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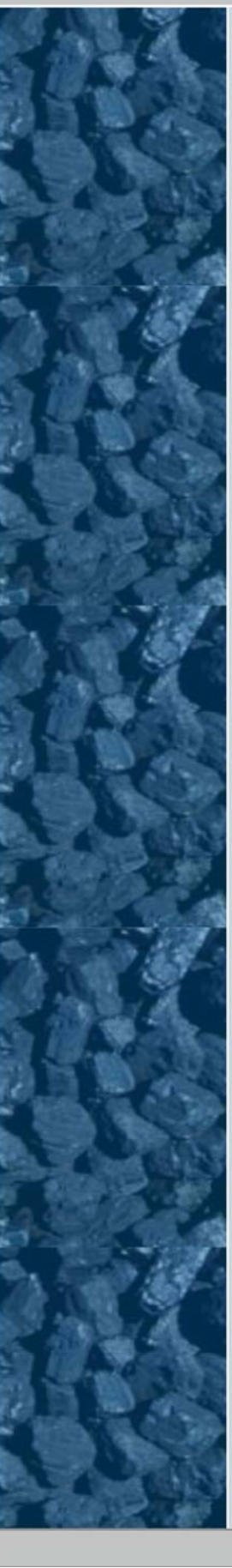

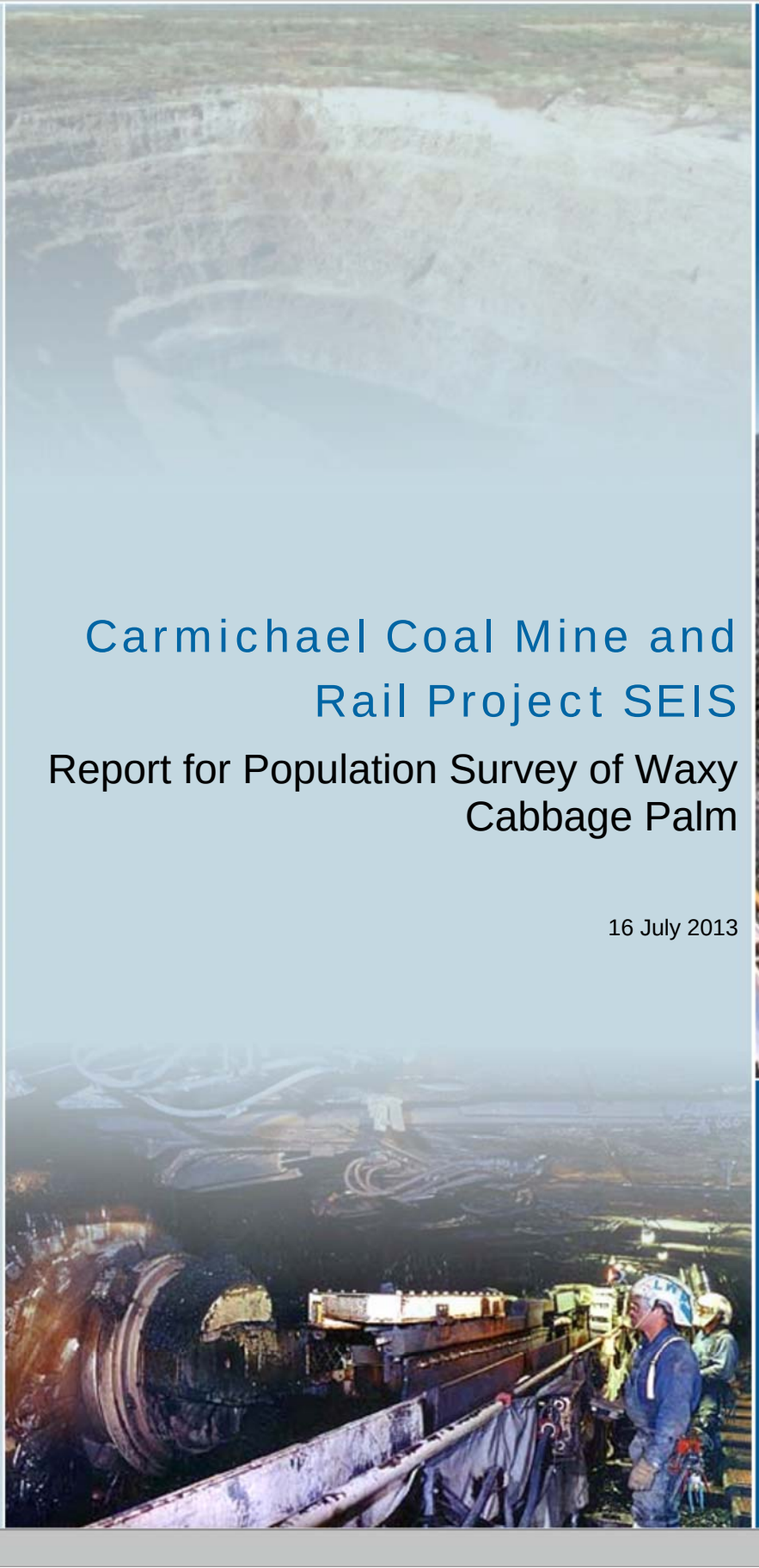

Carmichael Coal Mine and Rail Project SEIS

Report for Population Survey of Waxy Cabbage Palm

16 July 2013

GHD

This Carmichael Coal Mine and Rail Project SEIS: Population survey of the waxy-cabbage palm ("the Report") has been prepared by GHD Pty Ltd ("GHD") on behalf of and for Adani Mining Pty Ltd ("Adani") in accordance with an agreement between GHD and Adani.

The Report may only be used and relied on by Adani for the purpose of informing environmental assessments and planning approvals for the proposed Carmichael Coal Mine and Rail Project (Purpose) and may not be used by, or relied on by any person other than Adani.

The services undertaken by GHD in connection with preparing the Report were limited to those specifically detailed in Section 1.3 of the Report and did not include GHD undertaking testing at some parts of the site.

The Report is based on conditions encountered and information reviewed, including assumptions made by GHD, at the time of preparing the Report. Assumptions made by GHD are contained through the Report and that the information provided to GHD is accurate.

To the maximum extent permitted by law GHD expressly disclaims responsibility for or liability arising from:

- *any error in, or omission in connection with assumptions, or*
- *reliance on the Report by a third party, or use of this Report other than for the Purpose.*

Executive summary

GHD conducted a population survey of waxy cabbage palms (*Livistona lanuginosa* Rodd) targeted at palms located at and in areas adjacent to Moses and Little Moses springs and in Carmichael Coal Mine and Rail Project: Project Area. All palms surveyed were growing either beside Moses or Little Moses springs, or in the Carmichael River and fluvial land forms immediately adjacent to it, or its tributaries. The coordinates of each palm or cluster of palms (a cluster being where two or more palms are located within 5 metres of each other) was recorded, in addition to the height of each palm and the land form on which it was located.

A total of 831 palms were counted, with 19 of these individuals counted at Moses Spring, and the remainder in the Carmichael River (palms at Little Moses Spring, which is located directly beside the Carmichael River, were situated in the river or a tributary). The majority of individuals were situated in two areas of high population density (of 479 palms and 155 palms respectively). These areas of higher density may be simply stochastic, or they may be indicative of highly favourable conditions in those areas.

Based on the report findings, and assuming the population in the Carmichael River does not extend further upstream than Joshua Spring, it is estimated there may be another 800 palms in sections of the river not surveyed. Using the approximate adult population frequency of 11 percent, this suggests there may be another approximately 90 reproductive age waxy cabbage palms, bringing the total in the Carmichael River to 180 adults. However, given the high level of variability noted in this population per 500 m plot, the actual number may vary considerably from this estimate.

During the survey, four threatening processes were noted: weed infestation, feral pigs, cattle and bush fire. Rubber vine is established at various points along the Carmichael River, from Joshua Spring (and likely upstream) to the furthest downstream point surveyed, 2.5 km east of the Project Area.


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1. Introduction

1.1 Project overview

Adani Mining Pty Ltd (Adani, the Proponent), commenced an Environmental Impact Statement (EIS) process for the Carmichael Coal Mine and Rail Project (the Project) in 2010. On 26 November 2010, the Queensland (Qld) Office of the Coordinator General declared the Project a 'significant project' and the Project was referred to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (referral No. 2010/5736). The Project was assessed to be a controlled action on the 6 January 2011 under section 75 and section 87 of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The controlling provisions for the Project include:

- World Heritage properties (sections 12 & 15A)
- National Heritage places (sections 15B & 15C)
- Wetlands (Ramsar) (sections 16 & 17B)
- Listed threatened species and communities (sections 18 & 18A)
- Listed migratory species (sections 20 & 20A)
- The Great Barrier Reef Marine Park (GBRMP) (sections 24B & 24C)
- Protection of water resources (sections 24D & 24E)

The Qld Government's EIS process has been accredited for the assessment under Part 8 of the EPBC Act in accordance with the bilateral agreement between the Commonwealth of Australia and the State of Queensland.

The Proponent prepared an EIS in accordance with the Terms of Reference (ToR) issued by the Qld Coordinator-General in May 2011 (Qld Government, 2011). The EIS process is managed under section 26(1) (a) of the *State Development and Public Works Act 1971* (SDPWO Act), which is administered by the Qld Government's Department of State Development, Infrastructure and Planning (DSDIP).

The EIS, submitted in December 2012, assessed the environmental, social and economic impacts associated with developing a 60 million tonne (product) per annum (Mtpa) thermal coal mine in the northern Galilee Basin, approximately 160 kilometres (km) north-west of Clermont, Central Queensland, Australia. Coal from the Project will be transported by rail to the existing Goonyella and Newlands rail systems, operated by Aurizon Operations Limited (Aurizon). The coal will be exported via the Port of Hay Point and the Point of Abbot Point over the 60 year (90 years in the EIS) mine life.

Project components are as follows:

- The Project (Mine): a greenfield coal mine over EPC 1690 and the eastern portion of EPC 1080, which includes both open cut and underground mining, on mine infrastructure and associated mine processing facilities (the Mine) and the Mine (offsite) infrastructure including a workers accommodation village and associated facilities, a permanent airport site, an industrial area and water supply infrastructure

- The Project (Rail): a greenfield rail line connecting to mine to the existing Goonyella and Newlands rail systems to provide for the export of coal via the Port of Hay Point (Dudgeon Point expansion) and the Port of Abbot Point, respectively including:
  - Rail (west): a 120 km dual gauge portion running west from the Mine site east to Diamond Creek
  - Rail (east): a 69 km narrow gauge portion running east from Diamond Creek connecting to the Goonyella rail system south of Moranbah
  - Quarries: The use of five local quarries to extract quarry materials for construction and operational purposes

1.2 Study area

The Study Area as shown in Figure 1 is comprised of the environs of the Carmichael River within the proposed Carmichael Coal Mine Project Area and immediately upstream and downstream of the Project Area. The Project Area is bound by EPC areas 1690 and 1080 and offsite infrastructure areas.

1.3 Scope of works

GHD was engaged by Adani to conduct a targeted population survey of the waxy cabbage palm (*Livistona lanuginosa* Rodd) within the Study Area. In addition, this report contains opportunistic observations of the waxy cabbage palms located outside of Project Area, made during the performance of other work in the vicinity.

All data except opportunistic observations (identified in any data presentation) was collected by walking the survey sections of the Carmichael River and its immediate floodplain. The coordinates and height of each individual palm or palm cluster were recorded on a hand-held GPS unit. Detail regarding the land form element on which the palm or cluster was located was also recorded. Survey methodology was designed based on a similar published survey for waxy cabbage palm in the Burdekin River catchment (Petit and Dowe, 2003). There are currently no specific survey guidelines from the Commonwealth Department of Sustainability, Environment, Water, Populations and Community (DSEWPaC) for the waxy cabbage palm and, as such, the scientifically accepted method used by Petit and Dowe (2003) provided an appropriate methodology for the population survey conducted

The results of a desktop survey into the species and its known distribution and ecology are also presented, and the report includes observations made in relation to the ecology and population characteristics of the species in the Carmichael River and Moses Spring (and how they differ from the Burdekin Basin population).

1.4 Purpose of this report

The waxy cabbage palm is a vulnerable species (under Queensland and Commonwealth legislation) with a highly restricted distribution – previously thought to be restricted to the Burdekin River catchment, with the exception of four individuals recorded from Moses Spring (DSEWPaC, 2013).

