FLORA AND FAUNA SURVEYS OF THE WALCOTT RIVER THREATENED ECOLOGICAL COMMUNITY RAINFOREST SWAMPS

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Cover photograph

Eastern edge of the 19/2 Threatened Ecological Community Rainforest Swamp.

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SUMMARY

Flora and fauna surveys of two Threatened Ecological Community (TEC) rainforest swamps (19/2 and 21/4) adjacent the Walcott Inlet in the remote north-west Kimberley, were done in the early dry season of 2016. A third TEC (18/4) was rapidly assessed for plants and condition. Seven permanent monitoring quadrats were established at the two primary TECs, and formed the focus of the survey effort. The TEC's are situated on alluvial soils only a few meters higher than peak tide limit, and springs are presumably fed from local aquifers draining from the adjacent ridges of the Artesian and Edkins Ranges. Although centered on dense rainforest patches, each of the TEC boundaries contain a complex of habitats, including primary and secondary rainforest, reed swamps and interstitial woodland, driven on subtle relief differences. Boundaries between each habitat within the TEC are generally diffuse, and since they are all affected by the hydrogeological setting, and share a similar low fire frequency, the conjoined habitats are best considered a single complex Threatened Ecological Community.

The general condition of all sites was excellent. Only six weed species were detected, usually in low abundance except for *Triumfetta pentandra* on the margins of 21/4. Some extensive pig rooting was observed in parts of 21/4. Margins of most rainforests were partially burnt and recovering; this is likely to be part natural dynamics maintaining the rainforest. Fifteen mammal, 19 reptile, 5 frog, 54 bird, 157 plant and ca. 114 fungi species were recorded. Of note were the EPBC listed *Dasyurus hallucatus*, *Isoodon auratus*, and *Mesembriomys macrurus*, and the Kimberley-endemic *Wyulda squamicaudata* and *Zyzomys woodwardi*. Eight plant species with Priority conservation status were found at the 21/4 patch. The 21/4 patch is the only known Western Australian occurrence for two of these priority species. The other species are restricted to rainforest swamps or their margins. The first significant collections of fungi from TEC Rainforest Swamps suggests that they are unusually rich, and contain many species not (yet) found in surrounding savannas. The wax caps in the 19/2 rainforest swamps show signs of being especially diverse. No evidence of Myrtle Rust was observed on any Myrtaceae at any site.

Fire, feral animals, plant weeds, myrtle rust and saltwater intrusion from rising sea levels are the biggest and most immediate threats to these TECs. The rainforest patch 21/4 may be especially vulnerable to fire since it consists of several small pockets of rainforest and lacks any fire protection from geological features. Assessment of boundary changes and ongoing monitoring of the relationship between rainforest boundaries and fire frequency / intensity is needed. The small 21/4 rainforest patches bordered on all sides by woodland are especially vulnerable to high-intensity fires, and may require a targeted local burning regime when dynamics are better understood.

Continued control of feral animals is recommended to keep cattle damage to its current extremely low level. Increased control of pigs would be beneficial especially at 19/2. Weed management is mostly not necessary, with the possible exception of management of *Triumfetta pentandra* on the margins of 21/4. In the longer term, the TECs should be monitored for the presence of snakeweed (*Stachytarpheta species*), calotrop (*Calotropis* spp.), and gamba grass (*Andropogon gayanus*), which have the potential to be highly invasive in these habitats. Monitoring for Myrtle Rust should also be carried out, as it has potential to significantly damage some of the dominant tree species such as *Melaleuca* and *Syzygium*.

Additional survey effort to complete the plant inventories would also be beneficial, since several species from the original surveys were not relocated in the 2016 survey which focused on quadrat setup. The wax cap community, especially at 19/2, should be further explored to better understand the role of the swamp TECs in conserving fungal associations (e.g. through DNA barcoding of soil samples).

CONTENTS

BACKGROUND

The 'Assemblages of Walcott Inlet rainforest swamps' (Walcott rainforest swamps) were endorsed as a vulnerable threatened ecological community (TEC) by the WA Minister for the Environment on ??????8 May 2002. The community is distinguished in part by ?????. Other rainforest communities in the Kimberley are not centred on sub-coastal swamps and have different biotic assemblages.

There are three listed occurrences of the Walcott rainforest swamps, all on the southern border of the Walcott inlet, although at least one additional unsurveyed patch occurs just east of the mouth of the Isdell River. Walcott Inlet is a 60 km long inlet fed by three major rivers, the Calder, Charnley and Isdell, and lies about 150 km north east of Derby in the West Kimberley region of Western Australia.

Previous surveys of the listed occurrences of the Walcott rainforest swamps were carried out in 1987-1988 (McKenzie et al 1991). XXXMore detail on why the Walcott sites were recognised as unique

The three Walcott TEC's surveyed are all swamp-based rainforests on alluvial peat and sandy clays on the edge of the Walcott Inlet mudflats, situated below sandstone ridges, where the hydrology drives the formation of surface or subsurface shallow water table, that in turn has allowed formation of rainforest ecosystems.

OBJECTIVES

A survey of the three listed occurrences of the Walcott rainforest swamps was complete in June 2016 with Parks and Wildlife Staff, a consultant botanist, and consultant herpetologist and ???Dambimangari traditional owners. This work was part of a broader biodiversity survey program on and off the conservation estate, funded under the Kimberley Science Conservation Strategy. Surveys included terrestrial fauna, flora and vegetation. This report covers the surveys of the three occurrences of the north Kimberley mound springs TEC completed by between 1-13 June 2016.

The survey was completed to gather information as a basis for a more detailed description of the floristics and vegetation of the TEC. The information gathered was also used to provide recommendations about urgent management actions, will provide a basis for future monitoring, and will assist development of a recovery plan to guide future management in the longer term. The recovery plan will include descriptions of the substrate, floristics, vegetation structure, condition, threats, and recommendations for management.

Other work that has significant linkages to this survey of the rainforests swamps is XXXXXX

The results of these studies will have a significant influence on the content of the recovery plan for rainforest swamp TECs across the Kimberley.

METHODS

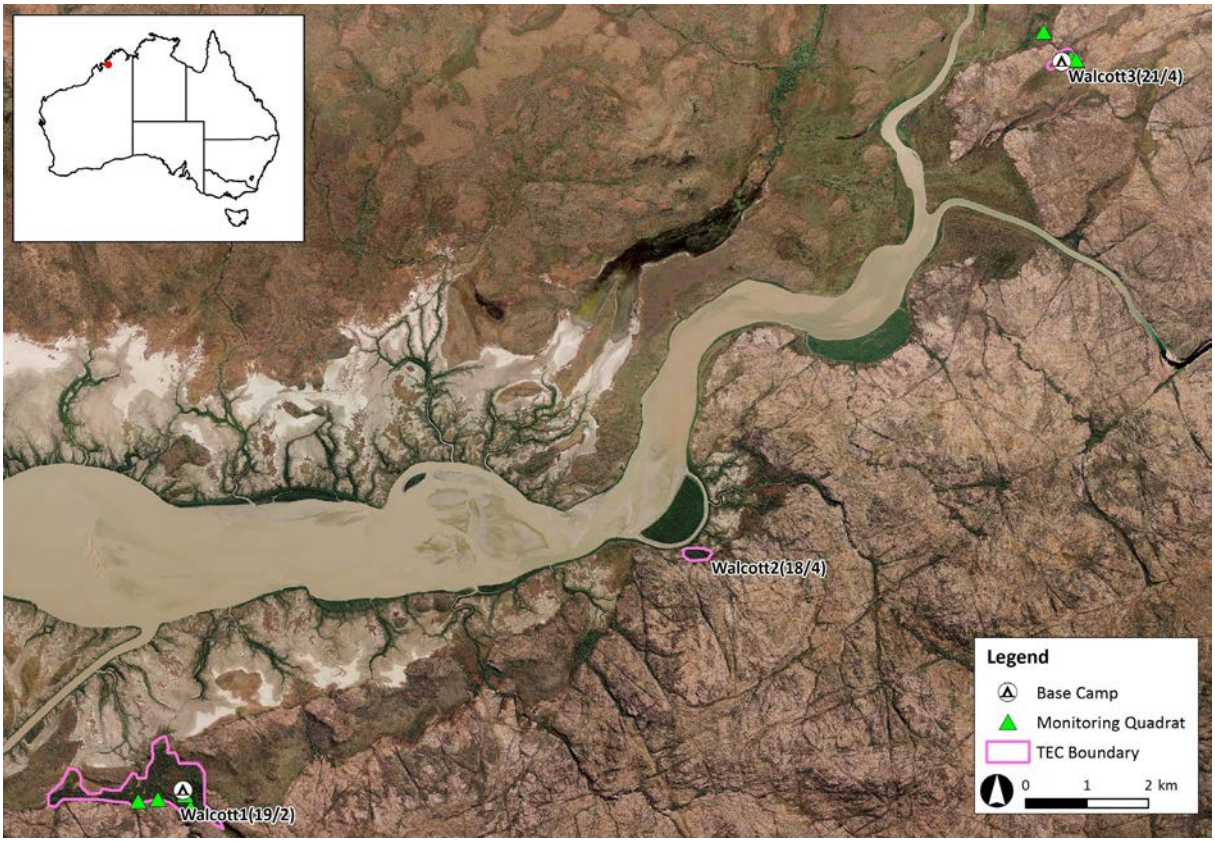


Fig. 2. Map of the Walcott inlet showing the three rainforest TEC's surveyed in 2016.

The following swamp rainforest TECs were surveyed:
19/2, 18/4, 21/4 (fig. 2).

Quadrat locations

- 19/2 (Walcott 1)
  - Four quadrats established:
    - Q1 – 50 x 50 m – woodland near camp
    - Q2 – 50 x 50 m – dense gallery rainforest in the core 19/2 site
    - Q3 – 50 x50 m – Melaleuca / open forest swamp
    - Q4 – 50 x 50 m – Rainforest
  - Flora list for vegetation of the rainforest / swamp complex.
- 18/4 (Walcott 2)
  - Brief two hour visit on 9/6/2016
  - Flora list for vegetation of the rainforest / swamp complex.
- 21/4 (Walcott 3)
  - Three quadrats established (all except 50 x 50 m) in core rainforest patches
    - Q1 – Gallery rainforest / burn
    - Q2 – Gallery rainforest on small creek [40 x 60 m]
    - Q3 – Low-lying alluvial swamp rainforest
  - Flora list for an additional small patch corresponding to the original 21/4 patch but not represented by a quadrat.
  - Flora list for vegetation of the total rainforest / swamp complex.

Table XX. Quadrat locations

Quadrats were permanently marked with at least one 1.6 m star picket. As such, they are suitable for future scoring and analysis of change, for monitoring purposes. A Threatened and Priority Ecological Community (TEC/PEC) Occurrence Report Form was completed for each quadrat.

The quadrat information for each site included:

- GPS location
- soil and landform
- comprehensive flora list
- vegetation structure
- vegetation condition
- threatening processes
- management recommendations

Vascular Plants and Fungi

Flora specimens were collected from the quadrats, and also from other areas of the TEC when species were found that were not represented in the quadrats. Note that a rigorously complete survey was done for each quadrat, but was not possible for the complete TEC areas due to limited time and focus on quadrats, so some additional species are to be expected in areas not visited. The flora specimens will be provided to the WA Herbarium for lodging where suitable. Data will be added to the corporate TEC/PEC database. Samples were also taken from flora collections for DNA analysis if needed at a later date. Incidental collections of fungi were also made when possible, although a complete inventory was not possible with the available resources. Significant collections of plants and fungi will be deposited at the Western Australian Herbarium at a later date, under the collection numbers between M.D. Barrett MDB 4995-5273 (not all numbers submitted).

The highly invasive Myrtle Rust (*Puccinia psidii*) is a serious pathogen of plants in the family Myrtaceae. Juvenile foliage of 50 plants of the dominant rainforest Myrtaceae, *Melaleuca* and *Syzygium*, were examined in or around each quadrat where present for signs of rust disease (blisters, pustules or rust).

