Survey of Assemblages of Bunda Bunda, and Big Springs organic mound springs of the west Kimberley threatened ecological communities

A report to the Kimberley Region - August 2017 survey of Bunda Bunda and Big Springs organic mound springs TECs
Funded by the Kimberley Science Conservation Strategy (KSCS)

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GOVERNMENT OF WESTERN AUSTRALIA

Department of **Biodiversity, Conservation and Attractions**

Assemblages of Bunda Bunda organic mound springs of the west Kimberley

Summary:

Assemblages of Bunda Bunda organic mound springs of the west Kimberley was endorsed as Vulnerable threatened ecological community (TEC) by the WA Minister for the Environment on 8 May 2002. There are two known occurrences totaling 27 ha that occur over a range of 1.2km (Appendix 1).They represent one of the most southerly occurrences of rainforest in Western Australia. The rainforest species of this community are common to rainforest patches across northern Australia, many of which have much greater species diversity, but are unusual in such a seasonally arid environment.

These coastal springs are located on tidal mudflats in Carnot Bay on the Dampier Peninsula north of Broome. The mound springs lie on a shallow aquifer of surficial sediments, over a major unconfined freshwater aquifer in the Broome Sandstone which meets a saltwater wedge along the coast. The mound springs were identified by Department of Water (2017) as ecosystems with high probability of groundwater-dependence.

Edge of dense rainforest patch – photo Mike Lyons

Current description:

Organic mound spring communities of Bunda Bunda, Dampierland Bioregion. The two known occurrences of these peaty mounds rise above the surrounding tidal flats and are composed of accumulated leaf litter and living vegetation, supporting a dense rainforest (closed forest) and a tall shrubland respectively, each with mangroves in concentriform arrangement. The smaller mound is dry in the centre, but encircled by a moat, fed by permanent freshwater seepage. The larger mound is wet and incompletely enclosed by a leptoscale channel or moat of variable depth which broadens to a microscale saline lake (300 m long, 50 m wide) on the north side. The moats and pools are saline and occasionally inundated during large tides.

View of mudflats mostly devoid of vegetation – photo Jill Pryde

1. Introduction:

The western end of the larger mound is covered by a very dense (closed) forest dominated by evergreen *Carallia brachiata* trees to 20 m and a bracken-like layer of the fern *Cyclosorus interruptus* (to 1 m). This is the most southerly population of *Carallia* in Western Australia. A few *Timonius timon* and dragon trees *Sesbania formosa* occur. The east end of the island is slightly lower, more moist and the leaf litter forms a 'spongier' substrate. It is covered by tall closed forest (< 20m) of *Melaleuca cajuputi, T. timon, S. formosa* with fewer *C. brachiata* and an understory of *C. interruptus.* Creepers including *Cassytha filiformis* and the broadleaved *Secamone elliptica*, drape from trees, and climbing maidenhair ferns *Lygodium microphyllum* form a curtain which filters the light. In the moat-like channel surrounding the large mound are mangroves and the mangrove fern *Acrostichum speciosum*, with an occurrence of the uncommon mangrove *Lumnitzera racemosa* on the eastern side. An endemic (Kimberley) mistletoe, *Amyema dolichopoda* also occurs on the site. The two mounds differ from each other and there is considerable spatial variation in vegetation within each site. There is a clear zonation in the vegetation around the smaller south-western mound spring. It is fringed by a ring of mangroves, predominantly *Rhizophora stylosa* and *Avicennia marina*. Within this lies a band of *Acrostichum speciosum* and trees of *Melaleuca cajuputi* and *Timonius timon* to 12 m.

In the dry centre of the island is a tall shrubland dominated by *Acacia neurocarpa* (<5m), over grasses and sedges. The mudflats around the two mounds are mostly bare of vegetation, however a *Sporobolus ?virginicus* grassland occurs closer to the shore.