Based on the desktop information targeted surveys for the species were not considered necessary during the ecological investigations for the Carmichael Coal Mine and Rail Project Environmental Impact Statement (EIS). However, during that survey this species was found

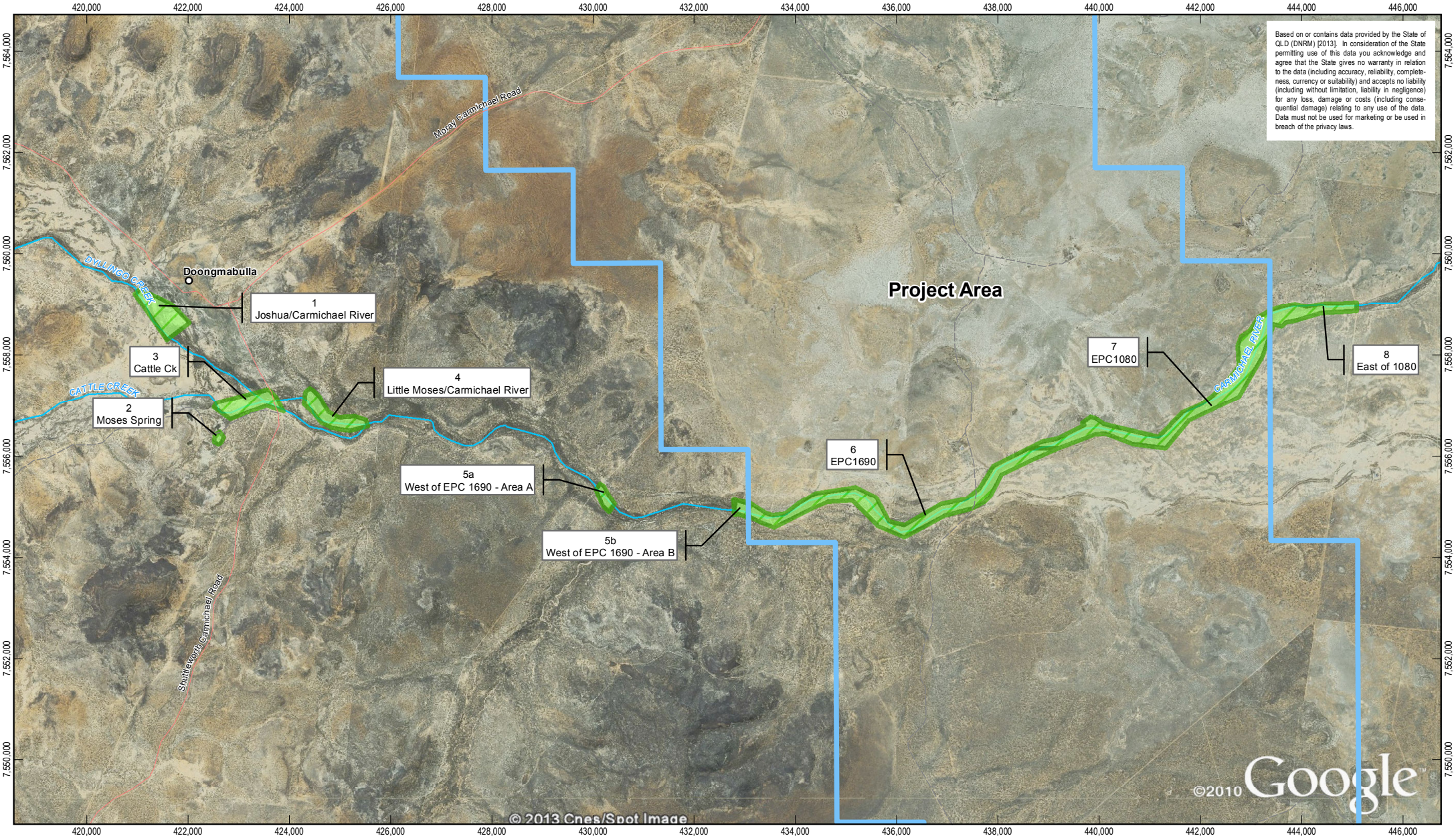
located in the riparian zone of the Carmichael River within Project Area at very low densities (suggesting a population density of approximately two to three palms per kilometre).

The primary purpose of this document is to report the findings of an additional survey conducted to confirm the actual population of the species as it occurs within the Study Area.

1.5 Limitations

Survey effort focussed on the Study Area. Accordingly, this report does not present a population assessment of the target species across the entire Carmichael River. In addition, errors associated with GPS equipment, particularly when underneath a dense canopy of vegetation, mean these locations should not be relied on for the purpose of infrastructure planning or other such detailed requirements – a horizontal error of at least +/- 15 metres (m) should be assumed for each point.

The ground layer in many areas surveyed is very dense and up to 1 m tall. In these areas, palm seedlings that are less than 1 m tall can be very difficult to find. Every effort was made to locate all waxy cabbage palm individuals within the survey areas, and observational effort across the 17.5 km of river channel surveyed provides confidence that sufficient effort has been applied to identify the entire population within the Study Area. This report is based on the assumption that the entire population was located for the areas surveyed.



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Kilometres

Map Projection: Transverse Mercator
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Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Homestead
- Local Road
- Track
- Watercourse
- Project Area
- Study Area

Adani Mining Pty Ltd
Population survey of the waxy cabbage palm

Job Number 41-25215
Revision B
Date 19 Jun 2013

Survey Area

Figure 1

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2. Literature review

2.1 Overview

The waxy cabbage palm, also known as the Cape River fan palm, the Ravenswood palm, the Halifax fan palm and the Burdekin palm, is listed as vulnerable under both Queensland and Commonwealth legislation. It was first described in 1998 in a complete revision of the Australian members of the genus *Livistona* (Rodd). This palm, which has a limited distribution in small groups on tributaries of the Burdekin and Belyando River (based on current understanding), had only been discovered by science in the late 1970s, although it has the distinction of being recorded by Leichhardt in 1845 on his famous journey of exploration from near Dalby to Port Essington (near the modern Darwin) (Dowe, 2009). The ecology and current known distribution of this species (prior to this survey) is outlined in the following sections.

2.2 Waxy cabbage palm ecology

2.2.1 Morphology

The waxy cabbage palm grows to approximately 20 m tall, and is a typical 'cabbage' palm, in that the leaves are broadly circular, reaching up to 190 centimetres (cm) in width (see Plate 1 and Plate 2). Leaf stems grow up to 200 cm long, and are armed with sharp thorns along the basal margins (Rodd, 1998). The species is distinctive for the long woolly hairs (= *lanuginose*, from which it derives its Latin name) on the stems of the leaves (the petioles) and the flower stalks (the inflorescence rachis) (see Plate 2). It is also considered to be 'functionally dioiceous' (Dowe, 2009), meaning that each plant is bisexual, but only female or male flowers, not both, are borne at any one time by an individual plant (Dr Paul Forster, pers. comm. 2 May 2013). In addition, waxy cabbage palm has the largest seed of any Australian Livistona, 25 – 36 millimetres (mm) in diameter (Rodd, 1998; Dowe and Jones, 2011).

Plate 1 Waxy cabbage palms at Moses Spring (left); showing blue-green waxy leaf surface (right)

Plate 2 Characteristic waxy cabbage palm woolly flower stalk (left); close up (right)

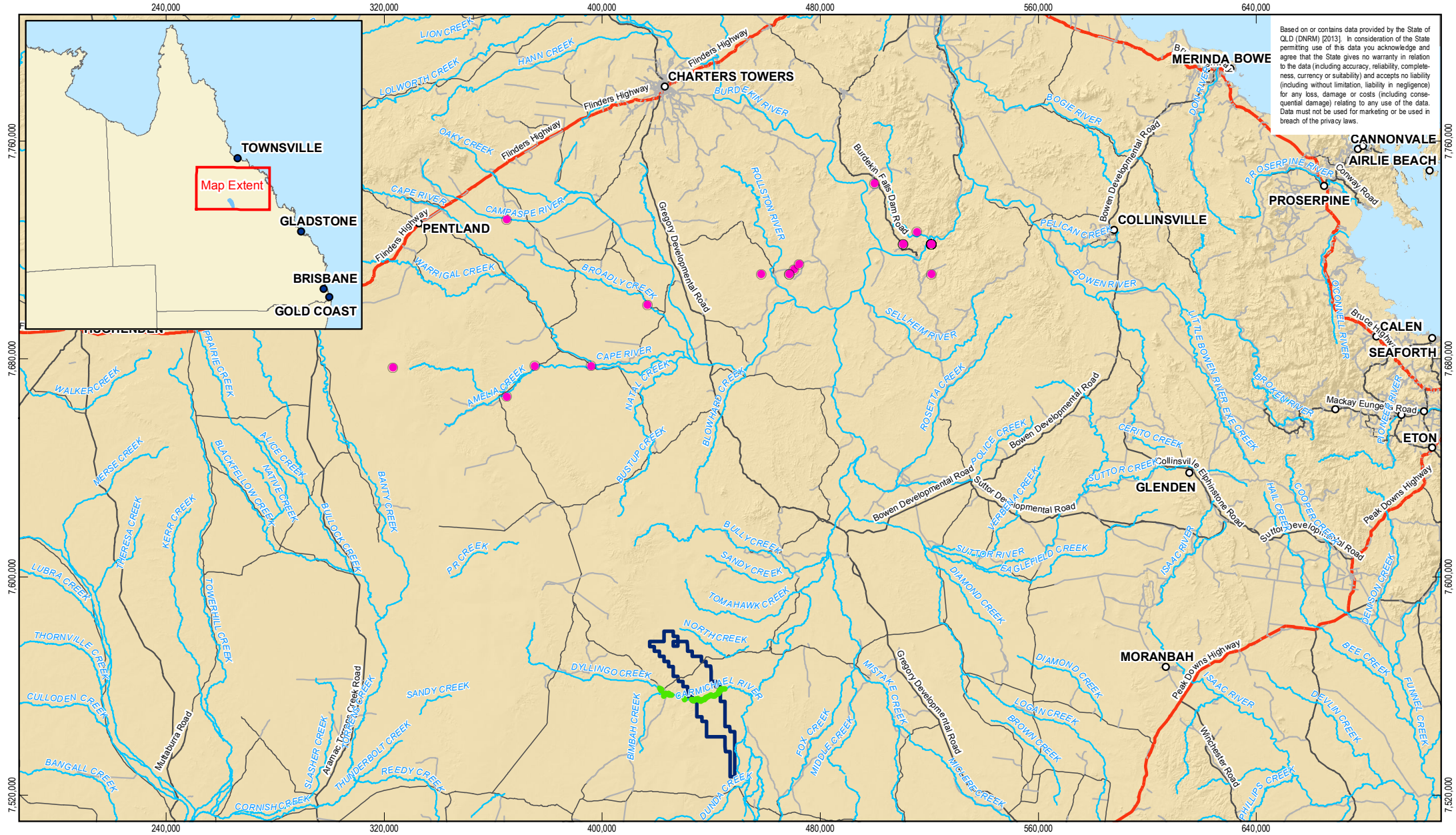
2.2.2 Distribution and population

In general, there is a shortage of records in Australian herbaria for the waxy cabbage palm (relative to other plant groups). This is no doubt owing to the difficulty in accessing reproductive features of tall palms. They do not tend to become reproductively mature until they are of such a height that the leaves, flowers and fruits are out of the practical reach of the tallest persons. There is also the practical problem of pressing leaves and other floristic features that are often greater than 1 m or more in diameter. All records of collections lodged with Australian herbaria are for palms located in tributaries of the Burdekin, primarily upstream and within 130 km of Lake Dalrymple, as mapped in Figure 2. The main river systems from which Australian herbaria records exist are the Cape and Campaspe rivers and their tributaries, in the Burdekin catchment (CHAH, 2013).

However, the waxy cabbage palm has been recorded prior to this survey at other locations including Doongmabulla and Carmichael River (see Plate 3) in the Belyando catchment (Figure 1) (DSEWPaC, 2013) (although the species does not appear on Protected Matters Search Tool results for this area). In addition, Dowe reports other known populations from the lower Suttor and Belyando River catchments. All known Belyando catchment populations (with the exception of Doongmabulla) are located within 40 km of the main population on the Cape River (Dowe, 2007) and 70 km north east of the Project Area. However, the waxy cabbage palm does not appear to be present in the actual Burdekin, Suttor or Belyando rivers themselves (Dowe, 2007; DSEWPaC, 2013).

All populations are reported to be ‘scattered, with rare dense congregations’, and most have ‘limited regeneration and unbalanced recruitment between size classes’ (Dowe, quoted in DSEWPaC, 2013). Population structure generally follows a ‘reverse J’ pattern (Dowe, 2007), under which a relatively large seedling count tapers off rapidly as age class increases, to show a slight rise when reproductive age is reached (thus forming a reversed and left-tilted ‘J’ – see Figure 6 for an approximation of this curve). Based on surveys conducted in 2002 by Dowe and Petit, it was estimated that the total adult (i.e. reproductively mature) population of the entire species (restricted to the Burdekin River catchment as it was at that time thought to be) is less than 1000 individuals (Petit and Dowe, 2003, quoted in DSEWPaC, 2013).

Plate 3 Waxy cabbage palms on Carmichael River channel bench (April, 2013)



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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- *Livistona lanuginosa*
- QLD Populated Place
- Watercourse (Major)
- Project Area
- Study Area

Adani Mining Pty Ltd
Population survey of the waxy cabbage palm

Job Number 41-25215
Revision A
Date 19 Jun 2013

Location of all current Australia herbaria records of the waxy cabbage palm

Figure 2

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2.2.3 Habitat requirements and growth characteristics

All known populations of waxy cabbage palm are growing on sandy, ephemeral watercourses or their floodplains. These watercourses are often braided or anastomosed systems, although populations do occur on single channel streams (Dowe, 2010; Rodd, 1998; DSEWPaC, 2013). At some sites, palms have been located growing on the floodplain, and these have been associated with a high water table (Dowe, 2009). However, individuals are usually located within or adjacent to the stream channel, where they can form an important component of the riparian canopy (Petit and Dowe, 2003). Riparian canopy vegetation recorded as associated with the waxy cabbage palm includes *Eucalyptus camaldulensis* (river red gum), *E. tereticornis*, *E. platyphylla* (referred to as *E. alba* in Herbrecs record E.J. Thompson 238), *Melaleuca leucadendra* (weeping paperbark), *M. fluviatilis* (narrow-leaved paperbark), *Casuarina cunninghamiana*, and *Corymbia brachycarpa* (Queensland Herbarium, 2013; Rodd, 1998; DSEWPaC, 2013).