Vertebrates

Terrestrial vertebrate survey methodology followed a widely used array of metal box (Elliot), pit-fall and funnel traps (e.g. Woinarksi 2010, Legge 2011; Radford et al. 2015). This consisted of a 0.25 ha quadrat (50 x 50 m), with 20 alternating large (10) and small (10) Elliot traps (baited with peanut butter and rolled oats) spaced at 10 m intervals around the perimeter, and one 20 m drift fence with four funnel traps (two on each end) and two 20 L buckets, placed in a suitable location within the quadrat. A single remote camera was placed within each quadrat, and baited with rolled oats and peanut butter. Traps were left open for five consecutive nights. Four of these quadrats were established at 19/2 and three at 21/4 (**Fig. 1, 2**). A line of 10 large Elliot traps (spaced at 10 m intervals) was also installed at 21/4, and additional cameras were placed at both patches (**Fig. 1, 2**). The extent of dense and sometimes impenetrable vegetation, as well as water that contained estuarine crocodiles dictated the location of 2016 survey sites.

Surveys (and their focus) in 2016 differed from those carried out in 1987–88 (**Table 1**). At patch 19/2, four quadrats (see above) were established to capture as much of the within-patch variation in habitat

types as possible, as opposed to the long transect that sampled the single habitat type in 1987–88 (**Fig. 1;** Friend et al. 1991). These quadrats corresponded with concurrent flora surveys (**see section X**) as well as TEC occurrence reports (**Appendix X**). These permanently established sites can be visited easily in the future for monitoring purposes. At patch 21/4 in 1987–88, no transects or quadrats were established; sampling was confined to opportunistic surveys of some taxa (e.g. Kendrick and Rolfe 1991). All previous surveys did not have access to remote cameras, but instead relied more heavily on spotlighting at night time (**Table 2**). Sampling effort also differed between the two surveys (**Table 2**).

Table 1. Survey focus of 1987–88 and 2016 Threatened Ecological Community rainforest swamp surveys.

Locality	Volant mammals	Non-volant mammals	Reptiles and amphibians	Birds	Flora	Fungi	Invertebrates
19/2							
1987–88	Yes	Yes	Yes	Yes	Yes	No	Yes
2016	No	Yes	Yes	Yes	Yes	Yes	No
21/4							
1987–88	No	No	Yes	Yes	Yes	No	Yes
2016	No	Yes	Yes	Yes	Yes	Yes	No

Table 2. Sampling effort of 1987–88 and 2016 Threatened Ecological Community rainforest swamp surveys.

Locality	Number of days/ nights surveyed	Elliot traps (number of trap nights)	Pitfall traps	Funnel traps	Spotlighting	Opportunistic surveys	Remote camera
19/2							
1987–88	8	Yes (560)	No	No	Yes	Yes	No
2016	5	Yes (400)	Yes	Yes	Minimal	Minimal	Yes
21/4							
1987–88	?	No	No	No	?	?	No
2016	5	Yes (350)	Yes	Yes	Yes	Yes	Yes

Limitations

The focus of the 2016 surveys was to establish quadrats and carry out vegetation and fauna surveys within them. Additional records of other species were collected only incidentally, and a complete inventory was not made. Consequently, the results of the 2016 survey are not directly comparable with the 1980s inventory surveys.

Limitations of frog surveys??? Spotlighting? Bats??

RESULTS

Walcott Rainforest Swamps

The TECs cover a series of vegetation communities that vary with hydrology from dense gallery rainforest to dense woodland with scattered rainforest elements, open savanna woodland, *Melaleuca* swamps, grassy swamps, and occasionally open water. The TECs are focused on swampy rainforests, but

incorporate associated swamp and woodland communities where their hydrology and fire dynamics was intimately associated with the rainforest. Although the boundary of the TECs was typically located at the junction with surrounding savanna woodlands, in the 19/2 site patches of woodland are incorporated in central areas, as the woodland is isolated by the marginal rainforests, swamps and mudflats, and has a fire frequency greatly reduced as a result of this isolation. Probably at least partly for this reason, many mammals were found to utilise this woodland, especially bandicoot, at a frequency much higher than expected for savannas in the West Kimberley. The reduced fire frequency in all communities had increased woody debris, leaf litter and soil carbon, and the Walcott TECs appeared to have a high diversity of saprophytic fungi as a result.

Vascular plants

A total of 157 vascular plant species were detected in the three Walcott Sites during the 2016 survey. This number is significantly higher than the 103 species reported in the 1980's rainforest surveys, due to inclusion of marginal rainforest and woodlands within the TEC area, that were excluded from the core rainforest areas in the original survey. A total of 24 species reported in the 1980's surveys were not found in the current survey, due to differences in focus between surveys. In the 1980's surveys the focus was on inventory of the complete patch, whereas the 2016 survey focused on creating and scoring quadrats for ongoing monitoring, so some areas of the TECs were not revisited.

The 50 x 50 m quadrats had between 23 and 74 species, with the richest quadrats those most heavily disturbed by fire, since those quadrats also exhibited encroachment of savannah species, and had rainforest margin species not present under the denser canopy. The total number of species recorded per TEC occurrence ranged from 50 at 18/4 to 117 at 21/4. In all cases more species were recorded per site in the current survey than in the previous Kimberley Rainforest Survey, partly due to the inclusion of all species in the current survey, while "non-rainforest" species were mostly (but somewhat inconsistently) excluded from the initial survey. Appendix 1 provides flora lists for the quadrats and total lists of species recorded for each of the TEC complexes.

Quadrat Vegetation Descriptions
(see Appendix 1 for full species lists)

TEC Walcott 1, Patch 19/2

Survey 1-8 June 2016

General notes on the 19/2 TEC:

The original rainforest patch 19/2 apparently only included the eastern part of what is now the TEC (although the plant species list likely includes at least a little broader area). The TEC boundary has been expanded to include several other rainforest patches in the immediate area, as well as other communities associated with the hydrological setting. The TEC occupies the area between the base of the sandstone ridge at the edge of the Artesian Range, and the saline-affected mudflats of the Walcott Inlet. The swamp communities present are driven hydrologically by two creeks flowing out of the ridge, with further swamps occupying additional shallow depressions that are likely old backwaters. Spring upwelling may provide additional water to some of the swamps. Depending on the water table depth and hydrology, there are dense swamp rainforests, *Melaleuca* swamps, *Phragmites* / *Mnesithea rottboelloides* dense tall grass swamps, *Melaleuca*-dominated creek lines, and open savanna grasslands. Completely open water was very scarce, confined to the deepest parts of the largest swamps. All of these habitats are rare in the Kimberley, except possibly for the *Melaleuca* swamps; even the savanna

woodland is very unusual for its very low fire frequency. The TEC boundaries are therefore considered appropriate, as is the conservation status.

Saltwater crocodiles can easily access all wet parts of the TEC, and any water should be approached with extreme caution. Creeks almost certainly contain crocodiles. The only water found safe to swim was ~ 1 km back into the Artesian Range above a ~ 10 m waterfall. A large (~ 4 m) individual was inhabiting the creek close to the base camp.

Four quadrats were established at 19/2, covering the major habitat types: savanna woodland, relatively open *Melaleuca* / rainforest swamp, a moderately dense rainforest, and a very dense gallery forest. Only wet swamps were not represented, due to the inability to trap, and to avoid crocodiles.

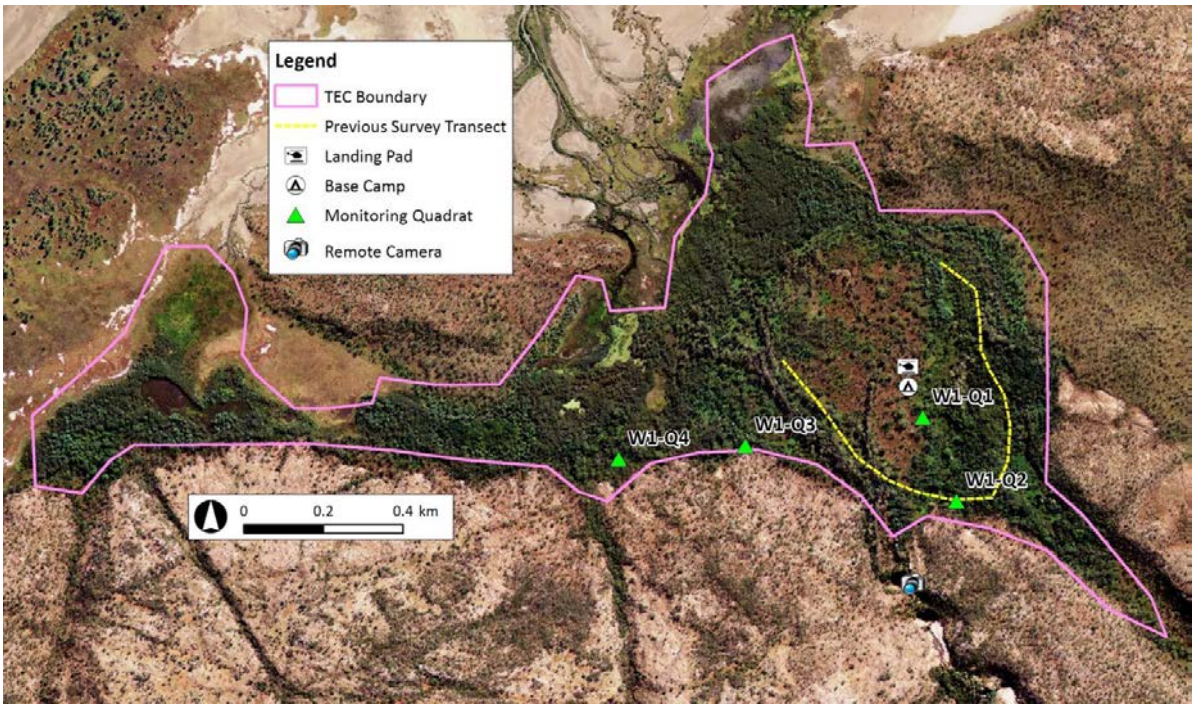


Fig. 1. Sampling quadrats at 19/2 Threatened Ecological Community (TEC) rainforest swamp.

New state records

Two fungi at 19/2 were newly reported from Australia from 19/2: *Pluteus chrysaegis* and *Hyphodontia niemelaei.* Two more collections represent the first species records from the Australian Monsoon tropics: *Hemitrichia serpula*, *Lenzites* (or *Trametes*) *warnieri.* Many fungi collections as yet unidentified are likely to represent additional new records. Amongst these are the first records for the Australian Monsoon Tropics of the genera *Cuphophyllus, Gloiocephala, Pholiotina, Physalacria* and *Sarcodon*, and the first records from the Kimberley of the genera *Hodophilus, Catatrama, Clavaria,* and *Clavulinopsis*. See the notes on fungi below for more detail.

Rare species

The only Priority listed plant species detected at 19/2 was the sedge *Scleria polycarpa* [Priority 1]. This species is confined (in the Kimberley) to swamp-based rainforests. At 19/2 it was found only in and around Quadrat 2 in dense gallery forest, but probably occurs elsewhere in this same dense rainforest pocket.

The reed *Phragmites karka* was previously listed at a Priority 3 species, but has since been downgraded. *Phragmites* is rare in scattered locations throughout the Kimberley, where it is confined to lakes, swamps and rainforest swamps, and very sporadically along rivers. It mostly occurs in places where cattle cannot easily access it, and appears to have declined significantly since the introduction of cattle. The swamps beside rainforest in the Walcott area (including several patches clearly visible from the air at 19/2) provide some of the largest populations of this species in the Kimberley, as noted by the Traditional Owners on the trip, who knew of its occurrence in at least one of the rainforest patches, since it was a known harvest site for making spears.

The presence of both *Cordia dichotoma* and *Cordia myxa* has been noted from 19/2 in the past. However, at the time of the original survey there was taxonomic confusion between the two names, although as national rainforest experts were present we cannot exclude the possibility it was a definitive record. No valid material of *Cordia myxa* is known from WA, and no specimens from the original survey are extant to validate the presence of *C. myxa*. Despite active searching, only *C. dichotoma* was found in the present survey, although many parts of the TEC were not visited. We tentatively suggest that the record of *C. myxa* is an error.

Significance: 19/2 is a rich assemblage of swamp complexes, with some of the largest, densest and tallest rainforest in the west Kimberley. In addition to the rainforest pockets, the patches of savanna woodland are particularly significant for having a very low fire frequency. The vegetation condition was excellent in most areas, and only three weed species were detected (*Euphorbia hirta, Passiflora foetida*, and *Sida acuta*), and present in low numbers. Although only one priority species of plant was detected, the plant assemblages are unusual and rare. Within the densest rainforest are potentially restricted fungi, and a potentially significant wax cap fungal community, however more data is needed to validate these ideas. These factors all contribute to the importance of this TEC for conservation.