2. Background

A survey of the Bunda Bunda organic mound springs was undertaken on 7 August 2017 by a team with expertise in TEC identification and inventory, biological survey including flora and vegetation, aquatic invertebrate fauna identification and wetland inventory. The survey was coordinated by the Kimberley District Nature Conservation Coordinator, with cooperation and assistance of Traditional Owners and Nyul Nyul Rangers.

Bunda Bunda mound springs are surrounded by coastal tidal mudflats north of Broome on unallocated Crown land (UCL). Access to the springs is via Crown Reserve 22615 Carnot Bay. The Traditional Owner group is Djaberadjabera and their permission is required to access the springs. Site visits are recommended during low tide at which time crocodiles are less likely to be present in the area.

Survey included field assistance from Traditional Owners and Nyul Nyul Rangers – photo Mike Coote

3. Objective:

The Kimberley Region is seeking to address knowledge gaps utilising funding from the Kimberley Science Conservation Strategy (KSCS). The aim of the survey was to update TEC baseline information, including description, condition and threats to the TEC and to establish permanent quadrats to record flora and vegetation and inventory of aquatic invertebrates, soils and water chemistry and to update boundaries of the wetland communities as required.

This report covers the TEC aspect of the survey, will assist with the development of a recovery plan, and provides recommendations for management.

4. Methods:

Bunda01 (Occurrence 01)

The following was recorded:

- general vegetation description, condition and structure across the mapped community;
- A flora list (Appendix 2) for vegetation within the quadrat and at random locations throughout the mound spring community;
- threatening processes; and
- management recommendations compiled.

In conjunction with the above, one site was selected to establish a permanent $50x50^2$m quadrat upland from a seepage zone in the north west of the occurrence in tall dense rainforest community over a dense undergrowth of ferns, thick leaf litter, climbing vines and ferns. The quadrat was permanently marked with one 1.6m star picket at NE corner site id KMS17A. Quadrat data (held by M. Lyons) for site include:

- GPS location;
- vegetation description, stratum and structure;
- soil and landform;
- flora specimens were collected from the mound springs seepage areas and damplands surrounding the springs. The flora specimens will be provided for lodging where suitable to the WA Herbarium. (Mike Lyons and Jill Pryde (DRF Permit no. 22-1718); Additional flora collected by M. Coote and A. Turnbull.

and

- Aquatic invertebrate survey, peat core and water chemistry in an area of standing water, located in the south east portion of the occurrence by A. Pinder, K. Quinlan and T. Sonneman.
- Assessment and mapping by the Wetlands group (M. Coote and A. Turnbull) using a handheld GPS in conjunction with aerial photography.
- Photographs of occurrence and surrounding landscape.

These data will be added to the corporate TEC/PEC database when available.

Bunda02 (Occurrence02)

No survey undertaken of flora and vegetation, aquatic invertebrates, peat core or water chemistry, however

- A brief edge survey was undertaken to assess vegetation condition and threats.
- Photographs taken.

Potential new occurrence

A vegetated mound that lies 215m west of Bunda01, not recorded on the TEC database, is likely to align with TEC database identifier Bunda02 (Occurrence2), and appears to have been incorrectly documented on TEC database.

