DOCUMENT NO	REVISION	DATE OF REVISION
	Final	07/09/2012

Occurrence of Keraudrenia spp. in Buru's proposed Commodore West seismic area

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September 2012

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1.1.1.1

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DISCLAIMER

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1. EXECUTIVE SUMMARY

Buru Energy is an oil exploration company operating in the Canning Basin area of northern Western Australia. In May 2011, Buru Energy commissioned Low Ecological Services to conduct a Level 1 flora and fauna survey on its Commodore lease. In two sites, flowering *Keraudrenia* spp. were provisionally identified by Low Ecological Services (Le Feuvrve *et al*. 2011). Of the two populations, one was identified by the WA Herbarium as *K. exastia*, and one as *K. katatona*. Prior to further exploration in the newly created Commodore West lease, Buru commissioned Low Ecological Services to further identify the abundance and extent of *K. exastia* in and around the seismic area. The results of this commissioned work are presented here.

Sixty four locations covering an area 50% wider and 50% longer than the proposed Commodore West seismic area were surveyed. Approximately 20 minutes was spent at each location, with the presence of *Keraudrenia* spp. assessed. Ten locations that were cleared as part of seismic surveys in 1982 or 2011 were also assessed. If *Keraudrenia* spp. inflorescence were present, these were sampled. Specimens were then taken to the Perth Herbarium where they were identified using the taxonomic key of Kimberley *Keraudrenia* spp. (Wilkins 1999) and reference specimens under microscope.

Twenty two percent of all surveyed locations contained *Keraudrenia* spp. Fourteen percent of surveyed locations included *Keraudrenia* spp. that were flowering, and were therefore sampled. *Keraudrenia* spp. were generally found in the red sands of the swale/dune complexes typical of the Great Sandy Desert. They were generally associated with *Corymbia zygophylla, Gardenia pyriformis, Grevillea wickhammi, Erythrophleum chlorostachys, Jacksonia aculeata, Calytrix carinata, Triodia* sp., and sometimes *Owenia reticulata* and *Melaleuca lasiandra*. These species are also common throughout the proposed Commodore West seismic area. *Keraudrenia* spp. were not found in locations that had been burnt within the last two years, but did not appear to prefer a particular time since fire. *Keraudrenia* spp. was found to be recruiting at one location on a seismic line cleared in 2011.

None of the sampled *Keraudrenia* spp. were positively identified as *K. exastia* by Low Ecological Services. However the taxonomic key did not adequately represent the sampled *Keraudrenia* spp. That is, the set of distinguishing features for the different *Keraudrenia* spp. that were identified by the taxonomic key were sometimes only partially present. After previously viewing other *Keraudrenia* spp. from the Commodore and proposed Commodore West seismic area, the author of the taxonomic key, Carolyn Wilkins, suggested that the species status of *K. exastia* may be taxonomically uncertain. That is, it is possible that it is not an entirely different species to, for example, *K. katatona*. This may explain the difficulties encountered in identifying the species of specimens.

2. INTRODUCTION

2.1 The Commodore and Commodore West Seismic Areas

Buru Energy Limited (Buru) is an Australian ASX listed company focused on exploring and developing petroleum and gas resources in the Canning Basin in the Kimberley region of north-east Western Australia. Buru holds interests and rights in tenements covering more than 75,000 km² throughout the Canning Basin, including the Blina and Meda facilities.

Buru's Commodore lease is located approximately 130km south of Broome, east of the Nita Downs pastoral lease. The Commodore lease originally consisted of both the Commodore and Commodore West seismic area, but was later split into two separate leases. The Commodore lease was surveyed by Buru in 2011. The Commodore West area is currently proposed to be explored, with eight proposed seismic lines of a total length of 167.2 km.

In May 2011, Buru Energy commissioned Low Ecological Services to conduct a Level 1 flora and fauna survey on its Commodore lease. In two sites, flowering *Keraudrenia* spp. were provisionally identified by Low Ecological Services (Le Feuvrve *et al*. 2011). They were then sent to Carolyn Wilkins at the WA Herbarium in Perth for further identification. Of these two species, one was identified by Carolyn as *K. exastia*, and one as *K. katatona*.

1.2 The distribution and ecology of *K. exastia* and *K. katatona*

There are three species of *Keraudrenia* spp. that have the potential to occur in the Commodore West area. These are: *K. nephrosperma*, *K. exastia* and *K. katatona*. *K. nephrosperma* is considered to be relatively common, and has a known distribution in Western Australia from IBRA regions Pilbara, Central Ranges, Gascoyne, Great Sandy Desert, Ord Victoria Plain, Tanami and Dampierland (Department of Environment and Conservation 2012). The species is also known from the Northern Territory, and is not listed as threatened or rare under WA or Commonwealth law. For these reasons, it is not described further in this report.

Keraudrenia exastia was first described by Wilkins (1999). Prior to 2011, it was only known from seven subpopulations covering 0.04km^2 near the Broome Wharf, WA (Department of Sustainability, Environment, Water, Population and Communities, 2011). The Broome Wharf site is pindan (red sandy soil), with subpopulations growing on both flat and dune sites. The understorey is dominated by *Triodia* sp., the midstorey by *Acacia* spp. and the overstorey by *Eucalyptus* spp. The species is known to flower between April and December, but is not known to readily fruit (Wilkins 1999). This feature, combined with stems sprouting from lateral roots in the Broome population, suggests that it reproduces clonally. This tendency means that the number of 'true' individuals, as opposed to suckers

or genetic clones, may be far less than 3360 (Broome Botanical Society 1995), and indeed closer to 300 (Trudgen 1998).

The small population size, restricted range and possible lack of genetic diversity mean that this species is listed as critically endangered under the Commonwealth's *Environmental Protection and Biodiversity Conservation Act (1999*), and declared rare flora under WA's *Wildlife Conservation Act 1950* with a ranking of Critically Endangered. Threats to the Broome population were identified by Department of Sustainability, Environment, Water, Population and Communities (2011) as road maintenance as all subpopulations are located close to the road, invasive weeds and development.

The population originally sampled by Low Ecological Services and provisionally identified as *K. exastia* by Carolyn Wilkins in May 2011 was along the main access track to the Kalgara Zinc mineral lease. Like the Broome Wharf population, this population was found in the red sands of a dune/swale complex. The understorey at this site was dominated by *Triodia schinzii*, with *Sorghum plumosom*, *Aristida hygrometrica* and *Ptilotus* sp. The mid and upperstorey was dominated by *Acacia* spp, and *Corymbia zygophylla*.

Keraudrenia katatona is officially known from only a few locations. These locations include Broome, southern areas of the Dampierland Biogeographic Region and the far northern border of the Great Sandy Desert (Department of Environment and Conservation, 2011). These areas are desert dunes in pindan, ranges or disturbed areas. *Keraudrenia katona* was previously found along old seismic lines in the Edgar Ranges (Wilkins, personal communication). The species is known to proliferate in newly burnt areas. *Keraudrenia katatona* is listed as a Priority Three species under the *Wildlife Conservation Act 1950*. Species in this category are generally not considered to be under imminent threat, but are poorly known, or are known from only a few locations.