Threats: As for the other Walcott TECs, the threats are cattle and pig damage, grass encroachment, fire damage, weed infestation, storm damage, rising sea levels and salt. However there is no evidence of impact from most of these, and only minor impact of fire, pigs and weeds. The most critical threats specific to this area are a potential loss of diversity and structure should the rainforest area decrease and cease protecting the interior area of the TEC from invasion by fire. Although currently very few, weeds may become a significant threat in the future, since further invasion is likely over time. The very extensive sandy and peat areas proximal to drainage lines all over the TEC are highly susceptible to invasion by *Stachytarpheta* species (Verbenaceae), as has occurred at the Charnley River homestead area, and also to Calotrope (*Calotropis* spp.) and Gamba Grass (*Andropogon gayanus*).

Recommendations for 19/2

Continued local fire and introduced animal control, and occasional monitoring is probably sufficient to manage this TEC in the short term. Future surveys should report plant species present in areas not visited during the present survey, in particular rainforest areas in the northern half and the western third, and (if possible safely due to the presence of estuarine crocodiles) the larger open swamps. Removal of cattle from the Walcott area appears to have been highly effective, as no evidence of cattle was found at the site. More effective control of pigs would be beneficial to the site, but is difficult to achieve. Weed control would probably be of limited value at the present time, but weed presence should be monitored occasionally to detect future arrivals. Current fire management practices in the 19/2 area appears to be sufficient to maintain the long-term rainforest boundaries at 19/2, but this should be validated from long-term aerial photography.

Detailed Description of Quadrats at 19/2

Quadrat 19/2 – 1, woodland

Woodland site just south of the camp, to the east of the main swamp rainforest, with the eastern edge of the quadrat more or less following a line of moderately dense drier-rainforest elements, at the transition from drier rainforest to open woodland.Open savanna woodland with scattered rainforest shrubs and trees embedded (e.g. *Alphitonia actinophylla, Antidesma ghaesembilla, Mallotus nesophilus*). The upper story was dominated by a single extremely large *Alphitonia actinophylla*; a second plant had relatively recently collapsed and was present as rotting woody debris – this plant can be observed still standing in aerial photos (e.g. Google Earth). The mid story of small trees was dominated by *Pandanus spiralis, Antidesma ghaesembilla, Ficus aculeata, Melia azedarach* and *Mallotus nesophilus*. The understory was dominated by the grasses *Cenchrus elymoides, Panicum mindaense, Staria apiculata, Hetropogon contortus* and *Aristida holathera*, and the vine *Cajanus hirtopilosus*, with scattered other grasses and herbs. The soil was a dark grey sand, with little leaf litter other than dead grass.

Condition: Excellent (100%). The intact and un-grazed, long unburnt savanna is a rare occurrence in the Kimberley. There was no evidence of animal damage, other than numerous bandicoot and macropod diggings. The woodland had not been impacted by fire for at least five years, and probably significantly longer. *Pandanus* trunks less than 4 m tall have unburnt leaf bases to the ground, and the only evidence of fire was on the bases of old *Pandanus* trees, and on the bark of a very old *Alstonia*, which had fire scars to 10 m high, from a very significant fire. It is possible that this patch was previously a more dense woodland, but was extensively damaged by fire ~ 10-20 years previously and is now gradually thickening, but this is speculative, and needs additional evidence from aerial photography.

Figure 2. Quadrat 1, woodland.

Signifiance: Although not part of the rainforest proper, the area represented by Quadrat 1 has a fire history strongly influenced by the presence of the rainforest, creek lines and mudflat, being protected from direct fire on all sides, and fire clearly only rarely occurs. Annual *Sorghum* was rare, covering only 1 %, while *Cenchrus elymoides* and *Cybopogon procerus* were the dominant perennial grasses. As such it is

one of the very few areas of savanna with very low fire frequency (< 5 years) in the north-west Kimberley. This fire exclusion may be partly responsible for the presence of so many bandicoot diggings in the woodland.

Threats: specific to this area of woodland are a potential loss of diversity and structure (e.g. increase of annual *Sorghum*) should the rainforest area decrease and cease protecting the interior area of the TEC. Weeds were very few (*Euphorbia hirta, Passiflora foetida*, and *Sida acuta*), and present in low numbers, however further invasion is possible over time. Sandy areas proximal to drainage lines similar to this are highly susceptible to invasion by *Stachytarpheta* species (Verbenaceae), as has occurred at the Charnley River homestead area, and also to gamba grass. It is also possible that this woodland could thicken over time from increasing density of dry rainforest species.

Quadrat 19/2 – 2, Rainforest

A very dense closed-canopy gallery rainforest over peaty black soil, dominated by a shallow swamp. This was the only quadrat placed within the core rainforest patch 19/2 described in the original survey. The quadrat upper story was dominated by *Syzygium nervosum*, with *Carallia brachiata* also abundant, with scarce *Timonius timon* and *Nauclea orientalis* trees, and had ~ 90 % cover. The lower mid-story was dominated by *S. nervosum* and *Carallia* saplings. The understory was dominated by *Cyclosorus interruptus* ferns, *S. nervosum* seedlings, and *Scleria polycarpa*. The vines *Stenochlaena palustris, Lygodium microphyllum, Flagellaria indica* were abundant and high-climbing. The southern quadrat margin was along the gallery rainforest / dry rainforest-woodland border, just within the fire-affected zone with the adjacent woodland / dry rainforest composed of *Tabernaemontana orientalis, Pandanus spiralis, Denhamia obscura, Ficus aculeata, Celtis philippensis, Livistona lorophylla, Owenia vernicosa, Buchanania aff. obovata* and *Planchonia carya*. Fire had heavily burnt to this boundary about five years previously and vegetation was re-growing. The other sides and interior of the quadrat were within the gallery forest and show no evidence of fire. A ~ 5 x 10 m area of depressed bog drainage line in the middle of the quadrat was more or less devoid of trees. The bog was depressed by ~ 1 m compared to the highest areas of the quadrat along the southern border and the NW corner. The bog area was partly bordered by *Nauclea* trees. The soil was a black peat.

Figure 3. Quadrat 2, gallery rainforest

Condition: Excellent. Only one very small area of old pig damage (~1 m^2). Fire had burnt up to the rainforest boundary where it meets sandstone within the last few years, and regrowth was evident in that area. However this was likely to be the long-term boundary of the rainforest patch, and such boundaries are likely to be maintained by fires. There was no evidence of dead rainforest trees in the burn area that were not present in the regrowth. The only weed detected in the quadrat was a single *Passiflora foetida* near the burnt margin with woodland on the southern edge. A significant weather event (most likely a thunderstorm) had affected the taller trees within the last few years, especially the *Nauclea* trees, which mostly have broken, dead and re-sprouting branches, and dead logs on the ground. This damage to Nauclea trees could be seen from the air through the core of this rainforest pocket, for about 200 m to the north of the quadrat. The sharply broken logs are evidence of violent damage, rather than drought-related die-off. Several other fallen or leaning trees were present within the quadrat, but these were likely natural succession rather than associated with a specific event.

Significance: A relatively large and very high quality gallery rainforest, and the habitat type continues for several hundred meters to the north of the quadrat. Fungi fruit bodies were especially abundant in Quadrat 2 at the time of visit, including agaric (mushroom), coralloid (club), polypore (bracket) and corticioid (skin) fruitbody forms. Wax caps were especially abundant (see below).

Threats: The dense gallery forest and high water table appear to very effectively exclude fire, up to the southern boundary. The bog would seem appropriate for pigs, but there is little evidence of occupancy. It is possible that this area becomes more attractive to pigs later in the dry season. A possible threat to this low-lying boggy area in particular is rising sea levels. The whole TEC is only just above the high tide level, and rising sea levels combined with storm surges could conceivably encroach salt water into parts of the rainforest patch represented by Quadrat 2.

Quadrat 19/2 - 3 Melaleuca / Carallia / Pandanus swamp

Quadrat 3 was an open forest situated across a shallow drainage line that was broad and swampy. The area was a mix of *Melaleuca* swamp and rainforest elements. The canopy was about 50 % closed, and was dominated by *Melaleuca viridiflora, Pandanus spiralis, and Antidesma ghaesembilla*, with small numbers of *Alphitonia excelsa*, *Sesbania formosa*, *Carallia brachiata, Corymbia bella* and *Eucalyptus houseana*. The lower story was dominated by the grasses *Germainia truncatiglume*, *Arundinella nepalensis*, and the vine *Cajanus hirtopilosus*. About half of the ground was covered by leaf litter, and most of that heavily disturbed by pigs. The soil was a dark grey sand. *Passiflora foetida* was the only weed species detected, occupying 1 % of the quadrat.

Figure 4. Quadrat 3, Mixed Melaleuca swamp / rainforest

Condition: Excellent (60%), Good (40%). The area seems quite intact aside from the extensive and deep pig rooting.

Significance: No particularly significant plant species were detected. The relatively open canopy and mix of species was typical of broad marginal areas around the core dense rainforest patches along the base of the sandstone scarp in the south of the TEC.

Threats: Quadrat three had been very heavily (~27%) pig-rooted, with some diggings to 50 cm deep. Aside from the apparent high attraction of this quadrat to pigs, the threats are as for the TEC as a whole.

Figure 5. Pig disturbance at Quadrat 3.

Quadrat 19/2 - 4 Rainforest

Situated about 40 m from the base of a sandstone ridgeline on the southern edge of the TEC. A closed canopy (60-70%) rainforest with a relatively simple canopy structure and some open areas near a narrow creek that flows through the centre of the quadrat. The canopy was dominated by *Carallia brachiata, Pandanus spiralis, Canarium australianum, Alphitonia excelsa* and *Coymbia bella*. Several other tree species were scatted through the quadrat. The understory was quite open in most of the quadrat, with the grass *Mnesithea rottboelloides*, shrubs *Thespesia thespesioides* and vine *Cajanus hirtopilosus* in areas with large breaks in the canopy. The soil was a dark grey sand, with 1-5 cm deep leaf litter in most of the quadrat. There was no evidence of recent fire. The aspect was flat aside from the steep banks of the creek. To the south of the quadrat up to the base of the ridge was a transition zone between rainforest and woodland, composed of drier rainforest and woodland elements: *Tabernaemontana orientalis, Syzygium bleeseri, Buchanania aff. obovata, Alphitonia excelsa, Melaleuca viridiflora, Acacia delibrata, Pandanus spiralis* and *Denhamia obscura*, and this habitat butted into the south-west edge of the quadrat. Many young *Homalanthus novoguineensis* plants, an early colonizer, were present in the quadrat, possibly a result of some past disturbance (e.g. pig rooting). In the other three directions the community was more or less continuous for some distance. There was evidence of bandicoot and wallaby diggings in the quadrat.

Figure 6. Rainforest at Quadrat 4.