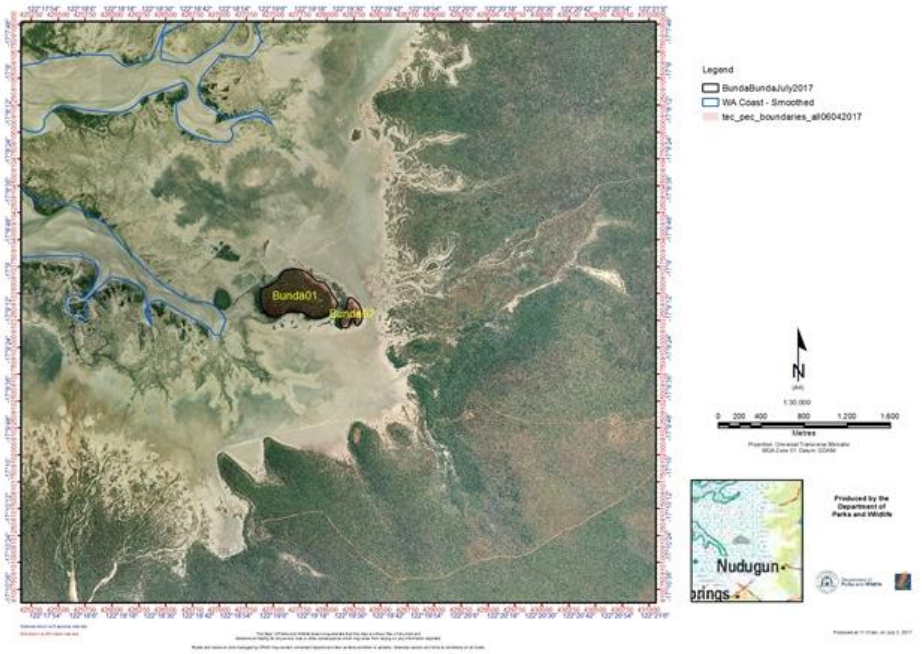
Wetlands group assessed and mapped the “potential new” mound spring using a handheld GPS in conjunction with aerial photography.

5. Limitations

One day was allocated to survey Bunda Bunda organic mound springs TEC and as a result limited the capacity to conduct a full assessment on status and condition across the entire community.

6. Results

Survey at Bunda Bunda organic mound springs TEC was undertaken to coincide with low tide. The TEC comprised two mapped occurrences (Bunda01 and Bunda02) which are situated about 300m from the shoreline, approximately 30m apart. The larger mound (Bunda01) occupies (~22.8ha), with the smaller mound (Bunda02) (~3.6ha) and occurs lower in the landscape. The vegetated mound that lies west of Bunda01 was briefly surveyed for consideration of addition to the TEC database. This spring occupies ~3.8 ha.



Appendix 1. Current mapped boundaries of Bunda Bunda mound springs TEC

Bunda01 (Occurrence01)

Bunda01 is a large vegetated mound surrounded by moats, stream channels and standing pools of water of variable depth. The outlier saline mudflats comprise occasional mangroves, sedges, grasses including *S. ?virginicus* and chenopods. A shrubland-woodland that encircles the mound includes *Melaleuca* sp., mangroves, and mangrove fern *A. speciosum* as well as the occasional *S. formosa*. In the north west portion of the mound, rising from the mudflats, vegetation transforms into a dense, closed rainforest, dominated by *C. brachiata* (>20m) and *T. timon* over a dense stratum of *C. interruptus* > 1m and thick accumulated leaf layer. The climbing fern, *S. palustris* and vines wrap around trees. The eastern and southern portion of the mound is lower in the landscape and has standing water <50cm in depth, contains scattered leaf litter, aquatic herbs, and ferns. Saturated peaty black soils and thick leaf litter combine to form a quaking substrate. This portion of the community is covered by a tall closed forest (>20m) of *C. brachiata, T. timon, S. formosa* and *Melaleuca* sp. over *C. interruptus*, climbing maidenhair fern, *Lygodium microphyllum* and vines.

Dense rainforest patch quadrat (KMS17A) site and Traditional owner

General condition was excellent (Bush Forever scales). The total number of weeds species was low, however the stinking passion vine (*Passiflora foetida*) is likely to become a major threat to the community. In exposed patches it has smothered native vegetation. In the quadrat it was recorded at low density. Introduced fruit trees, including bananas plants (*Musa* sp.), which occur in the south east portion of the occurrence, are likely to spread if not contained and will outcompete native plant species. Damage by cattle is evident where they have encroached wetter areas of the mound springs, primarily in the seepages in the south east and north west.