The waxy cabbage palm produces the largest fruit of any species in its genus, 25 – 36 mm in diameter (Rodd, 1998; Dowe and Jones, 2011). Flowering occurs from March to November (mid-wet to late dry season), and fruit has been recorded from September to January (mid-dry to early wet season) (Dowe, 2010). The primary mechanism of seed dispersal appears to be gravity, as evidenced by the large numbers of seedlings clustered around the base of mature female plants. However, numerous isolated individuals have also been recorded, indicating that another dispersal mechanism is active, most likely water (as the populations are almost exclusively located within the zone of flooding) (Petit and Dowe, 2003). Certainly, fruiting in the mid-dry to early wet season occurs in time for flood dispersal, and Rodd (1998) states that the seeds are well adapted to dispersal by flood. Any role mammals or birds may play in the dispersal of seeds is not known (Dowe, 2007).

The seed of the waxy cabbage palm requires deep burial in order to germinate (Dowe, 2007), an occurrence with a higher possibility if seeds are distributed by flood events, during which time large amounts of sand and fine debris are also being relocated. The fact that the seeds do not appear to float (S. Danielsen, personal observation) may increase the probability of deep burial. However, the presence of clusters of seedlings beneath mature palms indicates dispersal by flooding is not a pre-requisite of successful germination (whether the plant survives to maturity is another matter). Petit and Dowe (2003) postulated that successful recruitment may also rely on the overlapping of a number of climatic and environmental factors, including wet season flooding and early receding of those floodwaters coinciding with a successful seed-fall and some dry season rainfall. Such coinciding events are likely to episodic, and this may explain the irregular population structure of the waxy cabbage palm as observed in their survey.

When the seed germinates, it sends seedling roots as much as 100 cm into the soil (Dowe, 2007), this is no doubt facilitated by being located in relatively loose sandy alluvium. Deep burial of the growing stem and a deep initial root system means the developing stem is located beneath the ground for some time after germination, which incurs a number of advantages, including protection from grazing, fire (Petit and Dowe, 2003), dehydration, and scouring/uprooting during flooding.

Petit and Dowe (2003) nominated seven life stages for the waxy cabbage palm (the following is a direct quote):

1. Seedling: leaf blades are undivided
2. Fan: some leaves have commenced to develop fan morphology divisions
3. Rosette: all leaves have developed fan morphology divisions
4. Establishment: below ground stem has attained estimated width but no above ground stem is yet visible
5. Sub-adult: some above ground stem is apparent
6. Non-reproductive adult: palm attains height at which flowering is expected to shortly commence
7. Adult: a flowering palm, 4 –18 m tall

The results of population surveys conducted by Petit and Dowe (2003) indicated that in 90 percent of the populations they surveyed, adult palms were approximately 6 m tall, and that there was a good relationship between life stage and height. In a 2007 article, Dowe states that maturity is usually reached after 15 – 20 years, and although no details are recorded for waxy cabbage palm, the life span for at least one *Livistona* species (*L. eastonii*) is estimated to be up to 720 years (Hnatiuk, 1977).

2.2.4 Dispersal and population structure dynamics

As mentioned in Section 2.2.2, the structure of waxy cabbage palm populations (and those of a number of other palm genera) was found to generally follow a reverse 'J' curve pattern (Dowe, 2010) (see Figure 6 for an example of this type of curve). This indicates a proportionately very high number of seedlings with an increasing trend towards mortality as palms grow beyond the seedling stage and are gradually thinned out due to grazing, competition, climatic variation, poor micro-siting at germination, and other events such as floods. However, those that reach maturity (approximately 15 – 20 years) are generally well-established and able to withstand such factors, and the much longer time span inherent in maturity (perhaps 700 years or more) allows numbers in the adult age class to again increase (Dowe, 2010).

The degree of structural heterogeneity present in a watercourse may affect the age structure of a population through increasing recruitment success (Petit and Dowe, 2003). When a watercourse contains a range of structural features such as sandbars, levee banks, river terraces, point bars, pools and riffles, the velocity and direction of floodwaters will be continually shifting, providing opportunities for deposition of seed, suspended fines and debris. However, Petit and Dowe (2003) noted that 'differences [in population structure between their study sites] did not appear to be strictly related to stream type' (p. 213). The history of fire at a site is also a factor that influences population age structure, although the waxy cabbage palm has characteristics that render it able to resist fire to a certain extent (Dowe, 2010). Other factors that may affect the age structure of a population at a site include the presence of other fertile populations upstream, their ability to secondarily disperse to the site, and the history of exposure to threatening processes such as grazing and weeds (Petit and Dowe, 2003).

2.2.5 Threatening processes

Threatening processes listed for the waxy cabbage palm by DSEWPaC (2013) are:

- Inappropriate or modified fire regimes
- Changes to hydrology including building dams and barriers
- Weeds and pests through direct competition or habitat degradation
- Restricted geographic distribution
- Grazing pressure (stock will browse seedling leaves – Dowe, 2007)
- Grazing pressure trampling seedlings and disturbing the hydrology of its habitat
- Clearing and fragmentation for agriculture

It should be noted that waxy cabbage palm is believed to be somewhat fire resistant, as:

- The growing tip is located inside the stem
- The stem is buried underground during the seedling stage
- Leaf bases at the base of the trunk are retained in young waxy cabbage palms, and tend to act as a shield against low intensity fire
- Dead, dried leaves tend to be held away from the trunk, so the intense heat caused when this material burns is removed from the trunk (Petit and Dowe, 2003; Dowe, 2010)

However, frequent fires combined with continuous grazing may overcome this resistance (Petit and Dowe, 2003). In particular, Petit and Dowe (2003) stressed the threats to the species from frequent fires, heavy weed infestations, and grazing (mostly associated with trampling, not just of seedlings but through damage to river beds and banks which form habitat for the species). These authors considered that these threats together with 'its limited geographic range and the small isolated population size makes it vulnerable to rapid decline given unfavourable natural conditions such as extended drought periods' (Petit and Dowe, 2003, p.207).

3. Field survey findings

3.1 Survey methods

A survey of the population of waxy cabbage palm was conducted by GHD in April 2013. The areas systematically surveyed are presented below in order from upstream (west) to downstream (east) (see Table 1 for coordinates, and Figure 1 for locations):

1. A section of the Carmichael River adjacent to and downstream from Joshua Spring (within Doongmabulla station)
2. The population growing at Moses Spring (within Doongmabulla station)
3. The population growing at Cattle Creek (within Doongmabulla station)
4. The population growing in the riparian environs of the Carmichael River and the adjacent sections of its northern tributaries immediately adjacent to Little Moses spring and downstream (within Doongmabulla station)
5. A stretch of the Carmichael River approximately 3 km upstream of the Project Area western boundary (within Moray Downs station)
6. A 6.5 km continuous section of the Carmichael River within the Project Area
7. A 5 km continuous section of the Carmichael River within the Project Area
8. A section of the Carmichael River immediately east of the eastern boundary of the Project Area (within Moray Downs station)

Each survey area within the Carmichael River was divided into 500 m linear plots (i.e. 500 m as measured parallel with the river's direction of travel, replicating the survey method of Petit and Dowe (2003) to allow for direct comparison to the Burdekin Basin populations of waxy cabbage palm. A total of 35 plots, each 500 m long were surveyed. The full width of the river channel (i.e. all available suitable habitat no matter how far from the channel) was searched, and any individual palms located were counted, including those on the adjacent floodplain.

In addition, sections of Cattle Creek, a major tributary of the Carmichael River, were traversed during the course of travelling and other work being done at the time in Moses Spring, and opportunistic records were taken of palms when observed (most were located directly beside the main track to Moses Spring). These records were not obtained systematically and cannot be used for the purpose of determining the age class structure of a plot or estimating overall population size. However, they do point to the presence of the palm on this tributary (the Carmichael River is only 80 m away at this point, as Cattle Creek runs parallel to it for some kilometres).

No other palm species were observed in the survey area. The occurrence of palms in inland areas is unusual and no other palm species is known to occur in the Belyando-Burdekin catchment (Dowe, 2010; Rodd, 1998). Although palm seedlings are difficult to identify as juveniles, the lack of any other palm species likely to occur in this area, plus the verified presence of adult waxy cabbage palms in the area, indicates that the juveniles found during the survey are highly likely to be waxy cabbage palms.

Table 1 Summary of waxy cabbage palm population data collected at all sites surveyed

	Location	Longitudes on Carmichael River (WGS84)	River front (km) or area	Seedling (total/% freq)	Sub-adult (total/% freq)	Adult (total/% freq)	Total
1	Joshua Spring/ Carmichael River	146°14'3.34"E to 146°14'23.10"E	1 km	0 palms	0 palms	0 palms	0 palms
2	Moses Spring^	Within a radius of 100 m of 22° 5'46.07"S 146°14'58.88"E	3.6 ha	1 palm (5%)	9 palms (47%)	9 palms (47%)	19 palms
3	Cattle Creek*	146°14'57.28"E and 146°15'46.76"E	1.3 km*	1 palm % freq n/a*	3 palms % freq n/a*	1 palm % freq n/a*	5 palms
4	Little Moses Spring/ Carmichael River	146°15'56.60" E to 146°16'41.27" E	1.5 km	16 palms (89%)	1 palm (5.5%)	1 palm (5.5%)	18 palms
5	West of Project Area	Area A: 146°19'18.90" E to 146°19'29.94" E Area B: 146°20'53.43" E to 146°20'47.54"E	A & B: 0.5 km	50 palms (62.5%) 13 palms (65%)	26 palms (32.5%) 6 palms (30%)	4 palms (5%) 1 palm (5%)	80 palms 20 palms
6	Within Project Area	146°21'3.80" E to 146°24'36.09" E	6.5 km	258 palms (50%)	184 palms (36%)	75 palms (14%)	517 palms
7	Within Project Area	146°24'36.09" E to 146°27'15.10" E	5 km	158 palms (93%)	3 palms (2%)	8 palms (5%)	169 palms
8	East of Project Area	146°27'15.10" E to 146°28'11.40" E	2.5 km	2 palms (67%)	0 palms	1 palm (33%)	3 palms
	Totals[#]		17.5 km	499 palms (60%)	232 palms (28%)	100 palms (12%)	831 palms

^ Moses population not linear and not located on Carmichael River

* Cattle Creek was not population surveyed and therefore % freq is not applicable

[#] not including Moses or Cattle Creek

The survey consisted of two GHD ecologists walking the length of each 500 m plot, one on each side of the river, logging on hand held GPS:

- the coordinates of palm individuals or clusters (a cluster being where more than one palm was located within a 5 m radius of at least one other palm)
- the estimated height of each palm (in cases where clusters made measuring each palm difficult, an average was recorded)
- the location of each palm in terms of fluvial land form elements

The following lists the fluvial land form elements from which palms were recorded in order from the centre of the channel outwards:

- Bed of a channel
- Channel bar – the top of a mid-channel bar, not the bank
- Bank of a channel/channel bar
- Channel bench – the flat immediately adjacent to the outer edges of the river, an area subject to frequent flooding
- Scroll plain – a plain characterised by a short series (usually less than five) of long, curved, low ridges and intervening shallow swales formed as the river meanders across the plain
- Tributary – any tributary of the Carmichael River
- Alluvial plain – palms were only recorded on this land form at Moses Spring

Moses Spring was searched and only one cluster was located – growing within an area of approximately 2 ha in open woodland and grassland on the periphery of the spring. Individuals were photographed, mapped with a GPS, and the height was recorded (they were all on the same land form).

Vouchered specimens of adult waxy cabbage palms were submitted to the Queensland Herbarium from Moses Spring (voucher identification – SFDanielsen1870) and the Carmichael River within the Project Area (voucher identification – SFDanielsen1880). These specimens were confirmed as waxy cabbage palm and the samples were incorporated into the Herbarium collection (see Appendix B).

After surveying 5,179 waxy cabbage palms across eight sites in the Burdekin catchment, Petit and Dowe (2003) concluded there was a good [sic] relationship between life stage (as outlined in Section 2.2.4) and height of an individual. While GHD did not collect life stage descriptions for each individual counted, it is possible to use the height data collected during the GHD survey to approximate the life stages of Petit and Dowe (2003). These approximations are based on data provided in the 2003 Petit and Dowe report outlining the 10^{th}, 25^{th}, median, 75^{th} and 90^{th} percentile heights of each life stage in their study, and are as follows:

- Seedling, fan and rosette stages: palms measuring up to 2 m tall – this encompasses all of the seedling and fan stages, and the lower 90 percent of the rosette stage (the most advanced stage in this group) as measured by Petit and Dowe, but may also encompass the lower 10 percent of the next highest stage
- Establishment, sub-adult and non-reproductive adult stages: palms measuring 2 – 6 m – this encompasses the upper 90 percent of the establishment stage, all of the sub-adult

stage, and the lower 75 percent of the non-reproductive adult stage, but also the lower 10 percent of the next highest stage

- Adult: palms greater than 6 m tall – this incorporates the upper 90 percent of the adult stage, but also the upper 25 percent of the next lowest stage, non-reproductive adult.