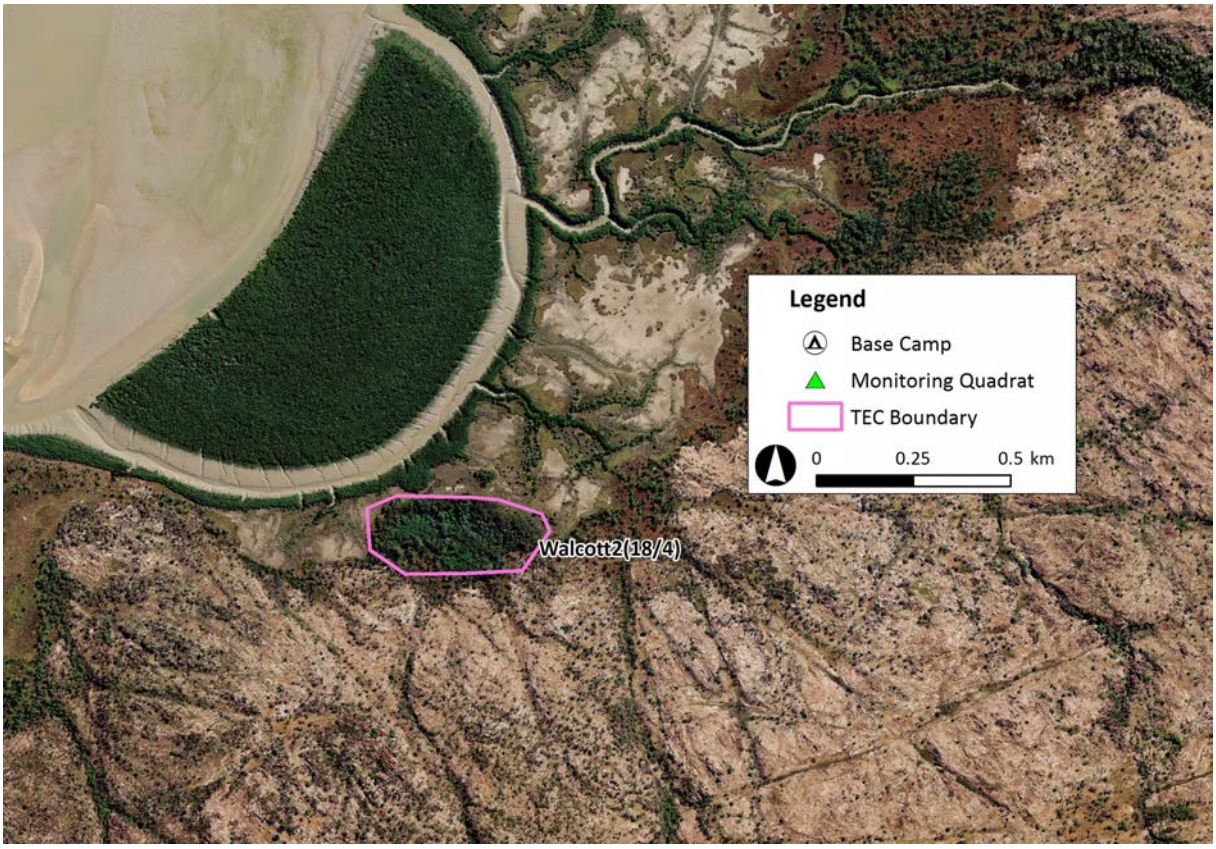
Condition: Excellent (85%), or Good (15%). Excellent aside from the moderately heavy pig rooting. The only weed species seen were very sparse *Euphorbia hirta* and *Passiflora foetida*.

Significance: There were no especially significant plant records or associations over and above the general TEC.

Threats: As for the TEC as a whole.

TEC Walcott 2, Patch 18/4
Rapid survey 9 June 2016

The patch 18/4 was visited by M. Barrett & A. Moncrieff for 2 hours on 9 June 2016. A plant species list was obtained from the landward side and centre of the rainforest, but based on a flyover, the mudflat side likely contained several species not recorded. A total of 49 species were recorded, including six that were found only at the rainforest edge, and appeared to be encroaching from the adjacent woodland. The patch was dominated by *Melaleuca viridiflora*, *Homalanthus novoguineensis, Alphitonia excels, Sesbania formosa* and *Timonius timon* with scattered *Canarium australianum.* The understory was dominated by the ferns *Lygodium microphyllum*, *Acrostichum ?speciosum*, , *Stenochlaena paulustris and Cyclosorus interruptus*. The fern *Acrostichum speciosum* has previously been reported from 18/4, but some plants matched *A. aureum*. The distinction of these two species has been questioned in the past, and further studies are needed.



The TEC occurrence form was filled out at a position about 50 m inside the rainforest from the boundary with woodland, at S 705081.20, N 8183341.67, zone 51K. At this point, the Upper story 12 m, of mixed *Melaleuca viridiflora* and *Alphitonia excelsa*; the mid stratum was 8-10 m mixed *Homalanthus novoguineensis* and *Carallia brachiata*. The understory was a mix of the ferns *Lygodium microphyllum, Stenochlaena paulustris and Cyclosorus interruptus*. The canopy in the interior was 10 % upper stratum (tall trees), 70-80 % cover in the mid-stratum (small to medium trees), and 100 % cover in the understory. Soil was black peaty alluvial mud with high humus content, and moist (water table high). Many young *Homalanthus novoguineensis* plants, an early colonizer, were present around the margin, clearly responding to recent fire disturbance.

Figure 7. Rainforest at 18/4. Left: dense ferns in interior of rainforest, on the landward side. Right: dense young *Homalanthus* and other regrowth within the broad fire-affected margin on the landward edge.

Condition: 95 % Excellent, 5 % very good (Bush Forever Scale). The only damage observed was some pig grubbing in marginal areas (medium pig damage). The southern side has experienced recent medium-intensity fire at the margin, and the margin is probably maintained by fire. The last fire was estimated to have been some time in 2015. In the patch interior there was no evidence of fire at all. No evidence of storm damage nor rising salt, nor cattle damage. Only two weed species were detected, sparse *Passiflora foetida* and *Triumfetta pentandra* in marginal areas (low impact).

Significance: This TEC is less complex than 19/2 and 21/4, with a single continuous rainforest patch that was more or less uniform, other than grading from drier rainforest through wet rainforest swamp into *Melaleuca* swamp from the landward edge into the mudflat. However in the central part adjacent to the mudflat is an additional patch of tall gallery forest that was not visited during this survey.

Threats: As for the other Walcott TECs, the threats are cattle and pig damage, grass encroachment, fire damage, weed infestation, storm damage, rising sea levels and salt. However there is no evidence of impact from most of these, and only minor impact of fire, pigs and weeds. Continued local fire and introduced animal control, and occasional monitoring is probably sufficient to manage this TEC in the short term.

TEC Walcott 3, Patch 21/4
Detailed survey 8-13 June 2016

A complex of small discreet rainforest pockets and swamps associated with alluvial soils along meandering creek lines. The precise location of the original 21/4 site was initially uncertain, as the lat/long of the initial Rainforest Survey location was inexact. The TEC had previously been marked only on the larger eastern rainforest pocket. Based on plant species recorded in the original survey (e.g. *Helminthostachys zeylenica*), it is clear that the original site was actually the south-west most of the patches. Owing to the location confusion, the original patch was not represented by three quadrat sites,

which were placed in the north-western and eastern patches. However, a nearly-complete species list was obtained from the original patch (designated “21/4 original”).

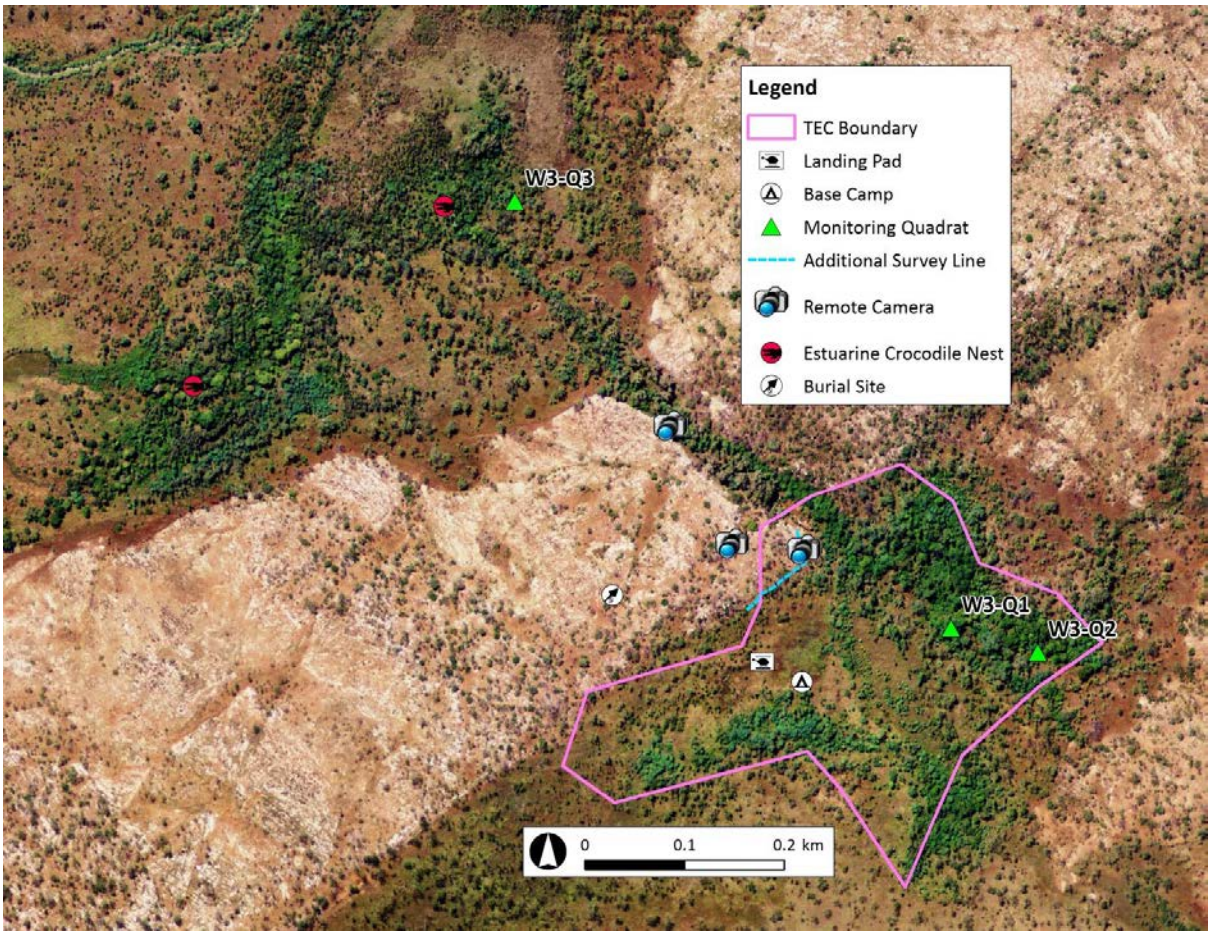


Fig. 2. Sampling quadrats at 21/4 Threatened Ecological Community (TEC) rainforest swamp. The purple line indicates the foundation TEC boundary, but note that the original survey was conducted around the mapped crocodile nest on the left of the image.

The boundary of the 21/4 site is recommended for modification (Figure 12), to encompass the full range of rainforest and swamp complexes in a manner similar to the 19/2 TEC.

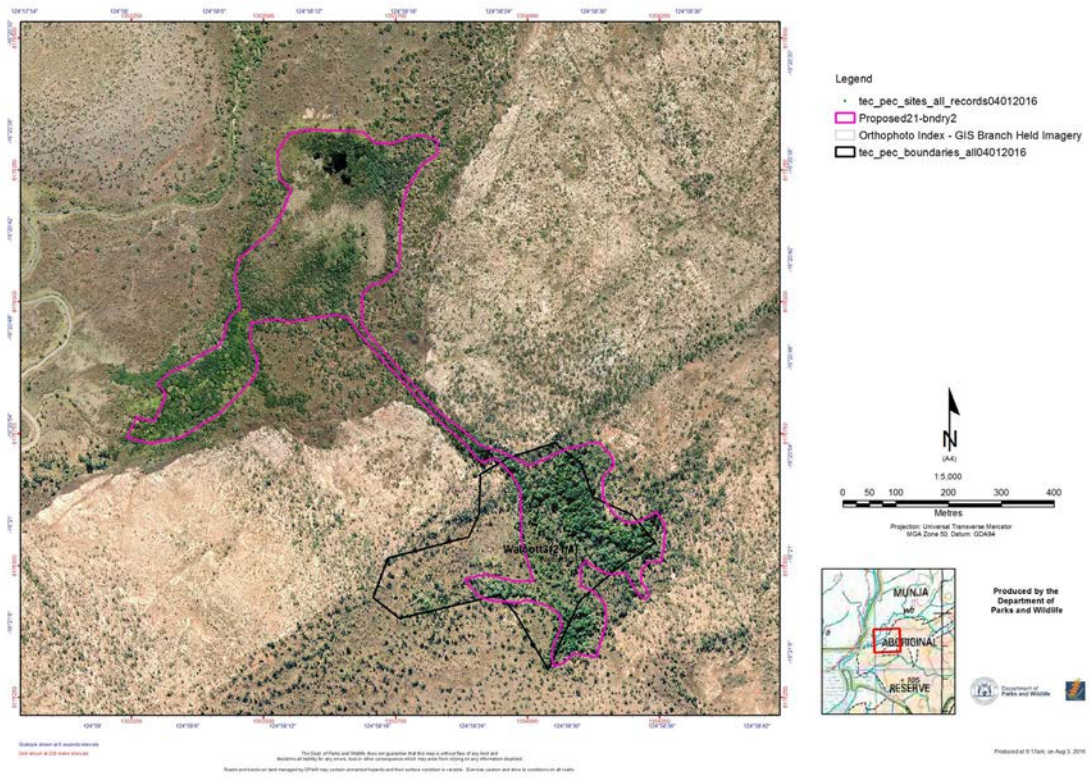


Figure 12. Existing (black) and proposed modified boundary (purple) of the 21/4 TEC site. The location of the original 21/4 site from the 1980's rainforest survey is the south-western-most area outlined in purple, disjunct from the current (black) TEC.