The weed *Passiflora foetida* likely to become a major threat - photo Mike Coote

Banana plants in south east portion of mound spring – photo Mike Lyons

Findings of the August 2017 survey in regards to flora and vegetation description and component flora species is mostly consistent with the historical TEC database record. Flora species previously recorded were found across the mound springs, however additional flora recorded will be added to the TEC database when identified. No DRF or Priority flora was found, although this information may change once all flora taxa has been processed. Range extensions for flora taxa were documented. Plant species considered useful indicators of rainforest communities and associated mound springs were present. The key threats identified for the mound springs are grazing, weed invasion, altered fire regimes, feral animals, potential hydrological changes (e.g. groundwater extraction) and tourism development.

Bunda02 (Occurrence02)

A brief edge survey of Bunda02 recorded a vegetation community with open structure and appears much dryer with no apparent moat or standing water. Based on observations from this partial survey, no mounding was evident. Vegetation

comprised a woodland of *Melaleuca ?cajuputi* subsp*. cajuputi, Timonius timon* and *Acacia ?neurocarpa* with little understory. The periphery of the community contained mangroves, predominantly *Rhizophora stylosa* and *Avicennia marina*. Records indicate that this occurrence was burnt in October 1995, which may account for the open canopy and lack of peat mounds. Vegetation was in Good condition (Bush Forever scales).

View of Bunda02 – photo Jill Pryde

The key threats identified for the mound springs are grazing, weed invasion, altered fire regimes, feral animals and potential hydrological changes (e.g. groundwater extraction) and tourism development.

Following the survey, mapping of the Bunda Bunda organic mound springs boundaries will be refined. Based on records from previous surveys the area identified as Bunda02, located east of Bunda01 appears to be incorrect. S. Black (2002) noted this area as "*Melaleuca* island". Survey is required to clarify if Bunda02 and the potential new occurrence constitute the TEC. This issue was raised by Environs Kimberley [email dated 22 May 2017].

Once all results of the August 2017 survey are available, the TEC database will be updated and include amendment and refinement of TEC boundaries, taxonomic flora list updates and other biota.

7. Conclusions:

The most significant threats to the integrity of Bunda Bunda mound springs are disturbance from cattle, weed invasion and too frequent fire. Cattle utilise water surrounding the community and vegetation for protection. Damage can be seen in the understory, especially in the areas of ponding water and wetter sites where trampling impacts are evident. Cattle also cause damage to soil structure and

provide unwanted nutrients affecting water quality. The stinking passion flower is likely to become a major threat if not managed. In some locations of the community the stinking passion flower is forming dense mats, smothering vegetation. This is likely to limit growth of native vegetation and modify the structure. The historically planted fruit trees, including banana plants, which occur in Occurrence01, should be removed. However this action is likely to necessitate negotiation with Traditional Owners.

Trampling by cattle evident in the understory – photo Jill Pryde

8. Management Recommendations:

- Seek funds to fence the mound springs complex to restrict cattle entering the TEC;
- Map *Passiflora foetida* across the community and seek ways to control or eradicate the highly invasive weed;
- Seek ways to remove fruit trees, particularly banana plants within Occurrence01;
- Design and implement a project to determine the hydrological drivers of the mound spring ecosystem;
- Design and implement a monitoring program that utilises quadrats established during the current survey. This will probably require establishment of a more comprehensive network of quadrats, and should be designed to provide information about the success of land management in the sensitive environment of the mound spring ecosystem;
- Determine whether Occurrence02 constitutes the TEC and if the vegetated mound to the west of Occurrence01 constitutes a new occurrence of the TEC. This would require hydrological investigation and vegetation survey.

9. References:

Department of Environment, Water and Heritage and the Arts (2008). A report on the application of draft criteria for identification of High Conservation Value Aquatic Ecosystem (HCVAE) on mound springs in Western Australia. Anne Shanahan and Michael Coote, Department of Environment and Conservation, Western Australia.