Sterile *Keraudrenia* spp were found at three locations by Le Feurve *et al* (2011) during the May survey and may have been either *K. exastia* or *K. katatona*. Understorey species in these sites included *Triodia schinzii, Aristida hygrometrica, Setaria apiculata, Panicum decompositum, Eriachne ciliata* and *Goodenia sepalosa* midstorey species included *Grevillea wickhamii, Senna notabilis, Calytrix exstipulata, Acacia adoxa, Acacia hilliana* and *Acacia monticola*, with the overstorey including *Corymbia zygophylla* and *Gardenia pyriformis*.

In response to the report of *K. exastia* by Le Feurve *et al*. (2011), Buru commissioned Low Ecological Services to re-visit the Commodore seismic area in 2011 for the specific purpose of locating *K. exastia* and *K. katatona*. Addison (2011) conducted a targeted search along the main access track into the area, around the original site at which *K. exastia* was provisionally identified, and at randomly selected intersections of proposed seismic lines. Of the 17 specimens collected, 3 were identified by Carolyn Wilkins as *K. nephrosperma*, 2 were sterile (and therefore unable to be identified) and 12 were *K. katatona*. No *K. exastia* were positively identified.

After viewing the specimens collected for Addison (2011), Carolyn Wilkins suggested that the original *K. exastia* identification may be less certain than she original thought, particularly given the minimal number of flowers on the original specimen. Given her advice, the original *K. exastia* identification was subsequently reclassified as provisional.

1.3 This report

Prior to the further exploration in the Commodore West area, Buru wishes to further identify the abundance and extent of *K. exastia* in and around the seismic area. In July 2012, Buru commissioned Low Ecological Services to:

- Undertake a flora survey to identify and map the occurrence of *K. exastia* at selected sites within the proposed Commodore West seismic survey area, including an appropriate control site and examination of existing seismic lines;
- Determine the pattern of occurrence of *K. exastia* so that potential mitigation measures for avoiding the species whilst laying out seismic lines, can be evaluated; and
- Provide advice on additional potential impact mitigation measures for *K. exastia* in conducting the proposed seismic survey.

The results of this commissioned work are presented, and discussed, in this report.

3. METHODS

3.1 Site description

The Commodore West lease is located on Crown Land on the northern edge of the Great Sandy Desert, in the Kimberley region of WA. Access to the lease is difficult due to the lack of roads. The closest road to the area is the graded, main access road to the Kalgara Zinc deposit. This road runs east-west, and is located to the north of the proposed Commodore West lease (Figure 1).

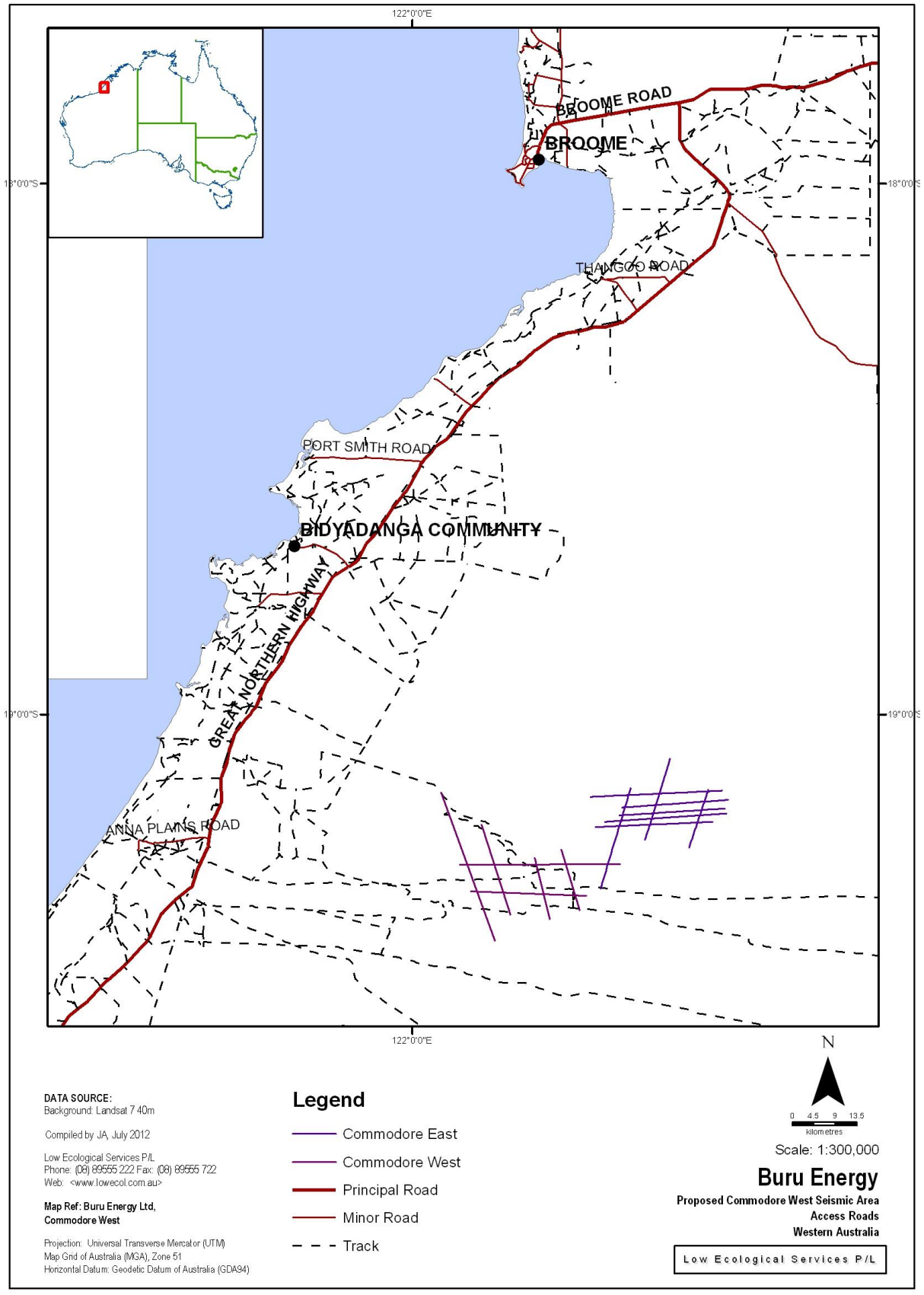

Figure 1 Proposed Commodore West Seismic Area, showing main access tracks.