Rare species

Eight plant species were detected in and on margins of rainforest that have priority status in Western Australia:

- *Adenostemma lavenia* var. *lanceolata* [Priority 3]
- *Glochidion apodogynum* [Priority 1]
- *Helminthostachys zeylenica* [Priority 3]
- *Merremia umbellata* subsp. *orientalis* [Priority 1, recommendation submitted]
- *Pavonia calycina* [Priority 3, recommendation submitted]
- *Scleria annularis* [Priority 1]
- *Scleria polycarpa* [Priority 1]
- *Scleria psilorrhiza* [Priority 1]

Glochidion apodogynum and *Merremia umbellata* subsp. *orientalis* are known in WA only from this single TEC (21/4), although both are relatively abundant there. Both are also found in the Top End and Cape York. *Adenostemma* and *Helminthostachys* were only found in swamp rainforests in WA, as noted under the description of the "original 21/4" site above, which was the only rainforest pocket within the whole 21/4 site where they occurred. *Pavonia calycina* was found just outside the "original 21/4" site, and in the grassy area of Quadrat 3 – it is discussed more fully above. *Scleria annularis, S. polycarpa* and *S. psilorrhiza* were found only in a small area in and adjacent to the NW corner of Quadrat 1, and appear to be very restricted in this TEC. *Scleria polycarpa* is a swamp rainforest sedge, while *S. annularis* and *S. psilorrhiza* were, at this site, confined to the fire-effected margins immediately adjacent to the rainforest, and may have a very restricted niche at this site, where they are potentially affected by

frequent fires. At least *S. psilorrhiza* appears to take several years following fire to reach reproductive maturity.

Phragmites karka was also present in the western swamps (see the discussion of this species in the 19/2 summary).

Significance: The 21/4 TEC is a significant area for specific conservation of eight priority species, including two found nowhere else in WA. The location of the rainforest swamps way from physical protection from fire renders them inherently vulnerable to repeated hot fires.

Figure 13. Rare species at 21/4.
Row 1: *Adenostemma lavenia* var. *lanceolata* [Priority 3] (a – flower, b – fruit); *Glochidion apodogynum* [Priority 1] (c – leaves and fruit) d – *Helminthostachys zeylenica* [Priority 3] whole plant with leafy sterile and emergent fertile fronds;
Row 2: a, b - *Merremia umbellata* subsp. *orientalis* [Priority 1 recommendation submitted] alternately arranged leaf with cordate base and angular stem and white sap; *c* - *Scleria polycarpa* [Priority 1] with characteristic 3-whorled leaves; *Pavonia calycina* [Priority 3, pending];
Row 3: a, b - *Scleria annularis* [Priority 1], plant and inflorescence; c, d - *Scleria psilorrhiza* [Priority 1] plant and characteristic winged stems.

Threats: As for the other Walcott TECs, the threats are cattle and pig damage, grass encroachment, fire damage, weed infestation, storm damage, rising sea levels and salt. However there was no evidence of impact from most of these, and only minor impact of pigs. However the small patch size and discrete nature of the rainforest pockets, and the lack of a clear protective boundary for any of them, makes them potentially vulnerable to cycles of weed and savanna grass invasion, followed by fire damage and retreat of the rainforest margin. This cycle is expected to be more damaging in drought periods. Two of the quadrats (Q1 and Q2) showed narrow but significant areas of fire incursion into the drier rainforest margins, and the presence of dead stems of small trees and shrubs suggests a retreat of at least a medium-term (5-20 year) rainforest boundary due to recent fires, although the same areas had much low regrowth or rainforest shrubs and trees. Comparison of satellite imagery is necessary to evaluate any longer-term changes. The 21/4 TEC also had the highest recorded number of weed species of the Walcott TECs, with six species detected: *Clitoria ternata*, *Euphorbia hirta*, *Passiflora foetida*, *Physalis angulata*, *Sida acuta*, and *Triumfetta pentandra* (fig. XXXX). Mango (*Mangifera indica*) has also been reported for 21/4 in the past, but was not detected in the current survey. The weed *Triumfetta pentandra* was particularly abundant in the burnt areas around Quadrats 1 and 2, and may be outcompeting native shrubs and seedlings. Germination of *Triumfetta pentandra* is stimulated by fire, and may increase with repeated fire. The large surface to area ratio of the rainforests in the 21/4 TEC make them more vulnerable to weed invasion than larger patches.

Management actions: Continued local fire and introduced animal control, and occasional monitoring may be sufficient to manage this TEC in the short term, however 21/4 requires more regular monitoring than the other Walcott TECs. Monitoring should include aerial imagery to determine long term trends in rainforest boundaries, and on-ground monitoring or spraying of weeds, especially *Triumfetta pentandra*. The seeds of *T. pentandra* are spiny, and attach to clothing, so visitors should regularly clean clothing to minimise tramping weeds through the system and creating a worse problem.

Figure 14. Weeds recorded in Walcott Rainforest patches. Top row, left to right: *Clitoria ternata*, *Euphorbia hirta*, *Passiflora foetida*. Bottom row: *Physalis angulata*, *Sida acuta*, and *Triumfetta pentandra.*

Detailed Quadrat descriptions for the 21/4 site

Quadrat 21/4 – 1, dense rainforest at creek junction

A tall (25 m) closed-canopy gallery rainforests at the confluence of two streams. The quadrat more or less followed the rainforest-woodland boundary on the southern side but crossed one of the streams at the eastern end. The western end ran through the main gallery forest, dominated by *Carallia brachiata*, with patches of *Syzygium nervosum, S. angophoroides, Ficus racemosa, Canarium australianum, Bombax ceiba, Glochidion apodogynum* and *Alphitonia excelsa*. The mid story was composed of Saplings of *Carallia, Syzygium, Myristica insipida, Litsea glutinosa* and *Ficus hispida*, with vines *Stenochlaena palustris, Flagellaria indica* and *Smilax australis*. The understory in the gallery forest was mostly bare or with seedlings of the proceeding tree species, but in the north-west corner was a large fern bank of 1.5-2.5 m *Nephrolepis hirsutula* and the sedge *Scleria polycarpa*. The northern and eastern sides of the quadrat traversed through drier parts of the rainforest that was recovering from a recent hot fire (estimated 2-4 years prior) that penetrated almost (within 1-2 m) up to the stream margins, with a strong incursion into the quadrat between the two stream lines on the eastern side of the quadrat. The presence of many *Pandanus spiralis* near the rainforest / fire scar margins may have contributed to the fire intensity. An estimated 52 % of the quadrat was fire-affected to some degree.
The fire incursion on the east side was almost completely devoid of grasses, but instead was composed of rainforest trees, shrubs and ferns (e.g. *Canarium australianum*, *Smilax australis, Stenochlaeuna palustris, Wrightia pubescens, Ficus aculeata*), suggesting that it was part of the rainforest prior to being burnt, and grasses have not (yet) invaded. However, the weed *Triumfetta pentandra* was abundant throughout the burn. On the northern and southern sides, many grasses (including *Sorghum stipoideum* and *Cenchrus elymoides*) were present on and near the quadrat margins, continuous with the adjacent woodland, suggesting that this was a long-term boundary; closer to the northern stream, however, numerous dead rainforest stems were present, with *Lygodium microphyllum* and *Passiflora foetida* vines densely growing around them, suggesting that this part of the rainforest patch had been heavily impacted by a recent hot fire, and is now regenerating back to rainforest. This interaction between regularly burnt woodland and fire free rainforest, with a dynamic occasionally burn margin, is the norm for rainforest margins not protected by rock or mudflat. However the presence of a strongly impacted margin means that this patch should be examined for past fire dynamics, and monitored in the future, to detect any long-term loss of the patch. The soil was a black alluvial silt, that along the creek lines was built up (and sometimes spongy) with organic matter and roots well above the narrow stony creek bed.

Figure 8. Rainforest at 21/4 Quadrat 1. Left: dense, layered rainforest near the south-western edge. Right: recently burnt and regenerating fire incursion on the eastern side of the quadrat.

Condition: Excellent (50 %), Good (50 %) (bush forever scale), with the proviso that the burnt area does continue to regenerate at least dry rainforest, rather than increase in abundance of weeds (especially *Triumfetta pentandra*). There was no evidence of pig or cattle damage, storm damage, and the elevation is too high to be affected by rising sea levels or storm surges.

Significance: *Glochidion apodogynum* and *Merremia umbellata* subsp. *orientalis* are priority species that were both numerous in the quadrat. The priority sedges *Scleria annularis, S. polycarpa* and *S. psilorrhiza* were found only in a small area in and adjacent to the NW corner of Quadrat 1, and appear to be very restricted in the 21/4 TEC. *Scleria polycarpa* is a swamp rainforest sedge, while *S. annularis* and *S. psilorrhiza* were, at this site, confined to the fire-effected margins immediately adjacent to the rainforest, and may have a very restricted niche, where they are potentially affected by frequent fires. The western portion of the quadrat was some of the densest and tallest patches of rainforest in the 21/4 TEC, and continues for ~ 50-70 m to the west of the quadrat boundary. This area was a roost for several hundred flying foxes, and was the part of the TEC used as a roost at the time of the survey.

Threats: Fire and weed invasion appear to be the major threatening processes at this point in the TEC. For a full discussion see the summary of threats to the 21/4 site.

Quadrat 21/4 – 2, rainforest along small creek

A dense closed forest along a small stream. This quadrat is rectangular in size, 40 x 60 m, with a slight concave bend in the NE side. The two longer sides run parallel to the creek line, and follow the rainforest / woodland boundary. At the SE end the quadrat runs slightly into the adjacent savanna woodland (by ~ 5-10 m). The NW side cuts across the creek through the densest part of the rainforest. Along the creek runs a band of dense, closed-canopy gallery rainforest dominated by *Syzygium nervosum* and *S. angophoroides*, with less numerous trees of *Carallia brachiata, Timonius timon, Glochidion apodogynum,*

Canarium australianum, Nauclea orientalis, and *Alphitonia excelsa*. Margins were dominated by *Glochidion apodogynum, Pandanus spiralis, Sesbania formosa, Timonius timon, Melaleuca leucadendra, Alstonia actinophylla* and *Ficus hispida*, and tangled with the vine *Merremia umbellata* (which in the Kimberley is restricted to the 21/4 site). The mid-story was dominated by *Syzygium* saplings and seedlings, and tangled with *Smilax australis, Flagellaria indica* and *Stenochlaena palustris*. Woodland margins contain the grasses *Heteropogon contortus* and *Sorghum stipoideum*, and the shrubs *Clerodendrum tomentosum* and *Premna acuminata*. Soil was a black alluvial silt, that along the creek lines was built up (and sometimes spongy) with organic matter and roots well above the narrow creek bed, which had a few stones visible in places. A hot fire had impacted three of the rainforest margins (estimated two years previously), burning into 5-10 m of the estimated previous rainforest margin on the longer sides, and 10-20 m on the SE end, where many *Pandanus* palms may have increased fire intensity. An estimated 28 % of the quadrat was fire-affected. The wetter parts of the burnt margins were most strongly recolonized by *Timonius* and *Glochidion*.

Figure 9. Rainforest at 21/4 Quadrat 2, showing dense patches of *Syzygium nervosum* seedlings and saplings (left) and tangled vines (right).

Figure 9b. Rainforest margin at 21/4 Quadrat 2, showing the short fire-affected rainforest zone transitioning to grassy savanna woodland.

Condition: Excellent (70 %), Good (30 %) with the proviso that the burnt area does continue to regenerate to rainforest, rather than increase in abundance of weeds (especially *Triumfetta pentandra*). There was no evidence of pig or cattle damage, storm damage, and the elevation is too high to be affected by rising sea levels or storm surges.

Significance: *Glochidion apodogynum* and *Merremia umbellata* subsp. *orientalis* are priority species that were both numerous in the quadrat.