Department of Water (2017) Groundwater dependent ecosystems of the Dampier Peninsula. Royalties for Regions groundwater investigation. Environmental Water Report series No. 29.

Government of Western Australia (2000) Bush Forever. Western Australian Planning Commission.

Appendix 2. Flora of Bunda Bunda TEC. Compiled from August 2017^ and historical survey data (not a comprehensive list)

Flora taxa	**form**
Acacia neurocarpa	Tall shrub
Amyema dolichopoda	Aerial shrub
Avicennia marina	Shrub/tree
Carallia brachiata	Tree (occasionally buttressed)
Cassytha filiformis	Herb/climber
Cyclosorus interruptus	fern
Cyperus breviculmis	herb
Ectrosia schultzii var. *schultzii*	herb
**Flaveria trinervia*	herb
Fuirena umbellata	sedge
Gymnanthera sp.	Twining shrub/climber
Lumnitzera racemosa	Tree/shrub
Lygodium microphyllum	fern
Mallotus nesophilus	Tree

Melaleuca argentea cf.	Tree
Melaleuca cajuputi subsp. *cajuputi*	Tree
Musa sp.	Rhizomatous, herb,
Rhizophora stylosa (mangrove)	shrub or tree (with stilt and aerial roots)
Schoenoplectus subulatus	sedge
Secamone elliptica	Climber
Sesbania formosa	Tree
Stenochlaena palustris	Fern
Timonius timon	Tree
**Passiflora foetida* L. Stinking Passion Flower	Woody climber

*denotes a weed

^The list of flora will be verified following formal flora identifications.

Survey of Assemblages of Big Springs organic mound springs of the west Kimberley

Summary:

The assemblages of Big Springs organic mound springs was endorsed as Vulnerable threatened ecological community (TEC) by the WA Minister for the Environment on 8 May 2002.

Big Springs organic mound springs are situated on the eastern shore of King Sound, adjacent to the boundary of Meda Station, 12 km east of the mouth of Meda River and 80km north of Broome. There are 23 occurrences covering a total of 62.7 ha recorded across a range of 3 km.

Big Springs organic mound springs – photo J. Pryde

Current description:

A complex system of freshwater seepages and peaty springs with internal moats with broad tidal flats on the seaward margin and cracking clay flats on the landward margin. A further feature is the scattered clusters of small outlying, densely-vegetated mound springs. The main seepage area has an extensive outflow swamp on its north west side. Within the complex, the substrate varies from peat through to peaty grey clay to grey clay. The main seepage area supports well developed rainforest vegetation dominated by forests of *Terminalia microcarpa*, a species not otherwise known south of Walcott Inlet, 90 km to the north east. Several mistletoe species (Loranthaceae) have been recorded in the *Terminalia* canopy, which reaches 20 m in places. Other trees present include cluster fig *Ficus racemosa,* banyan fig *Ficus virens,* the paperbark *Melaleuca ?leucadendra*, *Pandanus* sp., dragon tree *Sesbania formosa* and *Timonius timon*. Much less common species noted were *Antidesma ghaesembilla, Diospyros maritima* and Leichardt *tree Nauclea orientalis*. The understory varies from central open glades with turf of *Cyperaceae* to

pure leaf litter under the *Terminalia* canopies. Internal moats support the mangrove fern *Acrostichum speciosum*. Patches of duckweed *Lemna aequinoctialis* and less commonly, hornwort *Ceratophyllum demersum* occur. One population of climbing swamp fern *Stenochlaena palustris* was noted. The outer perimeter of the large seepage feature is relatively dry in most places with this ring generally dominated by dense thickets of *Melaleuca acacioides* and/or *Acacia ampliceps* with scattered *Bauhinia cunninghamii*, Chinese lantern *Dichrostachys spicata* and occasional boabs *Adansonia gregorii* of small stature. In the north west there is a perimeter swamp with extensive beds of narrowleaf cumbungi *Typha domingensis* and the sedge *Schoenoplectus litoralis*, with the occasional white-flowered black mangrove *Lumnitzera racemosa*. Outlying mound spring islands on tidal flats vary markedly in size and diversity of vegetation. Some of the smallest islands consist solely of *Typha domingensis*. Larger examples often feature *Pandanus spiralis, Sesbania formosa, Acacia neurocarpa* and occasionally *Terminalia microcarpa* and *Ficus* sp., with a range of *Cyperaceae*. Several islands were noted with unusual associations such as *Typha* growing with the mangrove *Lumnitzera* sp.