The proposed Commodore West seismic area is located in the Great Sandy Desert bioregion (Australian Natural Resources Atlas 2009) and has been geologically described by Beard (1990) as "gently undulating plain dominated by longitudinal dunes of varying frequency tending mainly WNW-ESE. Chief soils are red earthly sands and red siliceous sands, with exposures of ironstone gravels locally". Jurassic and Cretaceous sandstone found in the Canning and Amadeus Basins are covered by Quaternary red siliceous sand dunes. The soils surrounding the low ranges are clayey and silty (Australian Natural Resources Atlas 2009).

The proposed survey area lies within the Great Sandy catchment, which covers an area of approximately 404,000 km^2. Drainage is limited to short ephemeral creeks and rivers, which only flow after heavy rainfall (Australian Natural Resources Atlas 2009). There are salt lakes in some areas, which represent the course of former rivers (Beard 1990). There are also a series of springs on Nita Downs station, to the west of the proposed Commodore West seismic area.

The area's climate is seasonally wet/dry. The long-term average annual rainfall at Nita Downs is 510 mm, with the vast majority falling between December and March (Bureau of Meteorology 2012). Rainfall patterns can affect the flowering periods of some species. For this reason, Figure 2 compares the wet season preceding the 2011/2012 survey period with long term rainfall averages. The 2011/2012 wet season total was similar to the long-term mean, but March was unusually wet following a drier than usual February.

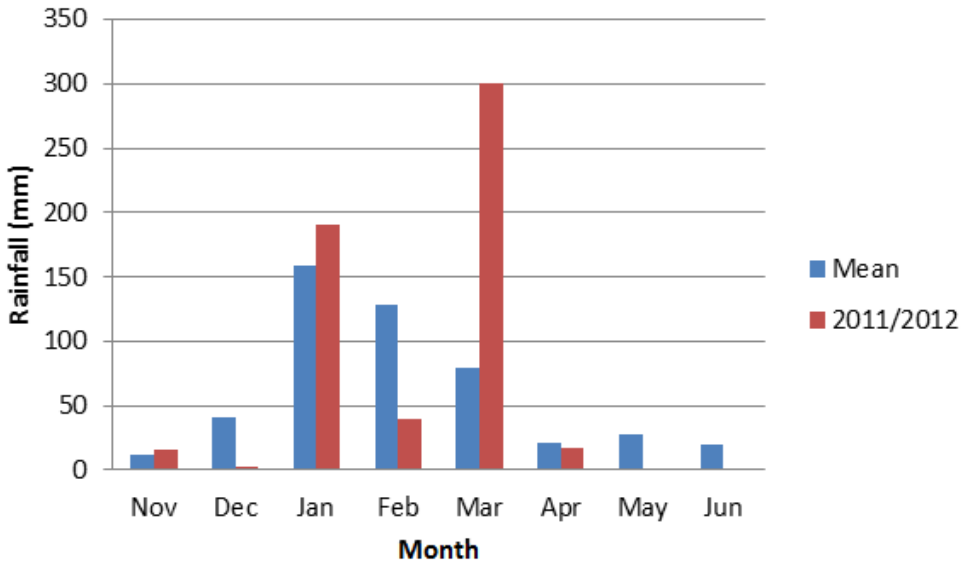

Figure 2 Rainfall patterns at Nita Downs Station (Bureau of Meteorology 2012). Data includes monthly means and monthly rainfall figures for the 2011/2012 wet season that preceded the survey.

The proposed Commodore West seismic area is located within the Great Sandy Desert IBRA Region in the Canning Botanical District, as defined by Beard (1990). The Botanical District is defined as "tree-steppe grading to shrub steppe in the southeast, comprising open hummock grassland of *Triodia*

pungens and *Plectrachne* (now *Triodia*) *schinzii* with scattered trees of *Owenia reticulata*, *Eucalyptus* spp. and shrubs of *Acacia* and *Grevillea*". This district covers the undulating plains of the Great Sandy Desert, dominated by longitudinal dunes of varying frequency (Beard 1990). Vegetation systems within the region were broadly mapped and described by Beard (1974) at a scale of 1:1,000,000. Specifically the vegetation is in the *Owenia reticulata* – *Triodia* spp. steppe.

The area is floristically similar to pindan, but the *Acacia* spp. layer is sparse and never forms the typical dense thickets of the pindan. Pindan is described by Beard (1979) as a "grassland wooded by a sparse upper layer of trees and a dense, thicket-forming middle layer of unarmed, phyllodal *Acacia*". There are scattered low (4 – 7.5 m) trees (mainly *Owenia reticulata* and to a lesser extent *Gardenia keartlandii,* now *Gardenia pyriformis*). There is a sparse shrub layer of *Acacia* and *Grevillea* and other species and a ground layer of hummock grasses (*Triodia* spp.) and bunch grasses (Beard 1974).

The proposed Commodore West seismic area it is located within the GSD1-McLarty sub-region and encounters three vegetation types, based on vegetation community associations related to physiognomy (Shepherd *et al*. 2002). These vegetation types are:

- 104: Hummock grasslands, shrub steppe, *Grevillea refracta* and hakea over soft spinifex.
- 699**:** Shrublands, pindan, *Acacia eripoda* shrubland with scattered low bloodwood (*E. dicromophloia*) and *E. setosa* (now *Corymbia zygophylla*) over soft and curly spinifex on sandplain.
- 713: Mosaic, hummock grasslands, open low tree steppe; bloodwood (*E. dichromophloia*) over soft spinifex/hummock grasslands, open low tree steppe; desert walnut over soft spinifex between sand ridges
- 1271: Bare areas; claypans

Northern Australian landscapes are prone to frequent burning. This can affect the likelihood of flora being present or absent during surveys. Figure 3 shows the 3 year fire history of the proposed Commodore West seismic survey area.