Threats: Fire and weed invasion appear to be the major threatening processes at this point in the TEC. For a full discussion see the summary of threats to the 21/4 site.

Quadrat 21/4 – 3, swamp rainforest

A small, moderately dense patch of rainforest in a very swampy setting interlaced with anastomosing streams over black alluvial mud. This isolated rainforest pocket was situated in a sea of 1.5-2 m tall woodland / grassland over alluvial soil. The SE corner of the quadrat was in the woodland, which was composed of scattered trees of 4-15 m *Corymbia bella*, *Planchonia carya*, *Erythrina vespertilio* and *Pandanus spiralis* trees over 1.5-2 m tall grasses *Arundinella nepalensis, Mnesithea rottboelloides* and *Germainia truncatiglume*. The only evidence of fire impact was a lack of a dead "skirt" on *Pandanus* palms in the SE corner (almost certainly the whole grassy area does burn occasionally), and old fire scars on Melaleuca trees in the SW corner. However the most recent fire was probably more than two years prior. The 15-20 m rainforest canopy was dominated by Melaleuca leucadendra, with large trees of *Terminalia platyphylla, Carallia brachiata, Glochidion apodogynum, Nauclea orientalis, Ficus racemosa, Corymbia bella, Alphitonia excelsa, Sesbania formosa* and *Syzygium nervosum*. The mid-story was composed of dense tangled 4 m *Ficus hispida* and 4-8 m *Pandanus spiralis*. Much of the ground under

the rainforest canopy was open, but with a large patch of the fen Cyclosorus interruptus. Four weed species were detected, all in very low abundance: *Euphorbia hirta, Passiflora foetida, Physalis angulata,* and *Triumfetta pentandra*.

Figure 10. Rainforest at 21/4 Quadrat 3. Interior fire-protected area (left) and grassy fire-affected margins (right).

Condition: Excellent (100 %). There was little evidence of cattle or pig damage, nor salt impact. Although the grassy margins clearly do burn occasionally, there was no evidence of impact on the rainforest patch itself (such as old dead stumps or burnt trunks). None of the trees showed signs of storm damage or drought stress.

Significance: The relatively rare species *Pavonia calycina* was found in the grassy area in the SE corner. This quadrat is one of the smallest and species-poor rainforest pockets in the 21/4 TEC, but is unusual for its very swampy surface, different to all other pockets visited.

Threats: The low elevation of this rainforest pocket makes it potentially vulnerable to rising sea levels or storm surges. As with the other small rainforest pockets at 21/4, there are no geological features protecting the rainforest from very intense and repeated fires. The swampy nature is potentially attractive to pigs, but no evidence of occupation was found. The extreme swampy nature and dense canopy in the core area will probably significant hinder weed invasion.

21/4 – Site 4 "original patch" (species list only, no quadrat)

This rainforest pocket was not immediately surveyed since it was relatively small, and only recognised as significant late in the survey period, when it was recognised as the original 21/4 survey site by the plant species list, which included the ferns *Marsilea* and *Helminthostachys*, both absent from all other Walcott sites surveyed. A small medium-height rainforest pocket with a fairly open understory along a meandering stream and partially protected by two elongated oxbow billabongs. This rainforest pocket is only 50-100 m from a tidal rivulet with sparse mangroves, that shoots off from the lower reaches of the

Calder River. Consequently it has immediate access to crocodiles, and was occupied. Extreme caution is recommended on surveys. No quadrat was set in this area, but it is recommended hat one be placed here in the future. The patch was small but floristically complex, with many species not found in any of the other rainforest pockets at the 21/4 TEC, or even in any the Walcott TECs in the current survey: *Adenostemma lavenia* var. *lanceolata, Diospyros humilis, Glycosmis macrophylla, Helminthostachys zeylenica*, *Pisonia aculeata*, although some of these were reported from Walcott rainforests in the first rainforest surveys. An old saltwater crocodile nest (with attendant croc) was located in the centre of this patch.

Four weed species were detected, all in very low abundance: *Clitoria ternatea, Passiflora foetida, Sida acuta* and *Triumfetta pentandra*. *Clitoria ternatea* was seen only in this pocket.

Figure 11. Rainforest at 21/4 “original” patch. Left: open rainforest at the core. Right: swamp billabong filled with *Adenostemma lavenia, Marsilea mutica* and *Persicaria barata* on the eastern margin.

Condition: Excellent. No evidence of fire except at the grassy margins. No clear evidence of cattle or pig damage.

Significance: The original 21/4 was a relatively diverse patch of rainforest, with 28 species of rainforest trees and shrubs, several of which were not detected elsewhere in the Walcott TECs. However, many of the species were present only as single plants, suggesting a degree of vagility in the species composition as new plants arrive or die off. Of particular note are two Priority Three taxa, *Adenostemma lavenia* var. *lanceolata* and *Helminthostachys zeylenica* that were detected only in this small pocket, and not in any of the other pockets at 21/4. The very low elevation and presence of open water swamps at this patch potentially explain the presence of these two species. The yellow *Hibiscus* relative *Pavonia calyina* was located just outside the boundary of this patch, in dense grassland adjacent to the swamp. The saltwater crocodile nest within this patch is also significant.

Threats: The immediate proximity of this patch to a tidal creek make it the most vulnerable patch surveyed to rising sea levels and extreme storm surges. Other weed, fire and animal threats are as for the other rainforest pockets at 21/4.

Fungi in the Walcott Rainforests

Fungi are often excluded from surveys due to the fact that short-lived fruiting structures are usually necessary for detection of their presence. A surprising result of the Walcott TEC floristic survey was the presence of an abnormally high number of species of fungi with observable fruiting bodies. The abnormally high abundance of fungal fruiting was almost certainly enhanced by the late rains that occurred during May, and possibly also by the poor wet season prior to that point.

A total of 148 collections of fungi (including several slime molds that are colonial amoebae rather than true fungi) were made opportunistically from the Walcott TECs, mostly in and around the quadrats. Six additional distinctive species were recorded from 21/4 based on sight observations without vouchers. These collections are estimated to represent ~84, 1 and ~53 species from each of 19/2, 18/4 and 21/4 respectively. About 20 species are estimated to be shared between 19/2 and 21/4, from a total of ~114 species across all of the Walcott TECs. It is not possible to estimate the true diversity of a site from a single, survey. Long term surveys in Europe still detect new species after 15 years. Most of the species at each site were only seen in a single fruiting cluster, suggesting that the diversity is probably well over double what was recorded. Based on other surveys, a total diversity of macro-fungi (those with visible fruitbodies) of between 200-500 species is expected at the more complex sites 19/2 and 21/4. The diversity of fungi in the Kimberley is unknown, however nearly 1000 species of macro-fungi (those with visible fruitbodies) have been collected to date (M. Barrett unpublished data), with the total estimated to be around 2-4000 species.

Fungal Richness and TECs

The TEC's are potentially significant for conservation of fungal diversity if they either harbor unusual richness, or if there are significant numbers of species that do not occur elsewhere (*i.e.* have a rare fungal community). There are reasons to suspect that both of these factors might be true for rainforest TEC's. Swamp Rainforest TECs have several characteristics that potentially increase fungal richness, or harbor species not present in other communities:

- High humidity due to their hydrology
- Higher organic carbon and other nutrients
- Very low to absent fire
- Numerous tree species absent or rare in the surrounding savanna

In the Australian monsoon tropics, ambient humidity and soil fertility are usually positively correlated with fungal fruitbody diversity and abundance, while high fire frequency lowers litter and woody debris, that typically lowers at least fruiting of macro-fungi. Fungi in soils form different guilds depending on their biotrophic interactions. Many fungi are saprotrophs, breaking down organic debris to obtain nutrients and energy. Other species form mycorrhizal symbioses with plant roots, the two most common types being ectomycorrhizas (ECM) that form sheaths of hyphae around root tips enabling exchange of nutrients and sugars, and vesicular arbuscular mycorrhizas (VAM) forming branches and nodules within and between cells of the root. Using seedlings of ECM-forming plants as baits, Brundrett et al (1996) found that annual fires in Kakadu woodlands greatly reduced the presence of ECM but not VAM-forming fungi in topsoil (0-10 cm) compared to 4-year unburnt woodland, however ectomycorrhizal species might still be active at deeper soil depths. The effect of angiosperm diversity in driving fungal diversity is more complex, with increased plant diversity generally driving increased fungal diversity. However this effect differs with fungal nutritional mode, and so in part depends on the variety of nutritional strategies employed by the angiosperms. Kimberley rainforests are dominated by arbuscular mycorrhizal species

that do not produce fruitbodies (e.g. *Endogone*, of which several collections were made), while ectomycorrhizal plants such as *Eucalyptus* and *Acacia* are rare. However some probable ectomycorrhizal plants are present in parts of the Walcott TECs: *Corymbia bella, Eucalyptus houseana, Melaleuca leucadendra*, and *M. viridiflora*. Despite their presence, both the density and richness of ectomycorrhizal tree species is lower than in most savannas, and so rainforests are not expected to contribute the same richness of ectomycorrhizal fungi as woodlands of the Kimberley.

As expected from the above hypotheses, the observed macrofungi of the Walcott TEC's were dominated by saprophytic species (as extrapolated from known nutritional modes of congeneric species), growing either on wood or soil. The ECM species were found either along creek margins in association with *Melaleuca* or *eucalypts*, or on rainforest margins close to eucalypts. Several species of both *Hygrocybe* and Clavariaceae were found within dense rainforest. The nutritional modes of both of these genera is uncertain, but appear to be biotrophic but not standard ECM (Seitzman et al 2011, Birkebak 2014).

Fungal community / species uniqueness

It is difficult to detect differences between Kimberley fungal communities on available data, since spot surveys are not directly comparable. Detection of fungal presence at as site, is difficult without extensive environmental sequencing, since it relies on collection of fruiting structures, which in turn are highly influenced by local and short to moderate-term weather conditions. Complete fungal inventory of macro-fungi requires very long term repeated survey (>>10 years), although environmental sequencing offers a more rapid assessment.

However, the species detected can be compared to the total Kimberley species list (maintained by M. Barrett). Many of the Walcott TEC species have not been found elsewhere in tropical Australia as yet, including in rainforests in the Top End. However survey of rainforest fungi is very incomplete, and it is likely that the species will eventually be found across northern Australia. The presence of many species not yet found amongst the better-surveyed savanna woodlands suggests that Kimberley rainforests might harbor many fungi not represented in other Kimberley habitats, as for hundreds of plant species that in the Kimberley are only found in rainforest habitats. Examples of new fungi records potentially restricted to rainforests in the Kimberley are: *Hodophilus* sp., *Clavaria* sp., *Clavulinopsis* sp., *Cuphophyllus* spp., *Gloiocephala* aff. *epiphylla*, *Hemitrichia serpula*, *Hygrocybe* spp., *Rigidoporus* aff. *vinctus*, *Physalacria* sp., *Sarcodon* sp. Of particular interest is the collection of several genera not previously known to occur in tropical Australia: *Cuphophyllus*, *Gloiocephala*, *Physalacria* and *Sarcodon*.

As well as the putative rainforest specialists, many species show broader distributions, including:
Cosmopolitan species (in many habits in the Kimberley): *Schizophyllum commune, Ceratiomyxa fruticulosa.*
Pantropical species (in many habits in the Kimberley): *Flavodon flavus, Hexagonia glaber, Lycoperdon curtisii, Hyphodontia niemelaei, Hypoxylon haematostroma, Pycnoporus sanguineus, Trametes warnieri*
Pantropical species that in the Kimberley are only known from rainforests : *Xylaria allantoidea, Earliella scabrosa.*
Asian-Malesian tropical species: *Auricularia cornea.*
Tropical Australian species (in many habitats across northern Australia, not yet known from elsewhere in the world): *Auricularia* aff. *mesenterica*, *Fuscoporia* aff. *gilva*, *Sebipora* aff. *aquosa*, *Truncospora* aff. *ochroleuca.*

Figure 15. Some fungi present in the 19/2 TEC. Row 1, left to right: *Clavaria* sp. (club fungus), *Clavulinopsis* sp. (club fungus), *Galerella* sp.
Row 2: *Xylaria allantoidea* (dead man's finger), *Physalacria* sp., *Hemitrichia serpula* (pretzel slime mold).
Row 3: *Rigidoporus* sp., *Sarcodon* sp. (tooth fungus, showing spore bearing hymenium composed of small spines), *Ceratiomyxa frutescens* var. *arbuscula* (Icicle fairy fans, a slime mold).