Diverse overstorey of Big Springs mound springs - photo M. Lyons

2. Background:

A survey of Big Springs organic mound springs was undertaken on 9 August 2017 by a team with expertise in TEC identification and inventory, biological survey including flora and vegetation, aquatic invertebrate fauna identification and wetland inventory. The survey was coordinated by the Kimberley District Nature Conservation Coordinator, with collaboration of Traditional owners and Meda Pastoral Station management.

Big Springs mound springs are surrounded by saline coastal flats at the mouth of the Meda River, King Sound (Appendix 1). The occurrences are confined to unallocated Crown land (UCL) surrounded by Meda Pastoral Lease. Access overland to the TEC is through Meda Station. The Traditional owner group is Warwa.

Appendix 1. Mapped occurrences of Big Springs Mound springs

3. Objective:

The Kimberley Region is seeking to address knowledge gaps utilising funding from the Kimberley Science Conservation Strategy (KSCS). The aim of this survey was to update TEC baseline information, including description, condition and threats to the TEC, to establish permanent quadrats to record flora and vegetation, inventory of aquatic invertebrate and water chemistry and soils, and to update boundaries of the wetland communities as required.

This report covers the TEC aspect of the survey, will assist with the development of a recovery plan and provides recommendations for management.

4. Methods:

Big Springs (Occurrence 01)

BigS01a and BigS01b

- general vegetation description, condition and structure across the mapped community were recorded;

- A fora list (Appendix 4) for vegetation within the quadrat and at random locations throughout the mound spring community;
- threatening processes noted; and
- management recommendations compiled.

In conjunction with the above, one site was selected to establish a permanent $50x50^2$m quadrat in the north west of occurrence in the well-developed, tall, dense rainforest community, in main seepage area. The quadrat was permanently marked with one 1.6m star picket at NE corner, site id KMS18A. Quadrat data (held by M. Lyons) for site include:

- GPS location;
- vegetation description, stratum and structure;
- soil and landform;
- flora specimens were collected from the mound springs seepage areas and damplands surrounding the springs. The flora specimens will be provided for lodging where suitable to the WA Herbarium. Mike Lyons and Jill Pryde (DRF Permit no. 22-1718); Additional flora collected by M. Coote and A. Turnbull.

and

- Aquatic invertebrate survey, peat core and water chemistry in areas of standing water by A. Pinder, K. Quinlan and T. Sonneman.
- Assessment and mapping by the Wetlands group (M. Coote and A. Turnbull) using a handheld GPS in conjunction with aerial photography.
- Photographs taken of occurrence and surrounding landscape.

These data will be added to the corporate TEC/PEC database.

Location of Quadrat KMS18a – photo J Pryde

Core samples taken within central mound– photo T. Sonneman

Dense leaf litter with aquatic herbs within extensive internal moats – photo M. Lyons

All remaining occurrences BigS03-BigS23

Smaller outlying occurrences that are recorded on the TEC database and potential new occurrences investigated:

No survey undertaken of flora and vegetation; aquatic invertebrate, peat core or water chemistry.

Wetlands assessed and mapped boundaries of mound spring occurrences that met criteria of a mound spring, using a handheld GPS in conjunction with aerial photography. Photographs taken of vegetated mounds.

5. Limitations:

One day was allocated to survey Big Springs organic mound springs TEC and as a result limited the capacity to conduct a full assessment on status and condition across the entire community.