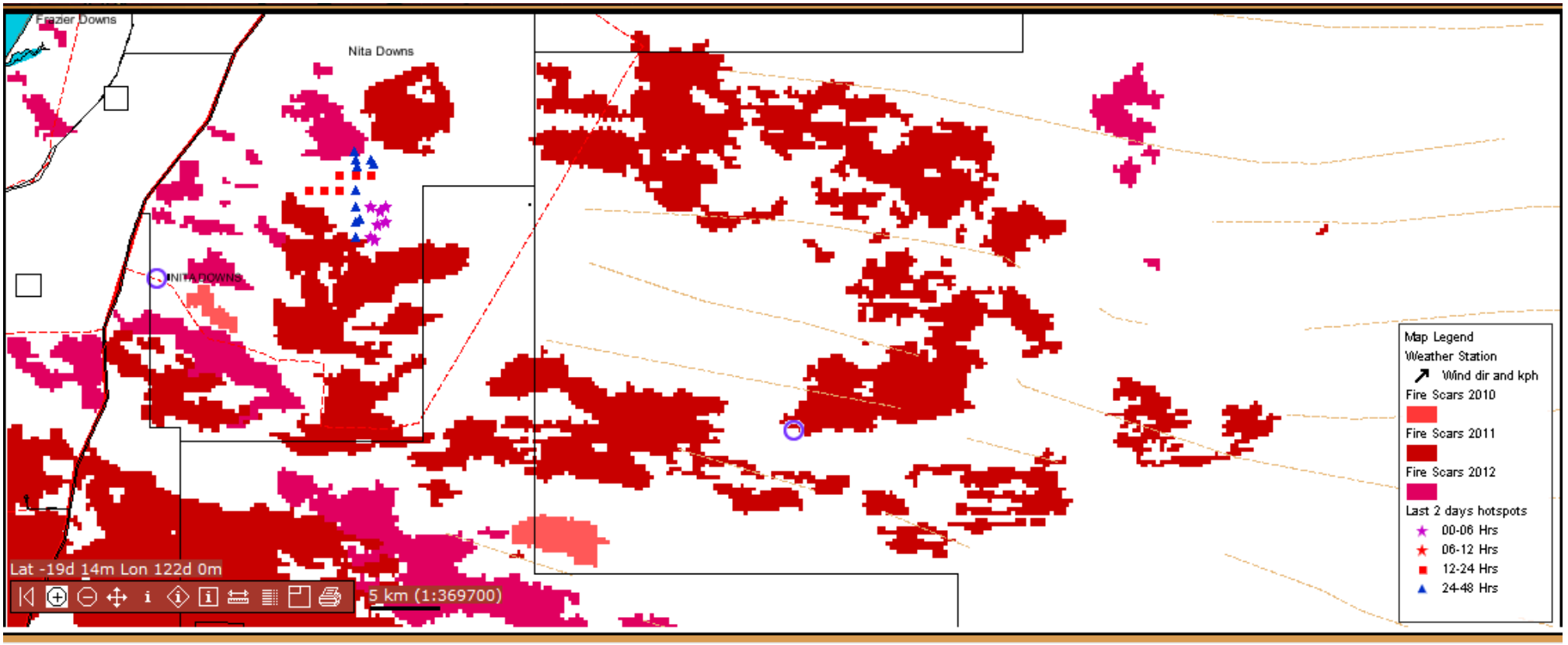

Figure 3 Fire scars for the period 2010 - 2012 in the proposed Commodore West seismic area (North Australian Fire Information 2012). The proposed Commodore West seismic area is located is the central section of the figure.

3.2 Methodology

Sixty four locations covering an area 50% wider and 50% longer than the proposed Commodore West seismic area were surveyed (

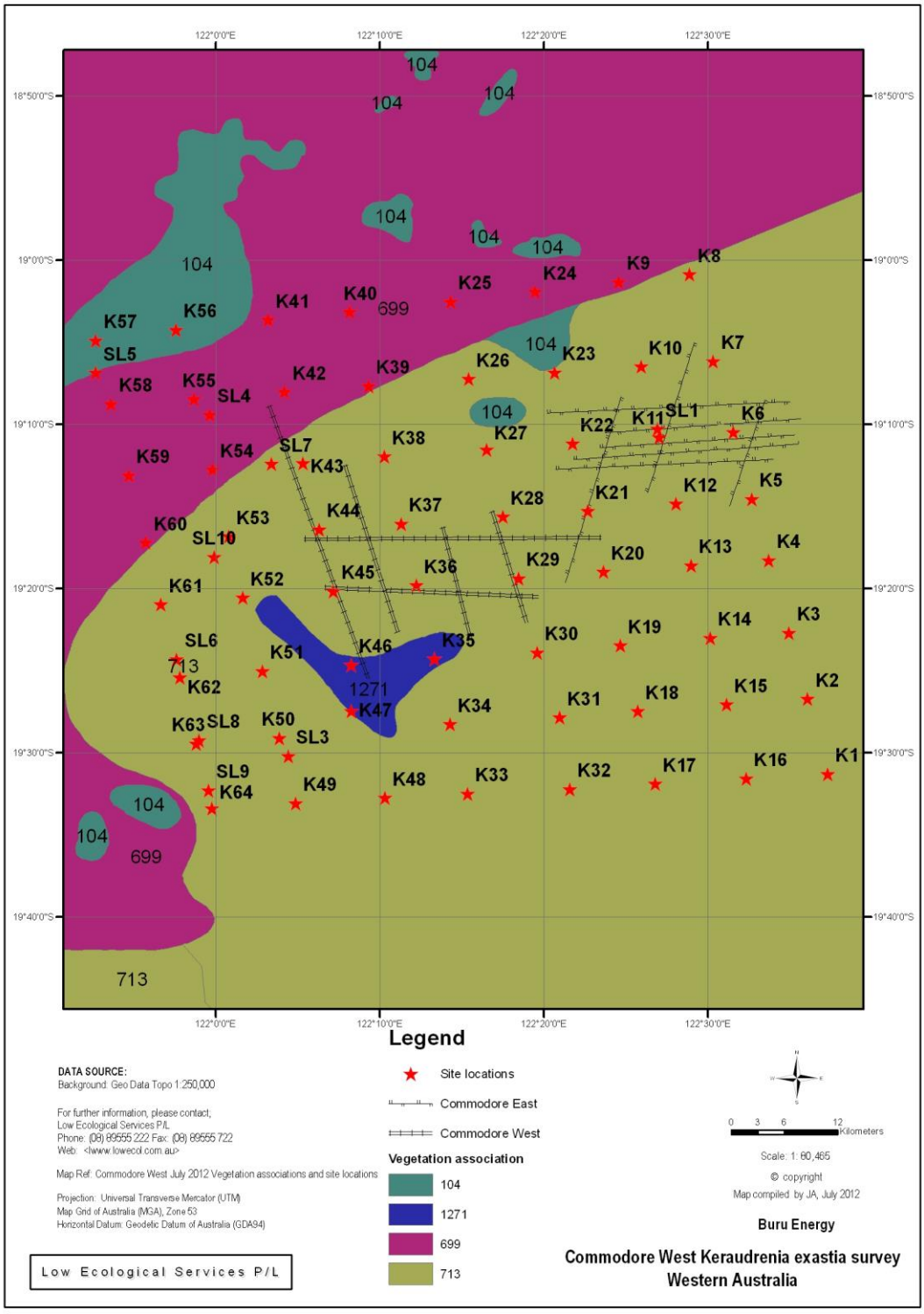

Figure 4 Location of sites assessed for the presence of *Keraudrenia* spp., showing vegetation communities of the area.).