These approximations were used in the next sections to analyse and discuss the population structure of waxy cabbage palm at the sites surveyed. For this purpose, the pre-adult life stages of Petit and Dowe have been reduced to 'super-stages' and labelled as follows:

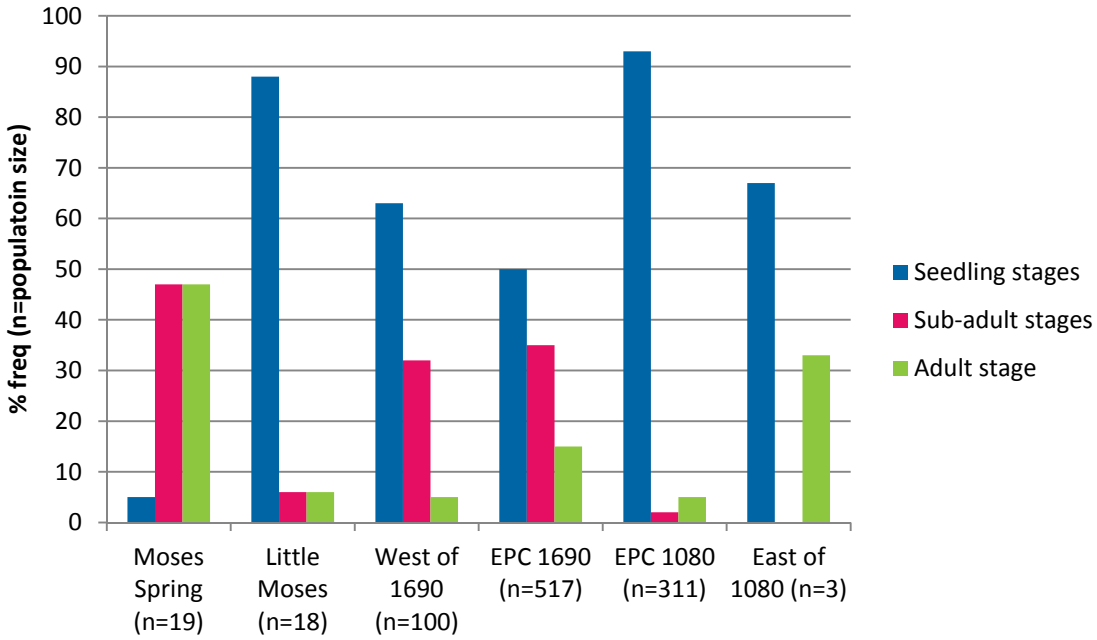
- Seedling stage – encompassing the seedling, fan and rosette stages of Petit and Dowe (2003)
- Sub-adult stage – encompassing the establishment, sub-adult and non-reproductive adult stages of Petit and Dowe (2003).

The adult or reproductive stage has been retained as outlined in Petit and Dowe (2003).

3.2 Summary of population findings

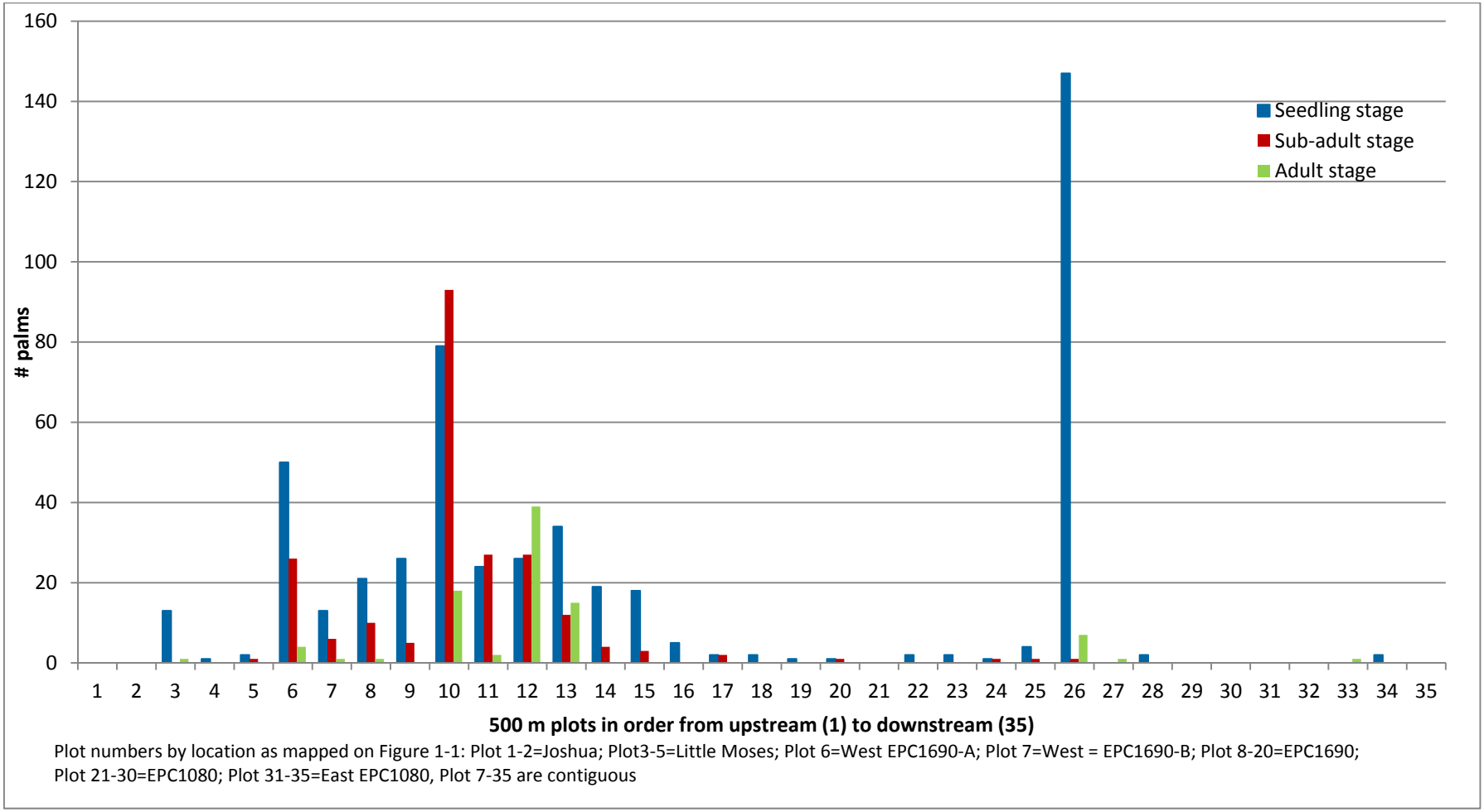
From areas surveyed and from opportunistic observations in April 2013 (see Figure 1), a total of 831 waxy cabbage palms in all life stages were counted within the Moses Spring population and along a collective 17.5 km of Carmichael River frontage. The results are summarised by section surveyed, and by life stage, in Table 1 (the findings are presented in order from upstream to downstream). To allow a visual comparison between sites, a bar graph showing the population structure at each location is provided in Figure 3. The five opportunistic observations taken at Cattle Creek are not included in this information as that data is not comparable to the Carmichael River survey data; i.e. it was not systematically collected for the purpose of population analysis in the same manner as the 500 m plots.

Figure 3 Percent frequency of life stages at sites with waxy cabbage palm



The following sections contain a discussion of findings and what this indicates for population structure and the local ecology of the species. Figure 4 summarises the population survey overall and shows the actual numbers of palms per 500 m plot surveyed, by life stage, in progression from the furthest upstream plot with palms recorded (Little Moses) to the furthest downstream plot surveyed. This graph provides a summary of all of the 500 m plots downstream from Little Moses, showing which had the highest populations, what the relative population structure of each plot was, and how density and population structure changed with distance downstream. As Moses Spring is located on a different land form to the Carmichael River population and is believed to be reproductively isolated from that population, it is discussed separately. Line graphs depicting the life stage composition of each population are provided as Figure 5 (for Moses Spring) and Figure 6 (for the Carmichael River as a whole).

Figure 4 Population structure for all 500 m plots in Carmichael River, showing population clusters and spatial change



Plot numbers by location as mapped on Figure 1-1: Plot 1-2=Joshua; Plot3-5=Little Moses; Plot 6=West EPC1690-A; Plot 7=West = EPC1690-B; Plot 8-20=EPC1690; Plot 21-30=EPC1080; Plot 31-35=East EPC1080, Plot 7-35 are contiguous

Figure 5 Population structure curve of waxy cabbage palm at Moses Spring

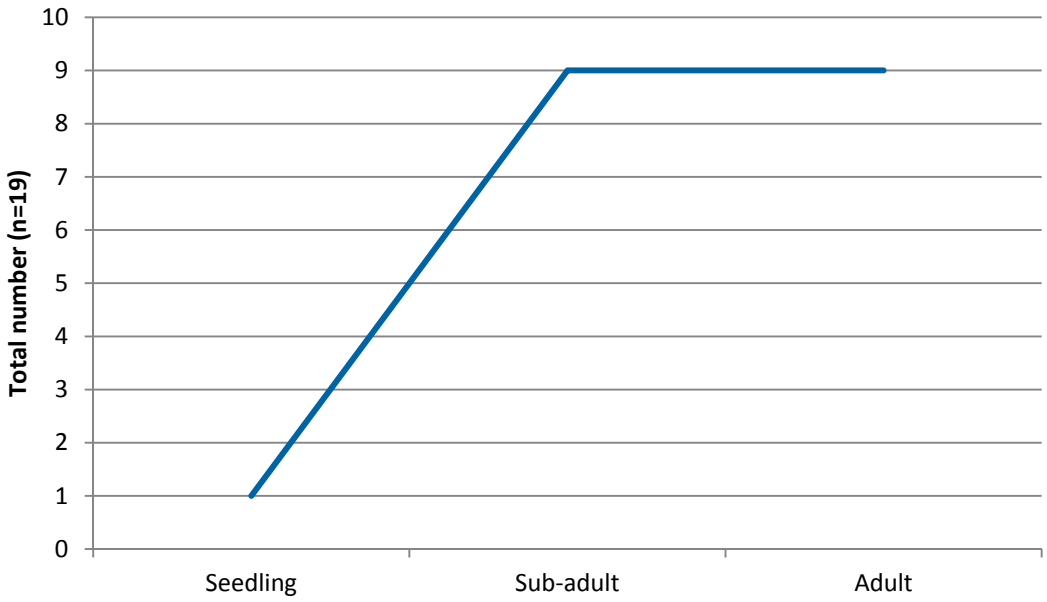
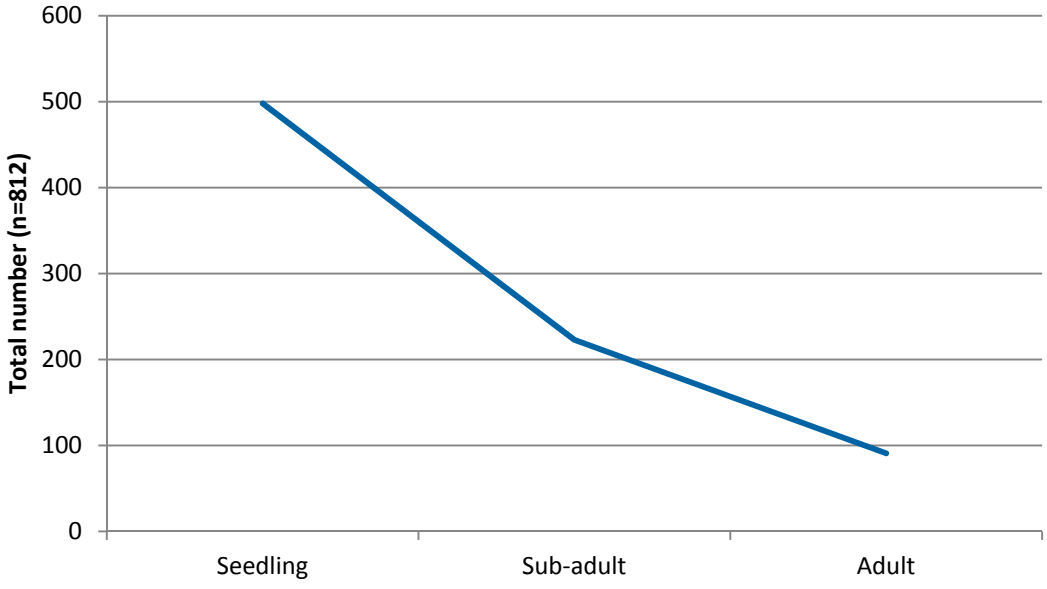


Figure 6 Population structure curve for Carmichael River/Cattle Creek waxy cabbage palm population



3.3 Population structure of waxy cabbage palm at Moses Spring

3.3.1 Landscape characteristics

A spring group is comprised of a cluster of springs located on a similar land form and where each individual spring is situated within at least 2 km of every other spring (Fairfax and Fensham, 2002). The Moses Spring group consists of a group of at least 65 individual Great Artesian Basin (GAB) springs located over an area approximately 2.6 km long and 850 m wide (GHD, 2013), and is protected as a nature refuge (the Doongmabulla Nature Refuge). It straddles Cattle Creek, a tributary of the Carmichael River, and is located on a broad alluvial plain possibly formed by either one of these watercourses. In at least three locations wetlands ranging in area from 0.6 – 2 ha have formed where outflow of water is either at a higher volume or a number of springs are clustered together. These wetlands are dominated by a mix of grasses, sedges and graminoids that include five threatened species endemic to the GAB (GHD, 2013). In, and adjacent to these wetlands, pools of standing water have collected as run off from the springs. Vegetation growing within the Moses Spring group comprises the regional ecosystem (RE) 10.3.31, described as GAB spring-fed *Sporobolus pamalae* tussock grassland, *Melaleuca leucadendra* woodland or sedgeland (Queensland Herbarium, 2013a).