6. Results:

Survey of Assemblages of Big Springs organic mound springs TEC was undertaken on 9 August 2017 to coincide with low tide. The TEC is comprised of one large densely vegetated mound which occupies (~8.5 ha), ~128m offshore, with 22 outlying mounds, much less developed and considerably smaller in area, ranging between ~0.20ha -1.3ha. These occurrences extend northward for approximately 3km, along salt flat margins.

Big Spring (Occurrence01)

The largest occurrence of Big Springs organic mound springs is a heavily vegetated mound to an elevation (~8m). The mound contains a mosaic of freshwater seepages, peaty springs and pools. Internal moats surround peaty mounds supporting large mature trees. Soils are brown peaty loam, mostly damp with light to very heavy leaf litter and decaying vegetation.

The community structure is a tall dense rainforest occurring on rises comprising *M. leucadendra* (>20m) with *Terminalia microcarpa, Timonius timon, Sesbania formosa, Nauclea orientalis, Carallia brachiata* and *Ficus* species. Patches of understory vegetation are more open and dryer, containing *Pandanus spiralis* over small grasses and sedges, including *Fimbristylis caespitosa*. Below the densely covered rainforest canopy, vines, climbing swamp ferns including *Stenochlaena palustris* surround trees and form dark impenetrable barriers.

Submerged aquatic herbs – photo M. Lyons

Dense rainforest patch – photo M. Lyons

Mistletoes (*Amyema* spp.) are present high in the overhanging canopy. Internal moats across the community ranged in water depth (>0.75m). Dominant in the moats are stands of *Acrostichum speciosum*, a large fern spreading (>2-3m). Moats were covered with leaf litter, aquatic herbs of *Lemna aequinoctialis* and an aquatic submerged hornwort, *Ceratophyllum demersum* forming a thick mat below the surface of the water. Present but not dominant was *Typha domingensis* and *Cyperaceae* spp.

Aquatic herbs and ferns form dense layers within internal moats – photo J. Pryde

A woodland emerging into a shrubland encircled the mound and included dense stands of *Melaleuca* spp. with occasional stands of *P. spiralis*, together with *S. formosa*, *Acacia* spp. and *Terminalia microcarpa.*

Woodland and moats surround the internal mound – photo K. Quinlan

General condition of Big Springs was Excellent (Bush Forever scales). The number of weed species recorded was low. A patch of date palms were located adjacent to the quadrat. No other major weeds were recorded within the quadrat. A fence that was installed in 2016 by the Kimberley District appears to have controlled cattle access.

Looking north along cattle exclusion fence with smaller occurrences in the distance – photo J. Pryde

Partial survey to the remaining outlier occurrences specified less developed mounds, mostly with no standing water. All mounds lacked well-developed vegetation structure and appeared low in floral species diversity. Mounds were restricted to one or combinations of *Melaleuca* spp. *P. spiralis*, *S. formosa*, *A. neurocarpa, T.*

microcarpa, Ficus sp*., Lumnitzera* spp., *T. domingensis and ?Schoenoplectus subulatus*. General condition of these occurrences ranged from Very Good-Degraded (Bush Forever scales). Dead tree stands and vegetation destroyed or impacted by cattle trampling was evident at some of the mounds.

The cracking clay tidal flats, surrounding these mounds is mostly devoid of vegetation at the time of survey. Stands of *Melaleuca* spp. *Acacia* sp. *P. spiralis*, *Bauhinia cunninghamii, Adansonia gregorii,* mangroves and *Sporobolus ?virginicus* were occasionally present. A tall grassland (unidentified) flanks Occurrence01 and is flourishing as a consequence of the fencing that excludes cattle. There is potential for the established grassland to increase fire risk to the mound springs. Management of the grass requires consideration.