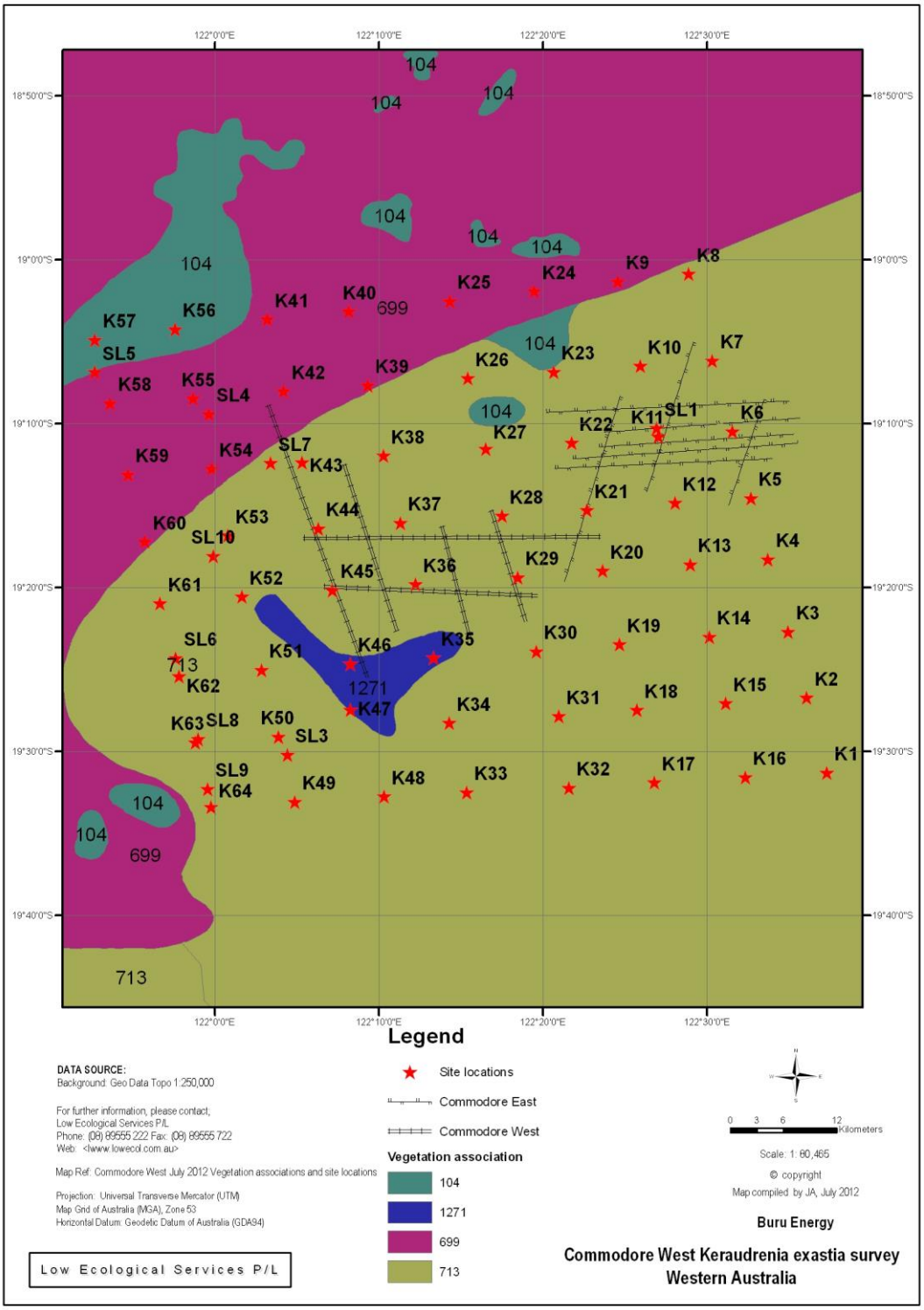

Figure 4 Location of sites assessed for the presence of *Keraudrenia* spp., showing vegetation communities of the area.

Approximately 20 minutes was spent at each location, with the presence of *Keraudrenia* spp. assessed. Ten locations that were cleared as part of seismic surveys in 1982 or 2011 were also assessed. If *Keraudrenia* spp. inflorescence were present, these were sampled. Specimens were then taken to the Perth Herbarium where they were identified using the taxonomic key of Kimberley *Keraudrenia* spp. (Wilkins 1999) and reference specimens under microscope.

4. RESULTS

4.1 Presence/absence

Twenty two percent of all surveyed locations contained *Keraudrenia* spp (Figure 5). Fourteen percent of surveyed locations included *Keraudrenia* spp. that were flowering, and were therefore sampled.