The land form at this location is level to gently undulating, with a very fine, almost white structure-less sandy soil that easily breaks down into a deep 'bulldust' when driven over or trampled. This soil is mapped as Quaternary alluvium (Bureau of Mineral Resources, Geology and Geophysics, 1972). Patches without vegetation of any kind are common, and where the soil has not been disturbed a fine soil crust is often present. The tree canopy in this area is generally 8 – 15 m in height, and *Acacia salicina,* weeping paperbark, river red gum and *Corymbia clarksoniana* are a conspicuous component of vegetation amidst the waxy cabbage palm population (see Plate 4). Nearby, dense patches of *Melaleuca nervosa* or quinine bush (*Petalostigma pubescens*) are common. Grasses include *Sporobolus contiguus, S. coromandelianus, S. australasicus, S. virginicus, S. pamalae* (one of the GAB spring endemics), *Eragrostis spartinoides* and *Diplachne fusca* var. *fusca* (formerly Leptochloa). Herbs and low shrubs of note were *Trianthema* sp. (Coorabulka R.W. Purdie 1404) and *Sclerolaena glabra*.

3.3.2 Survey findings

Previously, the waxy cabbage palm population at Moses Spring was thought to number four individuals (DSEWPaC, 2013). A first order watercourse runs along the south eastern edge of the spring group, and in the vicinity of this stream, 260 m south of the nearest Cattle Creek channel (which also contains waxy cabbage palm), a population of 19 waxy cabbage palms are located (Figure 7). The palms are located at the interface between two vegetation communities – a *Sporobolus pamalae* grassland forming part of the springs RE 10.3.31, and a river red gum (variety *obtusa*) and weeping paperbark woodland/open woodland forming part of the RE 10.3.14, which comprises much of the vegetation adjoining the south eastern edge of the Moses Spring.

Paper Size A4

0 25 50 100

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Homestead
- Livistona lanuginosa (Moses)
- Watercourse
- Local Road
- Track
- Moses Spring
- Project Area
- Study Area

*Note: Some points represent clusters of 2 or 3 individuals

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Waxy cabbage palm population at Moses Spring

Figure 7

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All waxy cabbage palms at Moses Spring are located within 100 m of a central point, generally within the river red gum/weeping paperbark community on the outskirts of the spring 'precinct', with a core population of 16 palms located within a 50 m radius. Two are growing close to one of the spring wetlands, with one 10 m palm located only about 20 m from the permanently inundated zone, at least 50 m from the nearest tall vegetation of any kind. This latter palm appears to be unhealthy – its crown had a battered look and the fan shape of the waxy cabbage palm leaf was not evident – rather, the leaves had many dead sections and were not opened fully.

Plate 4 Moses Spring waxy cabbage palm population: showing landscape (left); palm cluster (right) (April, 2013)

The range of heights recorded for this population varied from 2 – 12 m, and was weighted towards the adult or reproductive stage, with only one out of 19 in the seedling stage (see Section 3.1 – seedling stages are less than 2 m tall, adult height commences over 6 m). The population mean height was approximately 7 m. Two height clusters were observed – 32 percent of the population is in the 11.5 – 12.5 m height range and another 32 percent of the population is within the 3.5 – 4.5 m height range. These clusters suggest that recruitment may be episodic and that at least two recruitment events have contributed to this population. In support of this supposition, 47 percent of the palms present are growing in a group of three individuals (bases within 2 m of each other palm), and 32 percent are in a pair (see Plate 1 and Plate 4). In each of these groups, every member's height was within 1 m of the others. This suggests that the individuals in a cluster may be of a similar age and may have seeded from the same source and recruitment event. No palm seedlings were observed clustered around the base of adult palms, although seeds were observed around the base of some of the adult palms during the survey.

3.3.3 Observations on the Moses Spring population

Land form elements

The population at Moses Spring is unique in terms of waxy cabbage palm populations, as it is the only population known from a GAB spring group (based on current Australian herbaria records (CHAH, 2013) and the DSEWPaC website (DSEWPaC, 2013)). Therefore, it is instructive to compare the population structure to that of a more 'normal' population, as occurs on the Carmichael River. The spread of life stages at Moses Spring and the sites on the Carmichael River is represented graphically in terms of percent frequency of occurrence in Figure 3. This graph illustrates how different the waxy cabbage palm population structure at

Moses Spring (which is much smaller, located in atypical habitat, and relatively isolated) is from that of the Carmichael River population (which has a high level of internal connectivity and is located in more typical habitat for the species). In every instance, the Carmichael River populations have considerably higher numbers in the seedling stages than in the sub-adult or adult stages, and no other sub-population trends upwards as sharply or permanently as age increases.

Population structure

Given it takes 15 – 20 years to reach maturity (Petit and Dowe, 2003), the resulting curve (see Figure 5, and compare to Figure 6 for the Carmichael River), and the life stage clusters noted above, suggests a population with intermittent recruitment, with some recruitment events possibly separated by up to a decade. It also indicates that at Moses Spring, palms have a relatively high chance of survival once they reach sub-adulthood. This may be because taller plants in this location are not subject to the erosive forces brought by major floods, and the resulting erosion of banks and beds, to which palms growing in the main river channels are. Given adulthood could last for many hundreds of years (Dowe, 2010), adult plant numbers would be expected to accumulate to a point where they outnumber sub-adults, whose life stage may last a decade. Therefore, an equal population of both sub-adult and adult life stages, as is observed at Moses Spring, could be explained by an adult mortality rate that is higher than sub-adult mortality, or by the fact that this population is relatively new and adult numbers have not had a chance to build up yet.

However, given the relative abundance of adults, a much larger population of seedling stage palms would be expected based on the reverse ‘J’ curve population model exhibited by many palm species, including the waxy cabbage palm (Dowe, 2010; Petit and Dowe, 2003). The lack of seedling stage palms could be due to sex imbalances in the adult population, a comparative lack of successful pollination, or high rates of seedling mortality. If there were a high rate of seedling mortality it could be due to a number of factors unique to Moses Spring including:

- a more challenging microclimate for seedlings at Moses Spring than in the Carmichael River (open woodland has a significantly sparser canopy than riparian open forest, with the result that humidity is lower and top soil may dry out faster)
- a lack of flooding at this location (being 260 m from Cattle Creek, except perhaps in exceptionally wet years) means:
  - seeds will not be covered by sand and debris, which they appear to require to germinate (Dowe, 2007)
  - upper soil layers are not recharged with soil water regularly – although there is considerable quantities of groundwater in this location, unburied seeds must first germinate in a relatively dry environment and bury their roots perhaps some metres before accessing it
- the spring attracts feral pigs and cattle, both of which can trample or graze seedlings and young plants (although this factor is not unique to Moses Spring and surrounding land use includes grazing).

Estimated population extent

In their study of waxy cabbage palm populations in the Burdekin River catchment, Petit and Dowe (2003) presented percent frequency bar graphs for eight populations of this species measured over 500 m river frontage plots (with populations ranging from 70 to 2,726). Where populations had large numbers of adults relative to the developing life stages, Petit and Dowe (2003) considered that population senescence was possibly occurring, although they did not consider this to be a problem for riparian species with adult populations upstream.

However, Moses Spring is located on a broad alluvial plain approximately 260 m away from the nearest waterway (the Cattle Creek channel). It appears only likely to be inundated by very large flood events. In addition, adjacent to and upstream of Moses Spring, Cattle Creek changes in nature from a riparian open forest dominated by river red gum and weeping paperbark on sandy soils to a coolabah (*Eucalyptus coolabah*) open woodland on a clay loam alluvial plain.

Waxy cabbage palm is not recorded from this habitat type, and it is considered unlikely that this watercourse contains further upstream populations. Given this supposed lack of an upstream source of seed, and being upslope of the nearest watercourse, and upstream of the nearest known population, the Moses Spring population is considered likely to be vulnerable to recruitment declines. However, the relative abundance of sub-adults in the Moses Spring population does suggest that the population is recruiting, albeit intermittently. Given the more hostile environment at the spring for seedlings, it may be that successful recruitment requires conditions that only occur intermittently.

Although the palms at Moses Spring are situated in the Carmichael River catchment, their location in a GAB spring wetland is unique for this species (based on current Australian herbaria records (CHAH, 2013) and the DSEWPaC website (DSEWPaC, 2013)), and so this group are treated for the purpose of this report as a separate population. This is considered to be justified because:

- This group appears to have a very different demographic structure to that of other documented waxy cabbage palm populations (Dowe, 2010), including that of the Carmichael River (see Section 3.4 and Figure 5 and Figure 6)
- The unique demographic structure suggests this group is subject to different constraints to those in the Carmichael River
- The habitat in which the Moses Spring waxy cabbage palms occur is markedly different to that of the waxy cabbage palms recorded in the Carmichael River
- The group at Moses Spring is effectively separated from the Carmichael River group, given that only large flood events are likely to transport seed from Moses to the Carmichael River, and there is highly unlikely to be a movement of seed in the opposite direction
- The Moses Spring group is likely to be sustained by a very different source of water – a perennial artesian spring rather than more ephemeral, seasonal sources. The latter is more characteristic of waxy cabbage palm populations (Dr John Dowe, pers.comm, 21 September, 2012).

3.4 Population structure of waxy cabbage palm at Carmichael River area

Prior to the conduct of EIS studies (GHD, 2012b) there are no records of waxy cabbage palms occurring in the Carmichael River area (DSEWPaC, 2013). The Carmichael River area was systematically surveyed over 17.5 km of frontage as outlined in Table 1 (35 plots of 500 m). Of this 17.5 km, there are four separate sections, listed below in order from up to downstream:

- From Joshua Spring (located directly beside the Carmichael River) downstream for 1 km, to determine whether the waxy cabbage palm population occurs this far upstream (given Joshua, a perennial spring with a high output, is believed to provide a considerable amount of base flow to the Carmichael River throughout the year)
- From Little Moses (also located directly beside the Carmichael River) downstream for 1.5 km
- For 500 m at an easily accessible section near the western boundary of Moray Downs station, to confirm if the density patterns observed further downstream were consistent (called West EPC 1690 Section A)
- For 14.5 km from 500 m upstream of the western boundary of EPC1690 (a 500 m plot called West EPC 1690 Section B) to a point 2.5 km downstream of the eastern boundary of EPC1080 (called East EPC 1080).

3.4.1 Joshua Spring/Carmichael River section survey

Joshua Spring is a GAB spring in the Desert Uplands bioregion now modified to a turkeys nest dam (GHD, 2012b). It provides water for Doongmabulla station. A considerable quantity of water is surplus from the station usage and storage requirement and flows freely to an adjacent lagoon formed from a relict channel section.

The Carmichael River was observed to have long pools of water downstream from the Joshua Spring. These occur downstream for up to 27 km. In an attempt to determine the western limit (beyond the Project Area) of the waxy cabbage palm population on the Carmichael River, a search of the river was conducted using Joshua Spring as the western most starting point.

A search was conducted of the river channel and adjacent plain for 1 km downstream (east) of the spring. The river in this location is braided into two channels and ranges from approximately 70 – 200 m wide. A coolabah woodland characterises the surrounding vegetation on the northern bank, comprising the regional ecosystem RE 10.3.14, and the southern bank consists of *E. persistens* open woodland in the west (RE 10.7.2), becoming silver-leaved ironbark (*E. melanophloia*) woodland/open woodland towards the east of the section surveyed (RE 10.3.28) (Queensland Herbarium, 2013a). The Carmichael River at this point traverses a broad Quaternary flood plain (probably of its own making) and sections of outcropping sandstone of the Triassic Moolayember formation (Bureau of Mineral Resources, Geology and Geophysics, 1972).

The river channels are divided by steep sided bars and edged by steep banks approximately 2 – 3 m deep and vegetated with a fringing low open forest of river red gum, weeping paperbark, narrow-leaved paperbark, and a dense ground layer dominated by mat rush (*Lomandra longifolia*). This vegetation comprises the regional ecosystem RE 10.3.13 (Queensland Herbarium, 2013a). The class two weed rubber vine (*Cryptostegia grandiflora*)

was observed occasionally on channel bars and banks. Further downstream, the river opens out to a broad bar plain.

One kilometre of the Carmichael River (2 x 500 m plots) commencing at and running downstream of Joshua Spring was surveyed. No waxy cabbage palms were observed in these plots. However, in surveys conducted elsewhere in the Study Area sections of river 2 km long were encountered that lacked any waxy cabbage palm, so it is possible that further populations are located either up or downstream of this point. The nearest waxy cabbage palms recorded to these plots in this survey were located in Cattle Creek (adjacent to the Carmichael River) 2.5 km downstream of the Joshua Spring plots.

Based on the results of this survey it is unclear where the western-most occurrence of waxy cabbage palm on the Carmichael River may be located. Upstream of Joshua Spring (west) the river is broad and heavily braided, and suitable habitat is likely to be present.

3.4.2 Little Moses/Carmichael River section survey

Little Moses Spring group is located almost 2 km east of Moses Spring group on Doongmabulla station, and is part of the Doongmabulla spring complex (which includes Moses and Joshua). Based on observations made by GHD in reports on the Doongmabulla spring complex in 2012 and 2013, it is unclear whether Little Moses Spring group is artesian or sub-artesian, although it is within the official GAB area (GHD, 2012 and 2013). The main spring of the Little Moses Spring group appears to be formed in a relict channel of the Carmichael River, located with 50 m of the main channel.