Cracking clay tidal flats – photo A. Turnbull

Preliminary findings of the August 2017 flora and vegetation survey is mostly consistent with the TEC database record. Flora species previously recorded were found across the mound springs, however additional flora recorded will be added to the TEC database in future. No DRF or Priority flora were found, however range extensions for flora taxa were documented. Plant species considered useful indicators of rainforest communities and associated mound springs were present. The key threats identified for the mound springs include grazing, weed invasion, altered fire regimes, feral animals and potential hydrological changes (e.g. groundwater extraction) and tourism development.

One of the smaller vegetated mound to the north – photo M. Coote

For the majority of occurrences recorded on the TEC database, source locations were derived using aerial photography and therefore often inaccurate. Following the August 2017 survey, point location of occurrence and boundary mapping will be updated. Occurrences that do not constitute the TEC will be deleted and newly identified occurrences will be added to the TEC database.

Once all results of the August 2017 survey are available, the TEC database will be updated including amendment and refinement of TEC description and boundaries and updated flora lists and records of other biota.

8. Recommendations

- Design and implement a project to determine the hydrological drivers of the mound spring ecosystems and further investigate historical report that the spring is man-made.
- Design and implement a monitoring program that utilises quadrats established during the current survey. This will probably require establishment of a more comprehensive network of quadrats, and should be designed to provide information about the success of land management in the sensitive environment of the mound spring ecosystem
- Map weeds across the community and seek ways to control of the most invasive weeds.
- Devise management of the grassland occurring between Occurrence01 and the cattle exclusion fence to limit fire risk to the adjacent mound spring.
- Determine whether the small mounds constitute the TEC. This would require vegetation survey and hydrological investigation.

Introduced date palms located within rainforest – photo J. Pryde

9. Conclusions:

The most significant threat to the integrity of Big Springs organic mound springs is disturbance from cattle. Other threats include weed invasion, too frequent fire, and potential hydrological change. Fencing was constructed in 2016 to control impacts of cattle disturbance in Occcurrence01 and as a result the vegetation in this occurrence is in Excellent condition. Date palms are likely to become a major threat if not removed.

The newspaper reports from around 1993 that stated that the spring was man made, having arisen from water seeping from a bore installed in the 1960s, and that this requires investigation. It was considered that this was very unlikely to be the case however, based on observations during the August 2017 survey, such as the presence of the large peat-rich mound, providing a stable, permanently moist suite of microhabitats that would have taken many years to form and the age of plants present. Water continues to penetrate the increasingly elevated peat layers that are likely to be the result of pressure created by local and regional hydrological forces.

Canopy – photo M. Lyons

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Appendix 4: Flora of Big Springs TEC. Compiled from August 2017^ and historical survey data (not a comprehensive list)

Flora list	**form**	**Previously recorded at Big Springs (Environs Kimberley)**	**Recorded August 2017 (informal)**
Acrostichum speciosum	Large fern	+	+
Amyema sp.	Aerial shrub	+	+
Antidesma ghaesembilla		+	
Bauhinia cunninghamii	Tree	+	+
Carallia brachiata	Tree (occasionally buttressed)		+
Ceratophyllum demersum		+	+
Cyperus sp.	herb		+
Diospyros maritima		+	
Eleocharis ?geniculata	sedge		+
Fimbristylis caespitosa			+
Juncus sp.			+
Lemna aequinoctialis	aquatic herb	+	+
Melaleuca alsophila		+	+
Melaleuca leucadendra	Tree	+	+
Nauclea orientalis	Tree	+	+
Pandanus spiralis	shrub	+	+
Ficus racemosa	Tree	+	
Ficus virens	Tree	+	

Ficus sp.	Tree		+
Schoenoplectus subulatus	sedge	+	+
Sesbania formosa	Tree	+	+
Stenochlaena palustris	Climbing fern	+	+
Terminalia microcarpa	Tree	+	+
Timonius timon	Tree	+	+
Typha domingensis	Perennial herb	+	+

*denotes a weed

^The list of flora will be verified following formal flora identification