Polypores (bracket fungi) and other wood-decay fungi are especially rich in Kimberley rainforest sites due to the high amount of woody debris that is rarely if ever burnt. The polypore flora of rainforests differs from that of savanna woodlands, with many species reported only from rainforests in the Kimberley (eg.

Earliella scabrosa, Rigidoporus sp., *Rigidoporus* aff. *vinctus*, *Xylaria allantoidea*). Notable absences from the TECs, and also other Kimberley rainforests, were the tough and persistent polypores *Microporus xanthopus* and *Fomitopsis feei*, both of which are abundant in Top End Rainforests, east Queensland, and through south-east Asia, and their apparent absence from the Kimberley is surprising.

Of particular interest was the presence of six species of wax caps present at 19/2 in Quadrat 2 (the dense rainforest site), including one *Cuphophyllus* and four *Hygrocybe* of the family Hygrophoraceae, plus one species of the Clavariaceae genus *Carmarophyllopsis* which until recently was placed in the Hygrophoraceae (Young 2000), but is probably ecologically similar to *Hygrocybe* since it frequently grows co-mixed with them. Wax caps are of particular interest globally, as their assemblages are among the very few fungal communities formally listed for protection, including Australia's only listed fungal community, the Hygrocybeae assemblage of Lane Cove, NSW, which accommodates at least 30 species of Hygrophoraceae (wax caps) (Kearney & Kearney 2000). Although in the north temperate areas wax caps are most abundant in grasslands, in Australia they are most abundant in forests including rainforests with only a few species in grassland (Young 2005), and this pattern is also true of the Monsoon Tropics (M. Barrett obs.). The collection of six wax cap species at a single site in a single survey is significant in tropical Australia, where the previous record in 20 years of collecting by M. Barrett was been two species, at several rainforest patches in the Kimberley and Top End (including 21/4 in the current survey). Since all the collections of wax caps were from single patches of fruitbodies (ie. singleton collections), the true richness of Hygrophoraceae at 19/2 cannot be estimated, but is certainly higher than observed. It would require repeated sampling in different seasons to accurately assess the wax cap diversity at 19/2 (the Lane Cove assemblage took a team of people more than 10 years to document, Kearney & Kearney 2000). However, the available evidence suggests that 19/2 is likely regionally significant for its Hygrophoraceae richness. Only one of the species at 19/2 has previously been collected in tropical Australia, although one of the species was also found at the 21/4 site. Most are apparently undescribed species. The 19/2 site is therefore likely to be significant for the conservation of the individual *Hygrocybe* species, as well as the fungal community as a whole.

Three collections of two species of Clavariaceae (coral and club) fungi, representing the first Kimberley records of the genera *Clavaria* and *Clavulinopsis*, were found at 19/2 and 21/4. Clavariaceae species are generally rare in the Australian Monsoon Tropics, with the highest abundance to date found in swamp rainforests in the vicinity of Darwin. The abundance of clavarioid species observed at the Walcott TECs suggests that they might be hotspots for these in a similar manner to the related Hygrophoraceae.

Another potentially conservation-significant species was the *Sarcodon* sp. at 19/2 Quadrat 2. This *Sarcodon* is the first tooth-fungus species to be collected in the monsoon tropics. Many tooth fungi have restricted distributions and are of conservation significance in north temperate areas, but have been very poorly studied elsewhere.

Threats.

The highly invasive Myrtle Rust (*Puccinia psidii*) is a serious pathogen of plants in the family Myrtaceae. It has recently spread from its native South America to eastern Australia, and in 2015 was found to be established on the Tiwi islands in the Northern Territory, and found in Darwin and Berry Springs later the same year. The full extent of its environmental envelope is not yet known, since it prefers more humid conditions, but rainforest Myrtaceae are the most likely plants to be affected in the Kimberley. Myrtle rust is known to affect *Melaleuca* and *Syzygium* species (as well as the extremely rare Kimberley paleoendemic *Backhousia gundarara*), and especially affects the young foliage. Consequently, juvenile

leaves of 50 plants of *Melaleuca* and *Syzygium* (where present) were examined at each quadrat for signs of rust disease (blisters, pustules or rust). No evidence was found in any species at any site, with young leaves showing at most signs of wilting or insect damage. Continued monitoring for Myrtle Rust in Kimberley rainforests should be done where possible.

Figure 16. Wax caps at 19/2 Quadrat 2. *Cuphophyllus* sp., *Hodophilus* aff. *darwiniensis*, *Hygrocybe* sp. 1, *Hygrocybe* sp. 2, *Hygrocybe* sp. 3, *Hygrocybe* sp. 4. *Hygrocybe* sp. 2 is very unusual in lacking gills.

Mammals

A total of 14 native and one introduced species were recorded from the two TECs in 2016 (**Table 3**). Unlike previous surveys, rodents – particularly *Melomys burtoni* and *Rattus tunneyi* – comprised the majority of animal captures (**Table 3**). *Dasyurus hallucatus* was also well represented at both TECs (**Table 3**). Feral pigs as well as pig damage (rooting) was observed at 19/2 (**Table 1; Fig. 3**). Several notable (threatened and/or endemic) species were either captured or detected during 2016 surveys: *Isoodon auratus*, *Mesembriomys macrurus*, *Petropseudes dahli*, *Wyulda squamicaudata* and *Zyzomys woodwardii*; most of which were unaccounted for in previous surveys (**Table 3; Fig. 3**).

Table 3. Mammal records from Walcott River rainforest swamp patches.

Species	Common name	19/2		21/4	
		1987–88	2016	1987–88	2016
Canis lupus dingo	Dingo	-	+	ns	+
Dasyurus hallucatus	Northern quoll	7 (1)	16 [15]	ns	11 [7]
Isoodon auratus	Golden bandicoot	-	1 [1]	ns	-
I. macrourus	Northern brown bandicoot	1 (1)	7 [5]	ns	+
Macropus agilis	Agile wallaby	+	+	ns	+
Melomys burtoni	Grassland melomys	7 (7)	26 [26]	ns	24 [22]
Mesembriomys macrurus	Golden-backed tree-rat	1 (1)	2 [2]	ns	5 [4]
Petrogale brachyotis	Short-eared rock-wallaby	-	+	ns	+
Petropseudes dahli	Rock ring-tail possum	-	+	ns	-
P. nanus	Western chestnut mouse	-	-	ns	3 [3]
Rattus tunneyi	Pale field rat	2 (2)	11 [11]	ns	42 [38]
Sus scrofa	Feral pig	-	+	ns	-
Wyulda squamicaudata	Scaly-tailed possum	-	+	ns	-
Zyzomys argurus	Common rock rat	-	2 [2]	ns	+
Z. woodwardi	Kimberley rock rat	-	+	ns	+
	Total species	**6**	**14**		**11**

– = Not recorded.

\+ = Observed (includes camera traps).

ns = Not surveyed.

( ) = Number of specimens collected.

[ ] = Number of individuals captured.

Fig. 3. Remote cameras at patch 19/2 detected feral pigs (A); scaly-tailed possum (B); golden-backed tree-rat (C); and northern quoll (D).

Reptiles and amphibians

Some 19 species of reptile and at least three amphibians were recorded from the two TECs in 2016 (**Table 4**). Five reptiles and one frog were previously recorded at the two TECs in 1987–88, but were not accounted for in the present survey (**Table 4**). There were 11 species of reptile and up to five amphibians that were not accounted for previous surveys (**Table 4**). Both estuarine (**Fig. 4**) and freshwater crocodiles were observed at both rainforest patches.

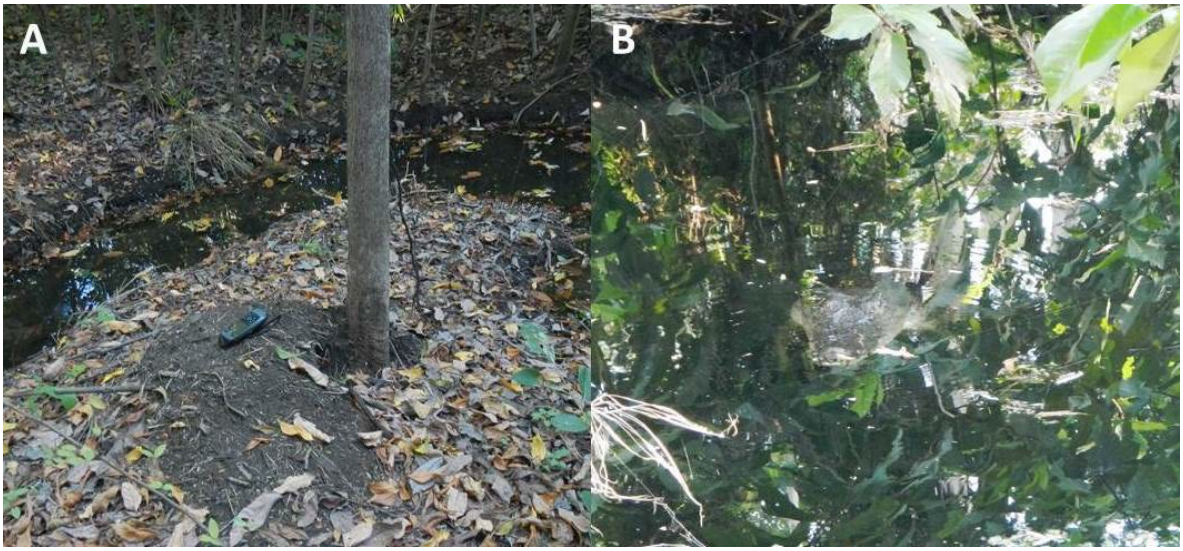


Fig. 4. An old estuarine crocodile nest at 21/4 (A); an estuarine crocodile in the creek at 19/2 (B).

Table 4. Reptile and amphibian records from Walcott River rainforest swamp patches.

Species	Common name	19/2		21/4	
		1987–88	2016	1987–88	2016
Reptiles					
Carlia amax	Two-spined rainbow skink	-	10 [10]	-	2 [2]
Carlia johnstonei	Rough brown rainbow skink	*	1 [1]	-	4 [4]
Crocodylus johnstoni	Freshwater crocodile	-	+	-	+
Crocodylus porosus	Estuarine crocodile	-	+	-	+
Cryptoblepharus metallicus	Metallic snake-eyed skink		-		2 [2]
Ctenotus inornatus	Plain ctenotus	*	-	-	-
Demansia papuensis	Greater black whipsnake	!	+	-	-
Denrelaphis punctulatus	Common tree snake	!	1 [1]	-	-
Diporiphora bennettii	Robust two-lined dragon	-	-	!	1 [1]
Eremiascincus isolepis	Northern bar-lipped skink	*	2 [2]	-	-
Furina ornata	Orange-naped snake	-	-	!	-
Gehyra occidentalis	Kimberley Plateau dtella	-	-	-	1 [1]
Heteronotia binoei	Bynoe's gecko	*	-	-	-
Lialis burtoni	Burton's snake lizard	-	1 [1]	-	-
Liasis olivaceus	Olive python	-	2 [2]	-	-
Lophognathus gilberti	Gilbert's dragon	*	+	-	1 [1]
Morethia ruficauda	Fire-tailed skink	*	-	-	-
Notoscincus ornatus	Ornate snake-eyed skink	!	1 [1]	-	-
Pseudonaja mengdeni	Western brown snake	-	1 [1]	-	-
Pseudothecadactylus cavaticus	Western giant cave gecko	-	-	-	+
	Unidentified snake	-	1 [1]	-	-
Tropidonophis mairii	Keelback	!	-	-	-
Varanus mitchelli	Mitchell's water monitor	-	-	-	1 [1]
Varanus panoptes	Yellow-spotted monitor	!	-	-	-
Varanus sp.	Unidentified goanna	-	-	-	+
Amphibians					
Crinia bilingua	Bilingual froglet	-	-	-	1 [1]
Crinia sp.	Unidentified *Crinia*	-	-	-	1 [1]
Litoria coplandi	Coplands rock frog	!	-	-	-
Litoria rothii	Roth's tree frog	-	-	-	1 [1]
Litoria tornieri	Tornier's frog	-	-	-	2 [2]
Uperolia sp.	Unidentifed *Uperolia*	-	-	-	3 [3]
	Total species	**12**	**13**	**2**	**15**

– = Not recorded.
\+ = Observed (includes camera traps).
* = Recorded as more than one individual.
! = Recorded as a single individual.
( ) = Number of specimens collected.
[ ] = Number of individuals captured.