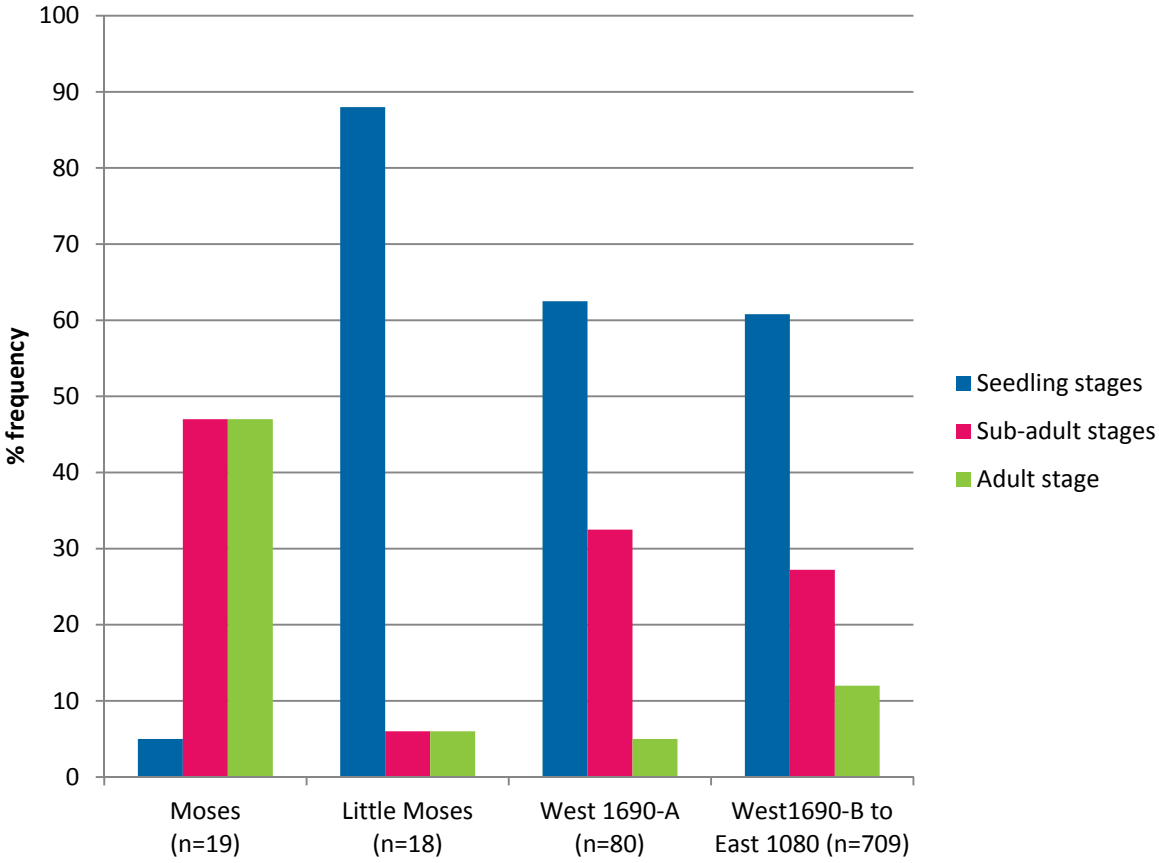
The Carmichael River in this location is approximately 50 – 70 m wide, and is divided into two channels, both of which are relatively deeply incised (3 m deep and approximately 10 m wide) with steep banks, and separated by a narrow bar (visible in Plate 5 left image). The channels are obstructed by a range of logs and other debris and the riparian condition appears to be very good, with only two weeds observed (rubber vine, in low densities, and Noogoora burr (*Xanthium pungens*)), and little sign of over-grazing, broad scale clearing or erosion (see right image in Plate 5). The river passes through a shallow ‘range’ between here and the Project Area, and the surrounding geology is predominately sandstone (Bureau of Mineral Resources, Geology and Geophysics, 1972).

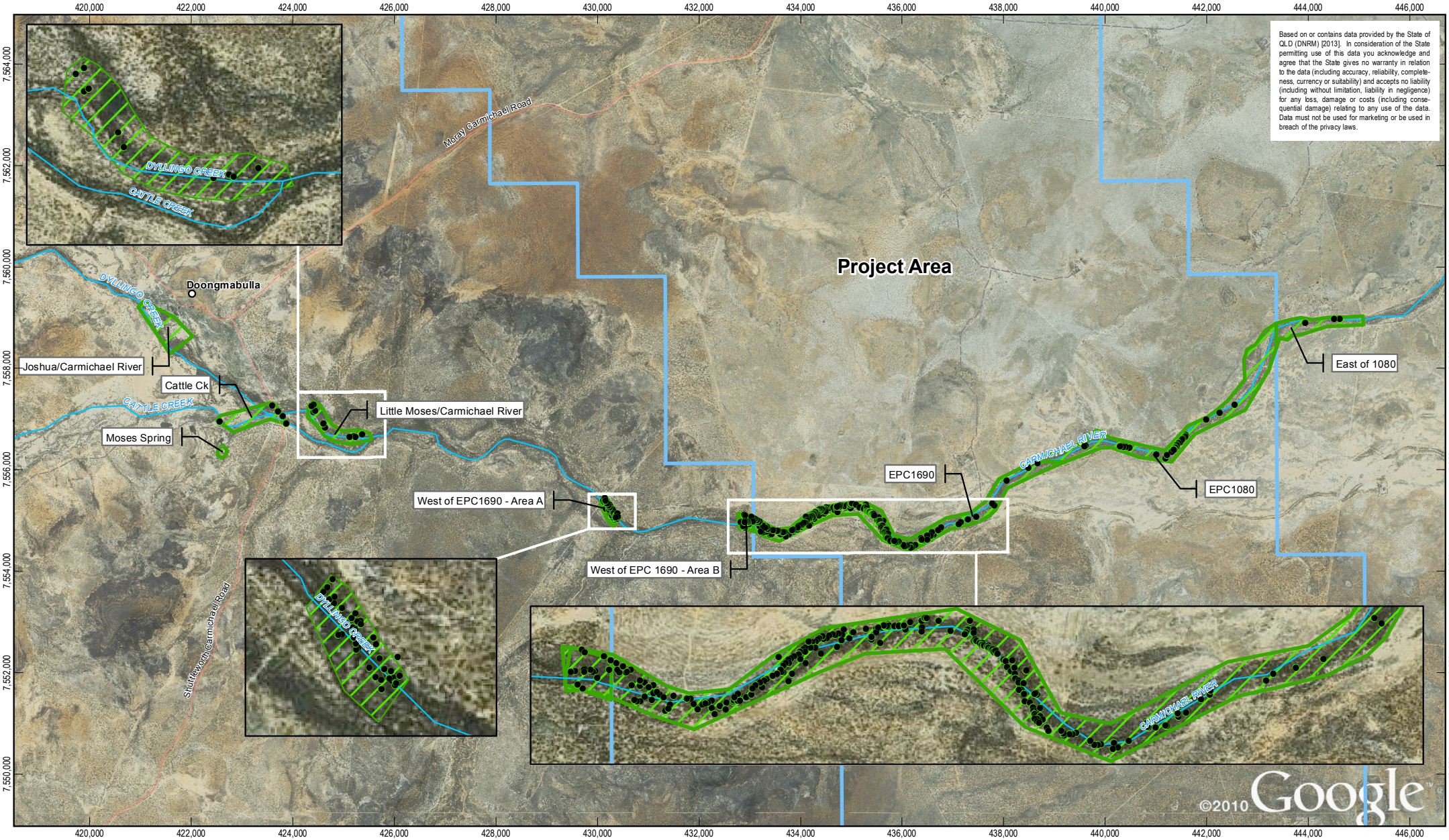
Plate 5 Carmichael River habitat near Little Moses Spring (April, 2013)

The riparian zone fringing the channel is similar to that seen in the Carmichael River for its downstream length for at least another 20 km (the furthest point downstream at which surveys occurred). It is characterised by an open forest with a canopy from 20 – 25 m tall dominated primarily by river red gums, some up to 10 m in circumference, frequently with weeping paperbark and narrow leaved paperbark dominating or co-dominating in places. Waxy cabbage palm constitutes a sub-canopy where it is present, but elsewhere there is a negligible to absent lower tree and shrub layer. The ground layer is generally dense, and is dominated by mat rush, with *Juncus continuus* growing in the channel beds and grasses including kangaroo grass (*Themeda triandra*), golden beard grass (*Chrysopogon fallax*), Queensland blue grass (*Dichanthium sericeum*), *Eragrostis elongata* and *Bothriochloa bladhii*. Buffel grass (*Cenchrus ciliaris*) and currant bush (*Carissa ovata*) become common on the fringe with the flood plain. Rubber vine was observed in this section of the river as well, on channel bars and banks as one or two stems, some of which was starting to gain access to the canopy.

Three 500 m plots of the Carmichael River channel were surveyed here. No waxy cabbage palms were observed at the Little Moses Spring group. However, nine waxy cabbage palms were recorded growing on a scroll plain near the main spring. Another nine were located intermittently for approximately 1.5 km downstream (to the junction of Cattle Creek with the Carmichael River). These palms were generally growing in the channel bench or on the top of a channel bar (which were up to 3 m tall with very steep banks), and all were located in the central bar or along the northern bank (perhaps due to river hydrology at this point during floods). In contrast to Moses Spring, 16 out of 18 of the palms present (88 percent) were in the seedling stages, with one in a sub-adult stage and one adult (8 m tall) (see Table 1). This is represented graphically in terms of percent frequency in Figure 8. Records of mapped waxy cabbage palms from the survey are shown visually on Figure 9.

Figure 8 Population structure of contiguous survey areas





Paper Size A4

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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Homestead
- Waxy cabbage palm population
- Watercourse
- Local Road
- Track
- Study Area
- Project Area

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Population survey of the waxy cabbage palm

Job Number 41-25215
Revision B
Date 19 Jun 2013

Waxy cabbage palm population in areas surveyed

Figure 9

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3.4.3 West of Project Area section A survey

Two plots were sampled (upstream) of the Project Area, both within Moray Downs station (see Figure 1). The results of both sections are presented in Table 1. Section A was surveyed to determine if the pattern of population density observed in the Project Area continued upstream. Section B extends 500 m west of the Project Area, and was surveyed to determine where the Project Area sub-population finished. Both plots were located in similar habitat and had similar hydrological features, with the exception that the channels were noticeably deeper in Area B (further downstream). As Section B is contiguous with the Project Area, it is discussed in Section 3.4.4.

The riparian corridor is wider in this section of the river than at Little Moses Spring – generally around 150 m from edge to edge, and the riparian vegetation is similar to that described above for Little Moses (see Section 3.4.2).

In total, 80 waxy cabbage palms were recorded in section A. The seedling stages comprised approximately 62.5 percent of the population, sub-adult stages approximately 32.5 percent, and the adult stage comprised 5 percent, which indicates a considerably low number of adults for the amount of recruitment evident, although this appears to be similar to the population structure of the main Carmichael River survey section described in 3.4.4 (see Figure 8). However, the Section A population is one of the densest clusters of waxy cabbage palm seedlings and sub-adult stages per 500 m of river frontage recorded in this survey (see Figure 4 – Section A is plot 6).

3.4.4 Carmichael River survey section

The main section of the Carmichael River surveyed comprised 14.5 km of channel frontage starting 500 m upstream of the western boundary of Project Area (at plot seven) and finishing 2.5 km downstream of the eastern boundary of Project Area (at plot 35) – a total of 29 consecutive 500 m plots. The river at this stage is as described in Section 3.4.3. On the southern bank, a local tributary of the Carmichael River, Cabbage Tree Creek, is mapped. Observations indicated, however, that this ‘creek’ is actually an abandoned channel bed, a ‘billabong’, and does not flow but is instead simply inundated. Despite the name, inspections indicated no waxy cabbage palms growing in or beside this water body for at least the southern 2 km (it was not possible to inspect the northern section). However, the habitat present (a clay loam plain) indicates the waxy cabbage palm is unlikely to be present.

A total of 709 waxy cabbage palms were recorded in this 14.5 km section of the Carmichael River, including 431 in the seedling stages, 193 in the sub-adult stages, and 85 adults (see Table 1). In general, the population structure of this section describes a gradual but consistent trend towards decline as life stage increases towards maturity (see Figure 8), which is a common population structure for palms, including the waxy cabbage palm (Dowe, 2010).

3.4.5 Observations on the overall Carmichael River population

Population structure

The population structure overall appears to approximate the 'reverse J' curve described by Dowe (2010) as a common population structure for palms, including the waxy cabbage palm. This indicates that the Carmichael River population of waxy cabbage palm has a similar demographic structure to that recorded by Petit and Dowe (2003) for this species at the majority of sites they surveyed. A high number of seedlings relative to sub-adult and adult life stages indicates that the population is producing sufficient amounts of viable seed and that favourable environmental conditions for germination to occur exist (Petit and Dowe, 2003).

The drop in numbers of palms in the sub-adult stages, in some cases by over 50 percent from the seedling life stage (see the bars for Little Moses and West 1690-B to East 1080 in Figure 8), suggests that significant environmental forces are acting on the plants post-seedling stage. To a certain extent the scale of the transition from stage to stage can be explained by grouping six pre-adult life stages into two, which was done so as to fit this data to the life stages model of Petit and Dowe (2003) for purposes of comparison. However, this treatment will only simplify the shape of the corresponding population structure curve for those first six life stages, it will not affect the overall trend, which will remain the same.

Riparian zones are periodically subject to considerable volumes of water and suspended debris, and in the sections of the Carmichael River surveyed evidence was noted indicating depth near the channel centre during the most recent floods would be up to 10 m. As palm trunks grow larger and project higher into the flood waters, with a broader crown of leaves, they will become more susceptible to these impacts and their surface area increases, with correspondingly more buffeting from floodwaters. In addition, sand bars and banks can be eroded and completely removed during floods when large logs and debris piles are deposited in new places (changing the direction and velocity of nearby water flows). This may account for the ongoing decline in population as life stages increase towards adulthood.