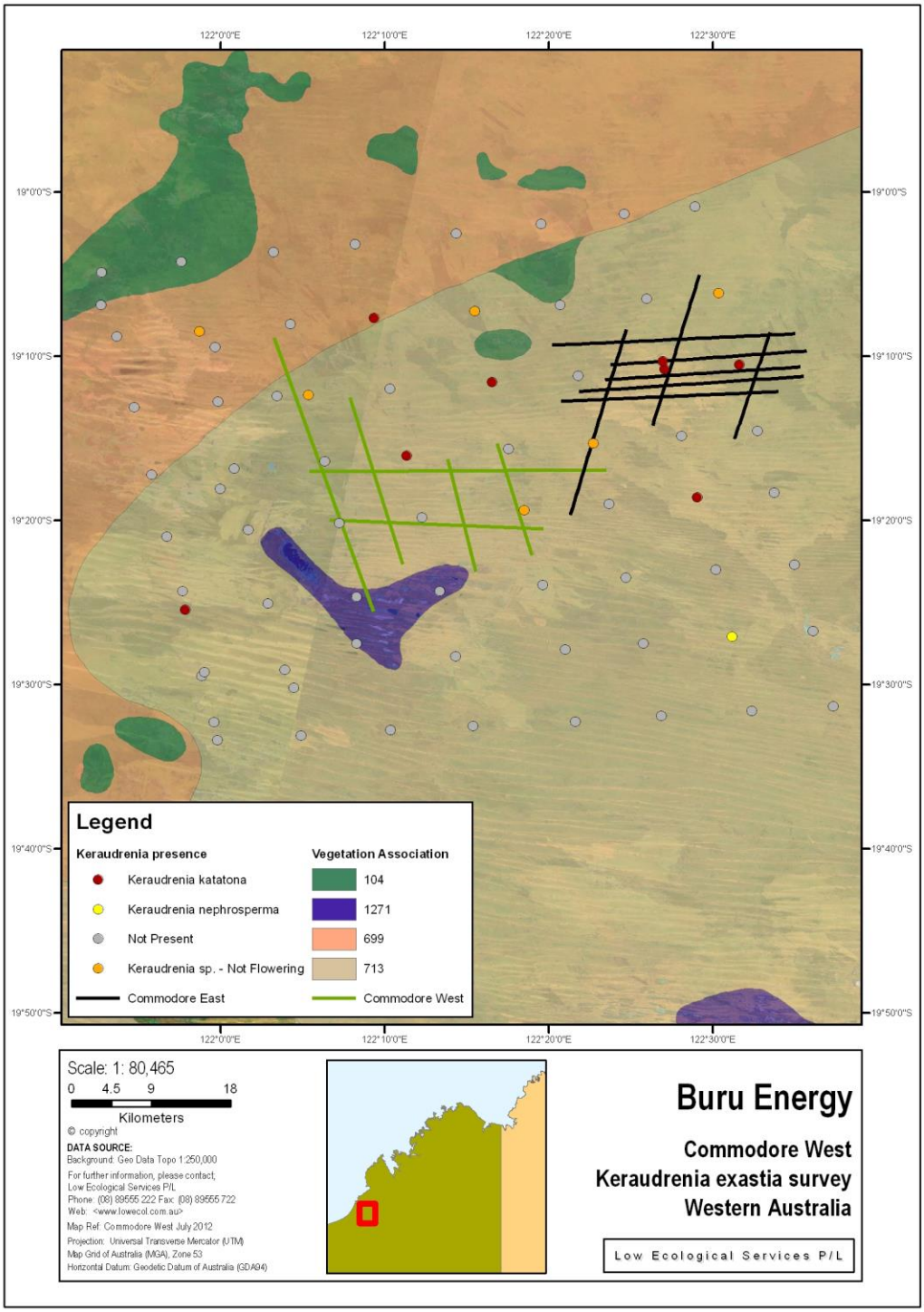

Figure 5 Location of *Keraudrenia* spp. sampled, as distinguished by phenology. This map was created using the identifying features shown in Table 1, and with the advice of Carolyn Wilkins (WA Herbarium). The map does not imply that *K. exastia* was not present at sites in which *Keraudrenia* spp. were not flowering.

No *Keraudrenia* spp. sampled had distinguishing features consistent with the *K. exastia* taxonomic key (Wilkins 1999). Some specimens had features that were consistent with *K. katatona.* However, many specimens had distinguishing features that appeared to be a mixture of both *K. katatona* and *K. exastia*. For example, red glands and a rounded apex on the calyx are distinguishing features of *K. katatona* (Wilkins 1999). However the *Keraudrenia* sp. located at site K6 had the red glands of *K. katatona* but the acuminate apex of *K. exastia* (Table 1).

Table 1 Distinguishing features of *K. exastia*, as per Wilkins (1999), and whether specimens showed any indication of these features.

Site	Replic.	Leaves concolourous?	Calyx lobe ovate rather than broadly ovate?	Calyx lobes as long, or longer than broad?	Calyx apex acuminate rather than rounded or sub-acute?	Calyx margin roughly fringed rather than entire?	7-9 flowers per inflorescence rather than 9-17?	Mid and lateral veins prominent, rather than reticulate venation?	Capitate glands absent on the underside of the calyx?
K11	1	No	Unclear	Unclear	No	No	Unclear	No	No obvious glands
	2	No	No	Possibly	No	No	Possibly	Unclear	No - red glands present
K13	1	No	Yes	Yes	Yes	Possibly	Yes	Unclear	No obvious glands
	2	No	No	No	Unclear	Possibly	-	Unclear	No obvious glands
K15	1	No	No	No	No	No	No	Unclear	No - red glands present
K27	1	No	-	-	-	-	-	-	-
	2	No	Unclear	Unclear	No	Possibly	-	Unclear	No - red glands present
	3	No	No	No	Unclear	Unclear	-	Unclear	No obvious glands
	4	No	Unclear	Unclear	No	No			No - red glands present
K37	1	No	Unclear	Yes	No	No	-	Unclear	No - red glands present
	2	No	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	No obvious glands
K39	1	No	Unclear	Possibly	No	No	Unclear	No	No obvious glands
	2	No	Yes	No	No	No	Unclear	Unclear	No - red glands present
K6	1	No	Possibly	No	Yes	No	Unclear	No	No - red glands present
	2	No	Yes	Yes	Yes	No	Unclear	No	No obvious glands
K62	1	No	No	No	Yes	Possibly	-	No	No - red glands present
	2	No	No	No	Yes	Yes	No	Unclear	No - red glands present
	3	No	No	No	Yes	No	No	Unclear	No - red glands present
	4	No	No	No	No	No	No	Unclear	No - red glands present
SL1	1	No	No	Possibly	Yes	Yes	Unclear	Unclear	No obvious glands
	2	No	No	No	No		No	No	No obvious glands
	3	No	No	Unclear	Unclear	Unclear	Unclear	Unclear	No - red glands present

Site	Replic.	Leaves concolourous?	Calyx lobe ovate rather than broadly ovate?	Calyx lobes as long, or longer than broad?	Calyx apex acuminate rather than rounded or sub-acute?	Calyx margin roughly fringed rather than entire?	7-9 flowers per inflorescence rather than 9-17?	Mid and lateral veins prominent, rather than reticulate venation?	Capitate glands absent on the underside of the calyx?
	4	No	No	Unclear	Yes	No	Unclear	Unclear	No - red glands present
	5	No	No	Unclear	Unclear	No	Unclear	Unclear	No - red glands present

4.2 Distribution

Keraudrenia spp. were found in the red sands of the swale/dune complexes and sandplains typical of the Great Sandy Desert. Small sample sizes make statistical tests inappropriate, but *Keraudrenia* spp. did not appear to favour any particular landform or vegetation association. *Keraudreni*a spp. were equally as likely to occupy dune crests, swales or plains. They were generally associated with *Corymbia zygophylla, Gardenia pyriformis, Grevillea wickhammi, Erythrophleum chlorostachys, Jacksonia aculeata, Calytrix carinata, Triodia* sp., and sometimes *Owenia reticulata* and *Melaleuca lasiandra*. These species are common throughout the proposed Commodore West seismic area, and surroundings.

Keraudrenia spp. were not found in locations that had been burnt within the last two years (see Figure 3 and Appendix 1), but otherwise did not appear to prefer a particular time since fire. A *Keraudrenia* sp. was found to be recruiting at one location on a seismic line cleared in 2011 (SL1 – see Table 1). The seismic line was cleared through a pre-existing *Keraudrenia* sp. population. An inflorescence was able to be collected from the remains of the existing population as recruiting juveniles were not flowering. At another location, a *Keraudrenia* sp. population had been partially cleared by a 2011 seismic line but had not yet recruited. Additional *Keraudrenia* spp. were not sighted along, or immediately adjacent to, the other seismic lines surveyed.

