Wet Tropics flora considered rare or threatened

Class	Threatened (X+E+V)	Rare or threatened (X+E+V+R)
fork ferns	25.0	25.0
tassel ferns	83.3	91.7
true ferns	6.4	17.1
cycads	12.5	12.5
conifers	0.0	20.0
monocots	5.7	12.6
dicots	2.7	11.1
Total	4.0	12.3

Included in the list are many rare and very restricted species belonging to the primitive angiosperm families referred to earlier in relation to The Age of the Angiosperms. These include *Idiospermum australiense* (Idiospermaceae), eight undescribed species of *Haplosticanthus* (Annonaceae), *Wilkiea wardelli* and *Tetrasynandra* sp. (Monimiaceae), *Endiandra anthropophagorum* and *E. microneura* (Lauraceae). There are also rare species within two undescribed genera in the Myrtaceae family, both with very restricted distributions. As noted earlier, the genera, *Barongia*, *Ristantia* and *Sphaerantia* may have considerable significance in relation to the evolution of sclerophyllous Myrtaceae taxa.

The list of rare and threatened species includes 16 monotypic genera restricted to the wet tropics. They are *Austromuellera trinervia*, *Baileyoxylon lanceolatum*, *Barongia lophandra, Crispiloba disperma*, *Hexaspora pubescens*, *Kuntheria pedunculata*, *Lenbrassia australiana*, *Mitrantia bilocularis*, Gen. nov. Q2, *Neostrearia fleckeri*, *Noahdendron nicholasii*, *Normanbya normanbyi*, *Oreodendron biflorum*, *Ostrearia australiana*, *Sphalmium racimosum* and *Whyanbeelia terraereginae*. Rare species in endemic ditypic genera include *Buckinghamia ferruginiflora*, *Darlingia ferruginea*, *Hypsophila halleyana*, *Peripentadenia mearsii*, *P. phelpsii*, *Sphaerantia chartacea* and *S. discolor*.

Within the Proteaceae there are several rare and very restricted species including *Alloxylon flammeum*, *Helicia blakei*, *H. recurva*, and undescribed species of *Carnarvonia*, *Orites* and two entirely new genera.

There are at least 70 species recorded only from the type locality and another 80 or so restricted endemic species for which current records indicate a north-south distribution of less than 25 kilometres.

Rare & threatened animals

The Wet Tropics has a total of 82 animal species officially listed as either rare or threatened. Endangered fauna include seven frog species, three marsupials, one bird and two butterflies (**Tables 9** & **10**). A further 16 vertebrate species are classified as vulnerable.

Table 9. Rare and threatened Wet Tropics animals[1].

Status	Mammals	Birds	Reptiles	Frogs	Fish	Butterflies	Total
Endangered	3	1	0	7	0	2	13
Vulnerable	6	7	3	0	0	2	18
Rare	16	9	15	11	0	0	51
Total	25	17	18	18	0	4	82

[1] *Nature Conservation (Wildlife) Regulation 1994* (including all amendments up to SL No. 354 of 2000), *EPA Wildnet (2001)*

Table 10. Percentage of total known Wet Tropics vertebrate fauna considered rare or threatened

Class	Threatened (X+E+V)	Rare or threatened (X+E+V+R)
Mammals	8.2	22.7
Birds	2.5	5.4
Reptiles	2.0	11.9
Frogs	12.1	29.3
Fish	0.0	0.0
Total	3.8	10.8

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