A total of 90 adult palms were recorded in the Carmichael River, and one in Cattle Creek. Given that the current estimate for the total adult population for this species is less than 1,000 (Petit and Dowe, 2003; DSEWPaC, 2013), an additional 91 adults (plus the nine at Moses Spring) is an increase of at least 10 percent to the known population.

Patterns of population density

Survey findings (refer Figure 4) indicate that the population is not spread evenly along the river. Density per 500 m plot varied between a high of 190 palms per 500 m at plot 10, to plots that recorded no palms at all (eight plots). The majority of plots (23 out of 35) had less than 10 palms per 500 m, and only six plots had more than 50 palms.

The most dense area of population was located between plot eight, which starts at the western boundary of the Project Area (where it crosses the Carmichael River at longitude 146°21'3.80" E) and plot 13, which is located approximately 3 km (as measured along the river) within the Project Area (where longitude 146°22'41.00" E cuts the river). A minor track running along a fence cuts the river at this point, and it is possible to drive across. Within this 3 km stretch the following was observed:

- 479 waxy cabbage palms, almost 60 percent of the total population recorded in the Carmichael River during this survey

- 76 adults, which constitutes 84 percent of all adults recorded in all plots in the survey and 16 percent of the total in this 3 km
- 15 palms 12 m or more tall (up to 18 m)
- 223 seedling stage and 180 sub-adult stage palms (46 percent and 38 percent of this sub-population respectively)

Areas of dense population with a high proportion of adults are likely to provide much of the seed material for the remaining downstream stretches of the river, and may be of high importance to the Carmichael River population. The river at this point has two main channels and a minor channel, with a long bar plain of approximately 80 m width separating the minor from the major channels. It is located primarily along a set of meanders, including a particularly long (2 km), wide (1 km) northward meander of the river, where water velocity may be slowed during flooding, and consequently water-borne debris such as palm seeds and sand may be deposited. Flood debris deposited from a recent flood indicates the flood level extends well up onto the surrounding scroll plain. It may be that the favourable depositional environment allows sub-adults and adults to survive for longer periods at this site compared to the Burdekin Basin populations, and thus to accumulate.

A second notably dense population area is located within plot 26, which contains 155 palms, consisting of 147 seedlings, one sub-adult and seven adults, all 9 – 13 m tall. This area is located near the downstream end of the Study Area. Downstream of plot 26, the remaining nine plots (4.5 km) contained four seedlings, no sub-adults and six adults in total. In contrast to the main area of dense population from plot 8 to plot 13, plot 26 is located on a straight section of the river. Given the advanced size of the adults and the extremely low proportion of sub-adults relative to both the adults and the seedling life stages, it appears that recruitment is less successful in this location, but that occasionally, individuals do persist into adulthood.

Potential influences on population distribution

The relatively high abundance of adults observed in the dense area of population from plot 8 to plot 13 noted above is possibly linked to the height of the water table in this location. Petit and Dowe (2003) listed the presence of a high water table as a potentially important factor supporting the persistence of waxy cabbage palm individuals at one site away from the main channel.

Estimating the overall Carmichael River population

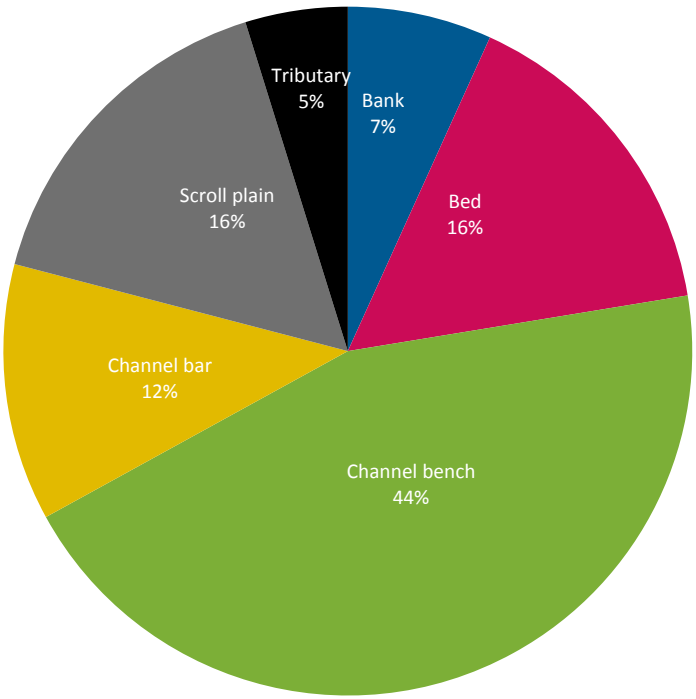
Between Joshua Spring and the Belyando River junction, there is another 18 km of Carmichael River frontage that has not been surveyed as part of the scope of this report. Based on the results of this survey, which found 812 waxy cabbage palms growing in 17.5 km of the river, there may be an additional 800 palms growing in this section of the Carmichael River. With an adult population frequency of approximately 11 percent, this indicates that potentially approximately 90 reproductive age waxy cabbage palms would be represented which could bring the entire Carmichael River adult population to around 180 individuals of reproductive age. It is not possible to say with any certainty at present whether the population extends upstream of Joshua Spring.

Land form elements

During the survey, the land form element on which individual waxy cabbage palms were growing in the Carmichael River was recorded (all palms in Moses Spring were growing on an alluvial plain). These results are illustrated in Figure 10.

In the sections of the river surveyed, channel benches varied from absent (in the upstream sections) to narrow (5 m) or up to 80 m or wider, and are usually carved out of the surrounding plain during floods. The surface of all channel benches observed at the Carmichael River were generally corrugated, the corrugations or low ridges (50 – 80 cm tall) being oriented parallel to stream flow. Mat rush in particular was common on this land form, which was generally characterised by a river red gum or coolabah woodland. The corrugations appear to have been scoured from the bench during flood events, when the bench was often up to 10 m under water (based on the height of debris clumps in tree branches), and this irregular shape may form an effective trap for palm seeds. Being located near the outer edge of flood water where the flow velocity is likely to be lower may also contribute to the deposition of a greater number of palm seeds. The most favoured land form element, containing almost half of the entire population, was the channel bench (see Plate 6), which is a narrow flat located between the low bank of an outer channel and the high bank, and beyond which the flood plain commences. It runs parallel to the channel.

Figure 10 Pie graph showing land form elements on which waxy cabbage palm were found



The two next most common land form elements hosting palms are the scroll plain and channel bed, which constitute 16 percent each of the Carmichael River population. Scroll plains are formed on the inside of a bend as a watercourse meanders across its flood plain, and are recognised by a set of shallow swales with gently undulating, low intervening ridges. These plains are often outside of the riparian zone in a drier environment, and palms located on this land form element may require a high water table to survive (Petit and Dowe, 2003). By contrast, channel beds form the deepest part of the channel, where large amounts of suspended sand and coarse debris is deposited (see Plate 7), often in traps formed by large log jams. Channel beds were usually free of vegetation, with the exception of sedges/rushes such as *J. continuus* and *Cyperus exaltatus* (and waxy cabbage palm).

Channel bars contained 12 percent of the waxy cabbage palm population in the surveyed sections of the river. Channel bars separate two (or more) channels within the river, and range from very narrow (a few metres) up to 100 m width or more, often with deeply corrugated surfaces similar to the outlying channel bars (see Plate 7). These bars generally had a dense ground layer of mat rush and grasses beneath an open forest canopy of river red gum and paperbark. Less commonly, palms were observed growing in the river bank (7 percent) or in tributaries of the Carmichael River (5 percent).

Plate 6 Channel bench in Carmichael River (left); scroll plain (right) (April, 2013)

Plate 7 Waxy cabbage palms growing in channel bed (left) and channel bar (right) (April, 2013)

3.5 Threatening processes observed

During the survey, four threatening processes were noted: weed infestation, feral pigs, cattle and bush fire. Rubber vine is established at various points along the Carmichael River, from Joshua Spring (and likely upstream) to the furthest downstream point surveyed, 2.5 km east of the Project Area. All locations of rubber vine observed were mapped during the survey. The worst infestation observed was in the midst of the main population cluster noted above (see Plate 8), where approximately 200 m^2 or more is now densely covered in rubber vine, and the vine has reached the mid-level of the canopy in some places (primarily growing into river red gums). Some palms are in the process of being smothered. If not removed or subject to management, within a decade the Carmichael River could have a much greater problem with this weed than the current population represents. This species can dominate riparian vegetation and severely degrade the biodiversity values of a waterway by growing over and smothering even tall trees, resulting in the death of smaller plants and the stunting and eventual death of trees. It grows parallel to the waterway and eventually can form a virtually impenetrable barrier, preventing access to water for stock and people (Parsons and Cuthbertson, 2001). Apart from rubber vine, the Carmichael River appears to be virtually weed-free, with the exception of occasional Noogoora bur, an exotic but not a declared weed.

During the survey, large groups of feral pigs were observed from time to time, including a pack of approximately 40 boars, sows and piglets. Evidence was noted of pig-rooting that had killed waxy cabbage palm seedlings, particularly in the western half of the Project Area (see Plate 8).

Cattle have access to all populations recorded, although no direct damage from cattle was observed (the damage photographed in Plate 9 was clearly the result of ‘pig-rooting’). Petit and Dowe (2003) noted that damage to waxy cabbage palm populations from grazing, trampling and stream bank erosion is likely to constitute a major threatening process, and recommended this be confirmed and measured with grazing exclusion experiments. However, the Carmichael River appears to have very little erosion besides that expected from a large watercourse that floods regularly. The dense ground vegetation present, much of which did not appear to be grazed (e.g. mat rush, *J. continuus*), and frequent large log jams are likely to play an important role in stabilising banks and beds.

Finally, a bush fire was observed over a number of days during the survey, burning along the river and adjacent country. A number of channel benches were burnt to the extent that ground cover was minimal and many large trees lost branches or were burnt out entirely. However, no palm appeared to have been killed by this fire, with scorched or burnt dead leaf stubs but no damaged crowns.

Plate 8 Rubber vine infestation in the Project Area, (April, 2013)

Plate 9 Pig damage to seedlings: stem stubs (left); rooted out leaves (right), (April, 2013)

4. Conclusion

GHD conducted a survey of waxy cabbage palms growing in Moses Spring, and in sections of the Carmichael River between Joshua Spring and a point just downstream of the eastern boundary of the Project Area, an area that included 14.5 km of continuous river frontage. Overall, 35 plots 500 m long and covering the entire width of the river at that point were surveyed (17.5 km of river frontage). The coordinates of each individual palm were recorded on a hand-held GPS, with details on height and the land form element on which it was located.

The survey findings can be summarised as follows:

- A total of 831 palms were recorded at both locations (the Carmichael River and Moses Spring). This is the first documented population survey of Carmichael River waxy cabbage palms, and considerably increases the number of waxy cabbage palms recorded from Moses Spring (which was previously thought to be three or four palms - DSEWPaC, 2013). Previously, surveys for this Project had detected palms in the environs of the Carmichael River, but no population survey had been conducted.
- Moses Spring has a population of 19 palms, with nine adults, nine sub-adults and one seedling. This population structure indicates recruitment is intermittent, and that the environment may be particularly harsh for seedling establishment, and/or favourable for pre-seedling growth. Alternatively, the population may be relatively young and still establishing, and is therefore exhibiting an atypical age structure.
- Opportunistic observations were made of waxy cabbage palms growing in Cattle Creek, a tributary of the Carmichael, near Moses Spring.
- The Moses Spring population exhibit major differences (different population structure, land form, habitat type, water source, and apparently effectively isolated from each other) to those of the Carmichael River population which justifies treating them as separate populations.
- The total number of waxy cabbage palms recorded in the environs of the Carmichael River during the survey was 807 individuals, comprised of 497 in the seedling stages (0.00 – 2.00 m), 220 in the sub-adult stages (2.01 – 6.00 m), and 90 adults (6.01 m and above).
- The population structure recorded at the Carmichael River is typical for many palms including the waxy cabbage palm, with a high number of seedlings gradually declining as life stages increase through the sub-adult stages to adult. This is indicative of healthy levels of recruitment within the population (Petit and Dowe, 2003). The population structure curve observed for the Carmichael River population is similar to that observed in other surveys of waxy cabbage palm populations elsewhere (Petit and Dowe, 2003).
- 65 percent of the Carmichael River population was growing on channel benches, scroll plains, or tributaries, land form elements situated near the periphery of the river channel. The remainder were located more centrally, in the bed, banks or channel bars of the river.
- Two areas of particular population density were noted. The most dense area starts at the western boundary of the Project Area (where it crosses the Carmichael River) and finishes approximately 3 km downstream. This area contains almost 60 percent of all waxy cabbage palm individuals recorded in the survey, and 84 percent of all adults (76

palms). In addition, 46 percent of all seedling stage waxy cabbage palms recorded and 38 percent of all sub-adult stages are located within this area.

- The density of the population in general was highly variable at the 500 m survey scale. The mean density per 500 m plot was 23 palms, with a sample standard deviation of 44.24.
- Based on these findings, and assuming the population in the Carmichael River does not extend further upstream than Joshua Spring, it is estimated there may be another 800 palms in sections of the river not surveyed. Using the approximate adult population frequency of 11 percent, this suggests there may be another approximately 90 reproductive age waxy cabbage palms, bringing the total in the Carmichael River to 180 adults. However, given the high level of variability noted in this population per 500 m plot, the actual number may vary considerably from this estimate.
- Waxy cabbage palm populations are thought to require access to ground water (Petit and Dowe, 2003), and high water tables may explain distribution patterns.