5. DISCUSSION

An assessment of the likely impact that the clearing of seismic lines at Commodore West would have on *K. exastia* cannot be specifically determined given the taxonomic uncertainty described in this report. However, the majority of this area is in vegetation community 713, which has not been subject to substantial clearing (Shepherd *et al*. 2002). The proposed area to be cleared represents a very small proportion of the total area of the vegetation community (Shepherd *et al*. 2002) in which *K. exastia* was provisionally identified by Le Feurve *et al*. (2011). Similarly, the mixture of fire patterns

within the one to three year time period (

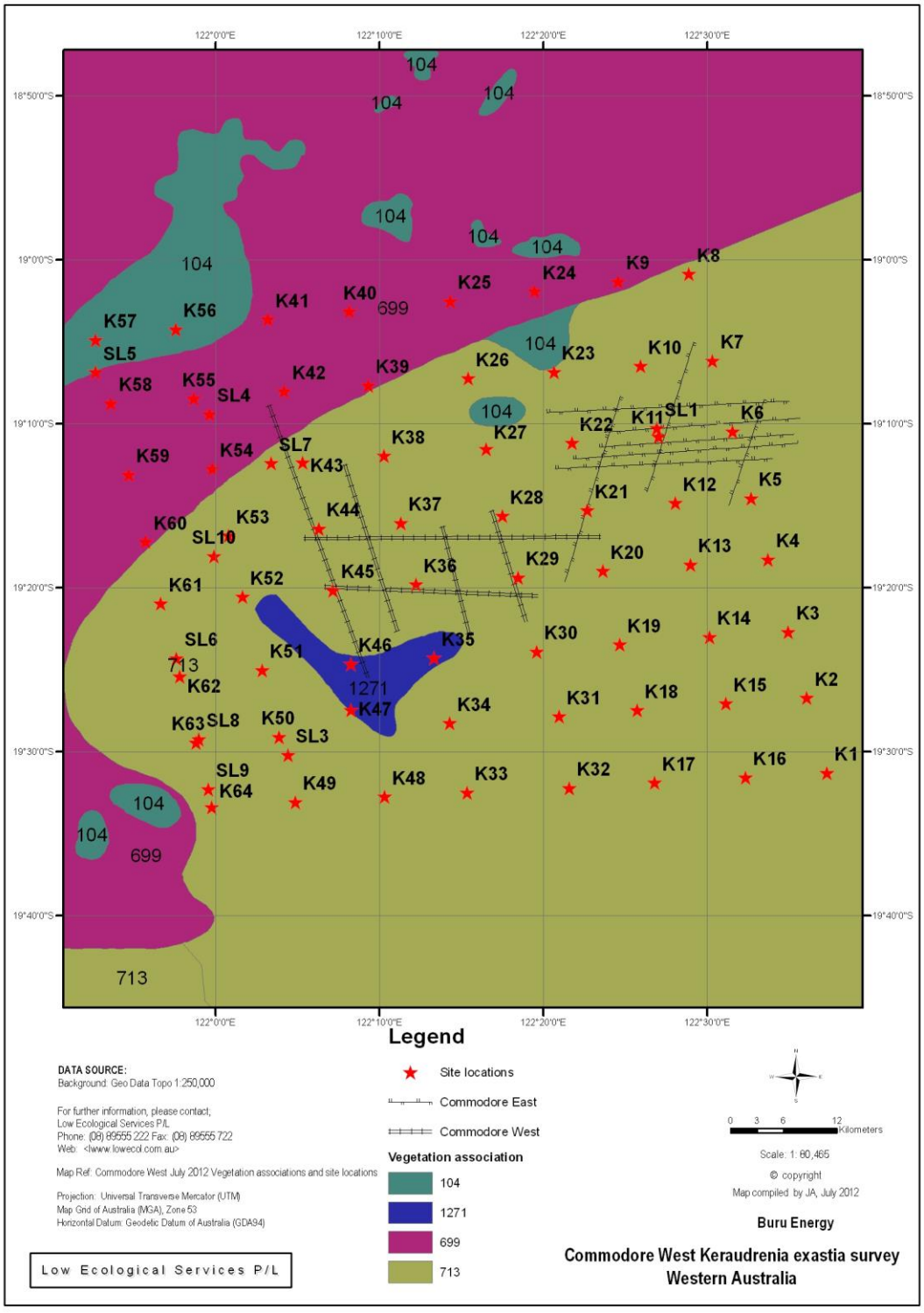

Figure 4 Location of sites assessed for the presence of *Keraudrenia* spp., showing vegetation communities of the area.) is typical of large areas of the southern Kimberley in which this vegetation community is located. The proposed Commodore West seismic area is therefore unlikely to be unique in having a fire regime that selects for *K. exastia*. The three aims of the commissioned work described here are now addressed directly.

Undertake a flora survey to identify and map the occurrence of *K. exastia* at selected sites, including an appropriate control site and examination of existing seismic lines

The pre-existing taxonomic key (Wilkins 1999) makes it difficult to adequately differentiate between *K. exasti*a and other *Keraudrenia* spp. It is possible that *K. exastia* is a hybrid species (Wilkins, personal communication, 2011). This makes it difficult to definitively map the distribution or density of the species through the proposed Commodore West seismic area at the present time. As such, Figure 5 does conclusively imply that *K. exastia* does not exist in the area. Further taxonomic work on *K. katatona/K. exastia* is needed.

Determine the pattern of occurrence of *K. exastia*

The issues around positively identifying *K. exastia* mean that the pattern of occurrence of *K. exastia* cannot be determined. However, *Keraudrenia* spp. in general appeared to be randomly located within the survey area. *Keraudrenia* spp. were not specifically associated within any one vegetation community or fire history within the survey area. There appears to be nothing atypical about the vegetation or landform type in which the original *K. exastia* specimen was provisionally identified by Le Feuvre (2011). If that specimen was indeed *K. exastia* (see Section 1.2 for why this may not be the case), this means that it is reasonably likely to be located throughout the entire proposed Commodore West seismic area. However, neither the results presented in this report, nor Addison (2011), positively identified *K. exastia* throughout the area.

Provide advice on additional potential impact mitigation measures for *K. exastia* in conducting the proposed seismic survey.

The issues described above make it difficult to suggest potential impact mitigation measures for *K. exastia* within the proposed Commodore West seismic area. The literature reviewed in this report, and the results of this report, highlight no particular landform or vegetation type within the proposed Commodore West area that can be specifically avoided due to a likelihood of *Keraudrenia* spp being present. To the untrained eye, *K. exastia* can be very easily confused with the two other *Keraudrenia* spp. and non-related purple flowering shrubs/subshrubs such as *Solanum* spp. Even if they could be positively identified, the tendency of *Keraudrenia* spp. individuals to be densely clumped within a single population would also make it highly impractical to avoid them whilst laying seismic lines. A 1 km radial buffer around the original, provisionally identified *K. exastia* species is one of the few mitigation measures that is likely to be practical. Buru's usual precautions against igniting fires, and strong weed hygiene controls, may be other potential mitigation measures.