Fig. 5. Johnny and James processing a northern brown bandicoot at 19/2 (A); Ben processing a golden-backed tree-rat at 19/2 (B); olive python at 19/2 (c); grassland melomys at 21/4 (D); Mitchell's water monitor at 21/4 (E).

Birds

In 2016 a total of 54 species were recorded from the two rainforest patches (**Table 5**). Across both patches, there were an additional 27 species not previously recorded in 1987–88, while there were 13 species listed from previous surveys, that were not accounted for in 2016 (**Table 5**).

Table 5. Bird records from Walcott River rainforest swamp patches.

Species	Common name	19/2		21/4	
		1987–88	2016	1987–88	2016
Accipiter cirrocephalus	Collared sparrowhawk	+	-	-	-
Accipiter fasciatus	Brown (Australian) Goshawk	-	+	-	-
Alcedo azurea	Azure Kingfisher	-	+	-	+
Aprosmictus erythropterus	Red-winged Parrot	-	+	-	-
Cacatua galerita	Sulphur-crested Cockatoo	+	+	+	+
Cacomantis variolosus	Brush Cuckoo	-	+	-	-
Calyptorhynchus banksii	Red-tailed Black Cockatoo	-	+	-	+
Centropus phasianinus	Pheasant Coucal	+	+	-	+
Chalcophaps indica	Emerald dove	-	-	-	+
Chlamydera nuchalis	Great Bowerbird	+	+	-	+
Chrysococcyx basalis	Horsefield's Bronze-Cuckoo	-	-	-	+
Cisticola exilis	Golden-Headed Cisticola	-	+	-	+
Colluricincla harmonica	Brown Shrike-thrush	-	+	-	-
Colluricincla harmonica	Grey Shrike-Thrush	+	+	-	+
Colluricincla megarhyncha	Little shrike thrush	+	-	-	-
Conopophila rufogularis	Rufous-throated Honeyeater	-	+	-	-
Coracina novaehollandiae	Black-faced cuckoo shrike	+	-	-	-
Coracina papuensis	White-bellied cuckoo-shrike	+	+	-	-
Coracina tenuirostris	Cicadabird	-	+	-	-
Coturnix ypsilophora	Brown Quail	-	+	-	+
Cracticus torquatus	Grey butcherbird	+	-	-	-
Dacelo leachii	Blue-winged Kookaburra	+	+	+	+
Daphoenositta chrysoptera	Varied Sittella	-	+	-	-
Dicaeum hirundinaceum	Mistletoe bird	+	+	+	-
Dicrurus bracteatus	Spangled Drongo	+	+	+	+
Ducula bicolor	Pied (Torresian) Imperial Pigeon	+	+	-	-
Geopelia humeralis	Bar-shouldered Dove	+	+	+	+
Geopelia placida	Peaceful Dove	+	+	+	+
Gerygone chloronota	Green-backed flyeater	+	-	-	-
Gerygone olivacea	White-throated Gerygone	-	+	-	-
Grus rubicunda	Brolga	-	+	-	-
Haliastur sphenurus	Whistling Kite	+	+	-	-
Lalage leucomela	Varied Triller	+	+	-	+
Lichenostomus unicolor	White-gaped Honeyeater	+	+	+	+
Lichmera indistincta	Brown honeyeater	+	-	+	-
Malurus lamberti	Variegated fairy-wren	+	-	-	-
Malurus melanocephalus	Red-backed fairy-wren	-	+	-	+
Megalurus timoriensis	Tawny Grassbird	-	+	-	+
Melithreptus albogularis	White-throated honeyeater	+	-	-	-
Merops ornatus	Rainbow Bee-eater	+	+	-	+
Myiagra alecto	Shining flycatcher	+	-	-	-
Myiagra nana	Paperbark Flycatcher	-	+	+	+

Myiagra rubecula	Leaden Flycatcher	+	+	-	+
Myiagra ruficollis	Broad-billed flycatcher	+	-	-	-
Neochmia phaeton	Crimson Finch	-	+	-	+
Ninox boobook	Boobook Owl	-	+	-	-
Ninox connivens	Barking Owl	+	+	+	+
Nycticorax caledonicus	Nankeen Night-heron	+	+	-	-
Oriolus flavocinctus	Yellow Oriole	+	+	+	+
Oriolus sagittatus	Green-backed Oriole	-	+	-	+
Pachycephala rufiventris	Rufous Whistler	+	+	+	+
Pardalotus striatus	Striated Pardalote	-	+	-	-
Philemon argenticeps	Silver-crowned Friarbird	+	+	-	+
Pitta iris	Rainbow Pitta	+	+	-	+
Podargus strigoides	Tawny Frogmouth	-	+	-	-
Poecilodryas cerviniventris	Buff-sided Robin	-	-	-	+
Poecilodryas superciliosa	White-browed robin	+	-	+	-
Poephila acuticauda	Long-tailed Finch	-	+	-	-
Psitteuteles versicolor	Varied Lorikeet	-	-	-	+
Ramsayornis fasciatus	Bar-breasted Honeyeater	-	+	-	+
Rhipidura leucophrys	Willie Wagtail	+	+	+	+
Rhipidura rufiventris	Northern Fantail	+	+	-	+
Taeniopygia bichenovii	Double-barred Finch	+	+	-	+
Todiramphus sanctus	Sacred kingfisher	+	-	-	-
Trichoglossus rubritorquis	Red-collared lorikeet	+	+	+	-
Turnix maculosus	Red-backed Button-Quail	-	-	-	+
Zosterops luteus	Yellow white-eye	+	-	-	-
	Total species	**39**	**49**	**15**	**35**

Fig. 6. Rainbow pitta at 19/2 (A); emerald dove at 21/4 (B).

CONCLUSIONS

The swamp rainforests of the Walcott Inlet are diverse and rare assemblages of rainforest and swamp species, and deserve a high level of protection. Threatening process appear to have minimal impact at the current time, but future shifts in climate, sea level, cattle and pig density, fire regime and weed invasion could all have significant impacts on the integrity of the TECs. The 21/4 site is considered especially vulnerable due to the presence of several small but rich rainforest pockets with a high surface to area ratio, and no geological protection from fires.

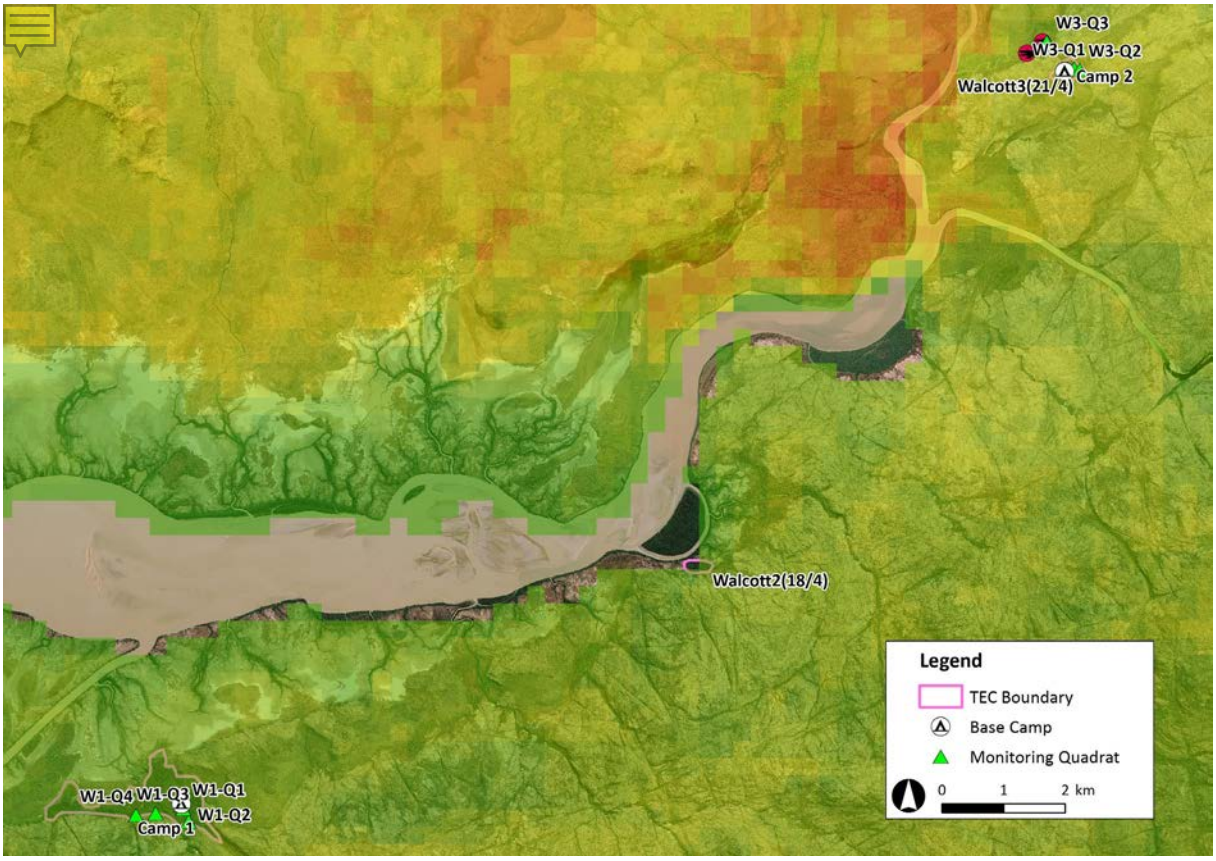


Figure XX. REQUIRES LEGEND

MANAGEMENT RECOMMENDATIONS

Assessment of boundary changes and ongoing monitoring of the relationship between rainforest boundaries and fire frequency / intensity is needed to understand the influence of fire frequency on the patches, and detect any significant contractions. The small 21/4 rainforest patches bordered on all sides by woodland are especially vulnerable to grass encroachment and repeated high-intensity fires, and consideration should be given to increased cool burns in the vicinity to lower the risk of hot burns late in the season. However, such action should be taken with caution, as fire dynamics are very complex – e.g. cool burns could also lead to a buildup of long grass in the adjacent swampy areas that ultimately increase fire intensity of late season burns and so do more damage than good. A solid understanding of past fire regimes and rainforest boundary dynamics will be essential to this assessment. Many of the quadrat borders were located along current rainforest/woodland transition lines to assist shifts in boundaries.

Continued control of feral animals is recommended to keep cattle damage to its current extremely low level. Increased control of pigs would be beneficial especially at 19/2, but is difficult to achieve.
Weed management is mostly not necessary, with the possible exception of management of *Triumfetta pentandra* on the margins of 21/4 near quadrats 1 and 2 (See under 21/4). In the longer term, the TECs should be monitored for the presence of snakeweed (*Stachytarpheta species*), calotrop (*Calotropis* spp.), and Gamba grass (*Andropogon gayanus*), which have the potential to be highly invasive in these habitats.

Monitoring for Myrtle Rust should also be carried out, as it has potential to significantly damage some of the dominant tree species such as *Melaleuca* and *Syzygium*.

Additional survey effort would also be beneficial. Complete inventories could not be completed in the time available due to the focus on quadrats, however several species were found that were not detected in the original surveys, and several species from the original surveys were not relocated. More complete inventory, and additional quadrats would help quantify whether this pattern is due to species turnover, significant changes in the rainforests, or merely incomplete sampling.
If practical, the wax cap community, especially at 19/2, should be further explored to better understand the role of the swamp TECs in conserving fungal associations. DNA barcoding of soil samples may be the most practical approach to assess this diversity, but opportunistic sampling of fruitbodies will also be necessary to validate barcodes.

Due to the presence of flooding waterways, frequent tree falls and remote location, fencing of the TECs is not a viable option, except possibly for occasional discrete patches of rainforest.

Other considerations
In future, sites could be accessed and resupplied from Mount Hart – shorter ferry times, etc. so can potentially take out more gear.
Longer lead in time is required for planning surveys to remote locations that have not been visited in more than 20 years. For instance there were no suitable landing sites at the Roe. Future survey sites should be re-visited earlier in the planning phase to ensure they can be landed at, and a camp established.

Appendix 1. Vascular plant lists.

Appendix 2. Vascular plant height and cover values.

Appendix 3. Fungi species list.

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