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Appendices


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Appendix A – HERBRECS entries for waxy cabbage palm


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As provided by Qld Herbarium 23 April, 2013

Collect_Name	Collect_Cod	Collect_Date	Locality	Altitu	Geodetic	Latitude	Longitude	Label
Irvine A.K.	1912	25AUG1978	GLENROY CK 75KM SE OF RAVENSWOOD	140	AGD66	S20 33 35.00	E147 08 53.0	Glenroy Creek, 75km SE of Ravenswood. Riparian open forest. Palm 16m tall overall, with stem 12m long x 36cm d.b.h. Persistent leaf sheaths and portions of petiole up to 20cm long present on basal 2m of stem which is brown in this area. The palm was present in a crowed colony of young to intereediate aged palm 4-14m tall.
Thompson E.J.	238	25SEP1991	7KM E OF HARVEST HOME NR CATTLE CK	242	AGD66	S20 41 06.96	E146 42 51.6	7km E of Harvest Home, near Cattle Creek. In woodland of Euc. alba and Euc. brachycarpa.
Dowe J.L.	292	18FEB1996	GLENROY CK 1KM N OF JUNCTION WITH STONEY CK 15KM N OF BURDEKIN FALLS	150	AGD66	S20 33 35.42	E147 08 53.6	Glenroy Ck, 1km N of junction with Stoney Ck, 15km N of Burdekin Falls. Open woodland adjacent to wide sandy seasonal creeks. Moderate fan palm, leaves grey/green, inflor bracts with thick fawn tomentum. Rare.
Fell D.G.	DGFCU31/1	26AUG2010	CAMPASPE RIVER, TRAFALGAR STATION, 45 K EAST OF CHARTERS TOWERS.		GDA94	S20 25 41.32	E145 57 33.9	Campaspe River, Trafalgar Station, 45 k east of Charters Towers. Riparian woodland 18-22m on sandy braided river channels with Melaleuca fluviatilis and Eucalyptus tereticornis. Second tree layer 10-20% cover with Casuarina cunninghamiana, Livistona lanuginosa, M. fluviatilis and Pandanus sp. Shrub layer includes Acacia holosericea, A. salicina and Ficus opposita. Ground cover 30-40% limited to linear stream islands with Lomandra longifolia, Paspalidium sp., Megathyrsus maximus subsp. pubiglumis, Arundinella setosa, Eclipta procera and Cyperus sp. Habit: a Cabbage palm. Robust but scattered populations along the river channels. Photo at BRI with specimen.
Halford D.	Q9031	24APR2006	GARDEN CREEK CROSSING, C. 17KM W OF LONGTON HOMESTEAD ON ROAD (PENTLAND-ARAMAC ROAD) TO YARROWMERE STATION	270	AGD66	S21 01 42.00	E145 45 52.0	Garden Creek crossing, c. 17km W of Longton homestead on road (Pentland-Aramac road) to Yarrowmere statton. Creek bed, sandy alluvium, open forest (Eucalyptus camaldulensis). Occasional. Treated with alcohol before drying.
Halford D.	Q9036A	24APR2006	AMELIA CREEK CROSSING, 30KM W OF LONGTON HOMESTEAD ON TRACK TO YARROWMERE HOMESTEAD	300	AGD66	S21 06 11.00	E145 40 14.0	Amelia Creek crossing, 30km W of Longton homestead on track to Yarrowmere homestead. Creek bed, sandy alluvial soil, riparian open forest. Tree 3m high. Occasional. Treated with alcohol before drying. Photo with specimen at BRI.
Halford D.	Q9075	01MAY2006	ROLLESTON RIVER CROSSING ON ROAD TO HARVEST HOME STATION, 54KM E FROM GREGORY DEVELOPMENT ROAD	190	AGD66	S20 40 38.00	E146 38 23.0	Rolleston River crossing on road to Harvest Home statton, 54km E from Gregory Development Road. River bank, sandy loam, Melaleuca/Eucalyptus riparian open forest. Tree 4m high, pettole 1m long, leaf fan 1.5m wide. Common. Treated with alcohol before drying.
Berney F.L.		JUL1900	HELLENSLIE CAMPASPE RIVER		GDA94	S20 30 50.00	E145 42 18.0	Campaspe River, Hellenslie. (See on top of the compactus units, wrapped in brown paper).

Appendix B – Vouchers for palms submitted to Queensland Herbarium


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www.qld.gov.au/environment/plants-animals/herbarium/

Queensland Government
Department of
Science, Information Technology,
Innovation and the Arts

Enquiries Tony Bean
Telephone 07 3896 9318
Your reference
Our reference ARB:ABP:mh 310/13

30 April 2013

Simon Danielsen
GHD Pty Ltd
GPO Box 668
BRISBANE QLD 4001

Dear Simon

The botanical specimens received by the Queensland Herbarium on 22 April 2013 have been identified as:

1857 *#*Eragrostis trichophora*
1858 *Chrysopogon fallax*
1859 *Isachne globosa*
1861 *Cenchrus purpurascens*
1862 *Sporobolus partimpatens*, this species is listed as Near Threatened under Queensland's *Nature Conservation Act 1992.*
1864 *Eragrostis parviflora*
1865 *Eryngium plantagineum*
1866 *Trianthema* sp. (Coorabulka R.W. Purdie 1404)
1867 *Eryngium fontanum*, this species is listed as Endangered under Queensland's *Nature Conservation Act 1992.*
1868 *Sporobolus mitchellii*
1870 *#Livistona lanuginosa*, this species is listed as Vulnerable under Queensland's *Nature Conservation Act 1992.*
1871 *Juncus polyanthemos*
1872 *Drosera indica*
1873 *#Chloris* sp. (Edgbaston R.J. Fensham 5694)
1874 *Sclerolaena tricuspis*
1875 *Cyclosorus interruptus*
1876 *Fimbristylis dichotoma*
1877 *Pluchea rubelliflora*
1878 *Juncus aridicola*
1879 *Cyperus* sp. indet., fertile material required.
1880 *Cyperus* sp. indet., inflorescences too immature for species identification.
1881 *Schoenus falcatus*

Download a full version of Census of the Queensland Flora 2010
http://www.derm.qld.gov.au/wildlife-ecosystems/plants/census_qld_flora.html

1882 *Myriophyllum artesium*, this species is listed as Endangered under Queensland's *Nature Conservation Act 1992.*
1883 *Sporobolus partimpatens*, this species is listed as Near Threatened under Queensland's *Nature Conservation Act 1992.*
1884 *#Streptoglossa* sp., unmatched. More material would be appreciated.
1885 *Juncus usitatus*
1886 *Cyperus flavidus*
1887 *#Livistona lanuginosa*, this species is listed as Vulnerable under Queensland's *Nature Conservation Act 1992.*
1888 *#Fimbristylis blakei*
1889 *Panicum larcomianum*
1890 **Cyperus rotundus*
1891 *Cyperus dactylotes*
1892 *Eragrostis sororia*
1893 *#Streptoglossa* sp., unmatched. More material would be appreciated.
1894 *Baumea rubiginosa*
1895 *Cyperus sanguinolentus*
1896 *Chenopodium auricomum*
1897 *#Sporobolus mitchellii*
1898 *#Paspalidium jubiflorum*
1899 Mixed specimen. Leaves: *Corymbia* sp. Fruits: *Eucalyptus camaldulensis*
1900 *#Solanum latens*
1901 *Panicum larcomianum*
1902 *Sporobolus actinocladus*

* Naturalised, non-native species
# These specimens have been retained for incorporation into the Herbarium collection, with thanks.

There is a charge of $1174.80 (11 hrs. @ $106.80 per hr. incl. GST) for these identifications and a tax invoice and receipt are enclosed.

Yours sincerely

G.P.Guymer
Director

Version 8 October 2010

Botanical specimens – a cover sheet

Botanical Specimens for Identification
Complete this form (one for **each** specimen) and send with specimen/s to:

Botanical Information and Advisory Service
Queensland Herbarium, DERM
Brisbane Botanic Gardens Mt Coot-tha
Mt Coot-tha Road,
TOOWONG QLD 4066
queensland.herbarium@derm.qld.gov.au

Office Use Only
Date received
Identification no.
Date of despatch

Name: Simon Danielsen
Company / Department: GHD Pty Ltd
Postal Address GPO Box 668
Brisbane **Postcode** 4001
Telephone: 07 3316 3431 **Fax:** 07 3316 3333
email: simon.danielsen@ghd.com

Please send results by ☐ post ☒ email ☐ fax ☐ telephone

Purpose ☐ threatened species ☐ poisonous ☐ weed detection ☒ commercial
other

Information required Please provide identification to lowest taxonomic level possible

Label Information: *Specimens sent to the Queensland Herbarium for identification are frequently retained in the collection for scientific research and geographic distribution records. The label information below when accompanying **each** specimen aids the identification process and greatly increases the scientific value of the specimen.*

Collector's Name & No.: Simon Danielsen – SFDanielsen1870 **Date of Collection**: 29 March 2013

Botanical name: *Livistona lanuginosa*

Locality (include distance to nearest town): Moses spring, Doongmabulla Station, 165 km west north west of Clermont

COORDINATES

Latitude 22° 5'44.15"S **Longitude** 146°14'57.18"E

Or **AMG Coordinates** (Zone, Easting, Northing):

Or **Map and grid reference** (eg 9442 333 666):

Source of Coordinates: GPS (GDA)

Situation (e.g. plain, creekbank, mountain): plain

Cultivated? NO

Vegetation Type (e.g. forest, heath, woodland): *Sporobolus pamalae* grassland

Soil/Geology/Regional Ecosystem: Alluvial soil near outskirts Moses mound spring group

Kind of plant (e.g. tree, vine, herb): Palm

Description (e.g. size, bark type, flower or fruit colour, frequency): A Livistona growing to 4 m, stem 2 m (nearby others to 12 m), with inflorescence stalks densely tomentose, leaves slightly waxy.

Abundance: 19 mature individuals at Moses, in size classes 1-3 m = 3, 3.1-6 m = 7, 6.1-10 m = 3, 10-14 m = 6

Other Notes: Leaf midrib provided (70cm long) and petiole 90 cm; other leaves up to 1.35 m wide, petioles up to 1.75 m. Sample includes 2 petiole sections, an inflorescence branch, 2 samples of inflorescence indumentum, a sample of fibrous material growing between petiole and stem, and fruit taken from the base of nearby palms (parts a-i). See photos overleaf.

The palm sampled (left)

Profile of leaf

Trunk of 12 m palm 20 m away from palm sampled

Palm sampled

Full inflorescence from 12 m palm located 20 m from the palm sampled (propped against branch in foreground)

Crowns of mature palms at Moses spring

Version 8 October 2010

Botanical specimens – a cover sheet

Botanical Specimens for Identification
Complete this form (one for **each** specimen) and send with specimen/s to:

Botanical Information and Advisory Service
Queensland Herbarium, DERM
Brisbane Botanic Gardens Mt Coot-tha
Mt Coot-tha Road,
TOOWONG QLD 4066
queensland.herbarium@derm.qld.gov.au

Office Use Only

Date received
Identification no.
Date of despatch

Name: Simon Danielsen
Company / Department: GHD Pty Ltd
Postal Address GPO Box 668
Brisbane **Postcode** 4001
Telephone: 07 3316 3431 **Fax:** 07 3316 3333
email: simon.danielsen@ghd.com

Please send results by ☐ post ☒ email ☐ fax ☐ telephone

Purpose ☐ threatened species ☐ poisonous ☐ weed detection ☒ commercial

other

Information required Please provide identification to lowest taxonomic level possible

Label Information: *Specimens sent to the Queensland Herbarium for identification are frequently retained in the collection for scientific research and geographic distribution records. The label information below when accompanying* ***each*** *specimen aids the identification process and greatly increases the scientific value of the specimen.*

Collector's Name & No.: Simon Danielsen – SFDanielsen1887a-e **Date of Collection**: 8 April 2013

Botanical name: *Livistona lanuginosa*

Locality (include distance to nearest town): Carmichael River, 150 km north west of Clermont on Moray Downs Station, approximately 17 km upstream from confluence with Belyando River

COORDINATES

Latitude 22° 5'45.45"S **Latitude** 146°25'22.56"E

Or **AMG Coordinates** (Zone, Easting, Northing):

Or **Map and grid reference** (eg 9442 333 666):

Source of Coordinates: GPS (GDA)

Situation (e.g. plain, creekbank, mountain): Bar plain just above Carmichael River channel

Cultivated? NO

Vegetation Type (e.g. forest, heath, woodland): *Eucalyptus camaldulensis* var. *obtusa* and *Melaleuca leucadendra*, *M. fluviatilis* fringing open forest

Soil/Geology/Regional Ecosystem: Alluvial

Kind of plant (e.g. tree, vine, herb): Palm

Description (e.g. size, bark type, flower or fruit colour, frequency): A Livistona 3 m tall (stem to 1.5 m tall), w/ conspicuous armature on lower petiole and waxy indumentum. 1887a and b = leaf sections, 1887c and d = entire petiole cut into 2 sections, 1887e = seed from nearby taller palm (recently burnt). Photos overleaf.

Abundance: 1 individual palm

Other Notes: Other palms observed elsewhere in river

Photos on this page and the next are of the individual from which sample 1887 was taken

Photos on this page are of one of the ~ 15 m palms observed in the Carmichael River

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1	S Danielsen	J Keane		J Keane		16/07/2013

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