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APPENDIX 1: SITE DESCRIPTIONS

Site	Soil type	Land type	Vegetation Specht (1970)	Vegetation Shepherd *et al.* (2002)	Dominant species	Fire history	Weeds	*Keraudrenia* spp. Present	*Keraudrenia* spp. Flowering
K1	Red sand	Swale	Tall open-shrubland	713	*Jacksonia aculeata, Grevillea wickhammi, Gardenia pyriformis, Erythrophleum chlorostachys, Triodia spp.*	< 3 years	0	0	0
K2	Clayey sand loam	Salt lake edge	Open-heath	713	*Melaleuca lasiandra, Grevillea sp., Acacia translucens, Eragrostis sp., Tecticornia sp., Xerochloa laniflora*	< 3 years	0	0	0
K3	Red sand	Swale	Tall shrubland	713	*Corymbia sp., Gardenia pyriformis, Grevillea wickhammii, Erythrophleum chlorostachys, Acacia sp., Triodia sp., Jacksonia aculeata, Crotalaria cunninghami, Triodia sp.*	< 3 years	0	0	0
K4	Red sand	Swale/dune edge	-	713	*Triodia sp., Crotalaria cunninghammi, Calytrix exstipulata, Grevillea wickhammii, Acacia sp., Grevillea eriostachya, Corchorus sidoides, Owenia reticulata,*	< 3 years	0	0	0
K5	Red sand	Swale/dune edge	Tall shrubland	713	*Corymbia zygophylla, Acacia sp., Grevillea wickhammi, Calytrix exstipulata, Triodia sp., Aristida sp., Corchorus sidoides*	< 3 years	0	0	0
K6	Red sand	Swale	Tall shrubland	713	*Corymbia zygophylla, Gardnia pyriformis, Acacia tumida, Calytrix exstipulata, Grevillea sp, Triodia sp., Aristida inequiglumis, Eragrostis*	< 3 years	0	1	1
K7	Red sand	Swale/plain	Tall shrubland	713	*Corymbia zygophylla, Gardenia pyriformis, Grevillea sp., Acacia sp., Acacia tumida, Grevillea wickhammi, Erythrophleum chlorostachys, Triodia sp., Hacksonia aculeata, Aristida holathera*	< 3 years	0	1	0
K8	Red sand	Swale/plain	Low woodland	713	*Corymbia zygophylla, Acacia holosericea, Gardenia pyrifromis, Acacia tumida, Grevillea wickhamii, Grevillea refracta, Erythrophleum chlorostachys, Triodia sp., Aristida sp.,*	< 3 years, hot	0	0	0
K9	Red sand	Swale/plain	Low woodland	699	*Corymbia zygophylla, Gardenia pyriformis, Grevillea sp., Eucalyptus dichromophloia, Erythrophleum chlorostachys, Acacia eriopoda, Grevillea refracta, Triodia spp.*	< 3 years	0	0	0
K10	Red sand	Swale/plain	Tall shrubland	713	*Corymbia zygophylla, Gardenia pyriformis, Eucalyptus dichromophloia, Acacia sp., Grevillea wickhammi, Acacia colei, Erythrophleum chlorostachys, Triodia sp., Chrysopogon sp., Eriachne obtusa*	< 3 years, hot	0	0	0
K11	Red sand	Swale/plain	Low woodland	713	*Corymbia zygophylla, Gardenia pyriformis, Acacia tumida, Erythrophleum chlorostachys, Grevillea wickhammi, Triodia sp., Chrysopogon sp., Calytrix exstipulata*	< 3 years	0	1	1
K12	Red sand	Swale/plain	Tall shrubland	713	*Eucalyptus dichromophloia, Melaleuca lasiandra, Grevillea wickhammi, Jacksonia aculeata, Acacia sp., Triodia sp., Newcastelia cladotricha*	< 3 years	0	0	0
K13	Red sand	Swale	Tall open-shrubland	713	*Gardenia pyriformis, Jacksonia aculeata, Acacia spp., Grevillea wickhammi, Triodia spp., Newcastelia cladotricha., Solanum sp.*	< 3 years	0	1	1
K14	Red sand	Swale	Tall open-shrubland	713	*Corymbia zygophylla, Erythrophleum chlorostachys, Acacia sp., Grevillea wickhammi, Triodia spp., Chrysopogon sp., Indigofera sp., Jacksonia aculeata*	< 3 years	0	0	0
K15	Red sand	Swale	Tall shrubland	713	*Owenia reticulata, Calytrix exstipulata, Grevillea wickhammi, Gardenia pyriformis, Grevillea eriostachya, Triodia sp.*	> 3 years	0	1	1

Site	Soil type	Land type	Vegetation Specht (1970)	Vegetation Shepherd *et al.* (2002)	Dominant species	Fire history	Weeds	*Keraudrenia* spp. Present	*Keraudrenia* spp. Flowering
K16	Red sand	Swale/dune edge	Tall shrubland	713	*Corymbia zygophylla, Grevillea wickhammi, Erythrophleum chlorostachys, Acacia sp., Triodia sp., Spermococe sp., Stackhousia intermedia*	< 3 years	0	0	0
K17	Red sand	Swale	Tall open-shrubland	713	*Gardenia pyriformis, Owenia reticulata, Erythrophleum chlorostachys, Acacia translucens, Grevillea wickhammi, Triodia sp., Trianthema, Cyperus sp.*	< 1 year	0	0	0
K18	Red sand	Swale	Tall shrubland	713	*Corymbia zygophylla, Erythrophleum chlorostachys, Gardenia pyriformis, Grevillea wickhammi, Triodia sp., Newcastelia cladotricha, Corchorus sidoides*	< 3 years	0	0	0
K19	Red sand	Swale	Low woodland	713	*Corymbia zygophylla, Eucalyptus dichromophloia, Gardnia pyriformis, Grevillea wickhammi, Grevillea refracta, Calytrix exstipulata, Triodia sp., Aristida inequiglumis, Erythrophleum chlorostachys*	> 3 years	0	0	0
K20	Red sand	Swale	Tall shrubland	713	*Corymbia zygophylla, Acacia colei, Acacia sp., Erythrophleum chlorostachys, Gardenia pyriformis, Triodia sp., Newcastlia sp., Tricodesma zeylandia*	> 3 years	0	0	0
K21	Red sand	Swale/dune edge	Low woodland	713	*Corymbia zygophylla, Gardenia pyriformis, Jacksonia aculeata, Acacia sp., Calytrix exstipulata, Triodia sp., Aristida inequiglumis, Newcastelia cladotricha*	> 3 years	0	1	0
K22	Red sand	Swale/dune edge	Low woodland	713	*Eucalyptus dichromophloia, Corymbia zygophylla, Acacia monticola, Acacia colei, Gardenia pyriformis, Triodia sp., Chrysopogon sp., Eriachne obtusa*	> 3 years	0	1	0
K23	Red sand	Swale	Low woodland	713	*Corymbia zygophylla, Gardenia pyriformis, Acacia sp., Grevillea wickhammi, Triodia sp., Acacia adoxa*	> 3 years	0	0	0
K24	Red sand	Plain	Tall shrubland	699	*Corymbia zygophylla, Owenia reticulata, Acacia sp., Grevillea refracta, Gardenia pyriformis, Triodia sp., Newcastelia cladotricha*	-	0	0	0
K25	Red sand	Plain	Low woodland	699	*Corymbia zygophylla, Owenia reticulata, Gardenia pyriformis, Erythrophleum chlorostachys, Hakea sp., Triodia sp.*	> 3 years	0	0	0
K26	Red sand	Plain	Low open-woodland	713	*Melaleuca lasiandra, Triodia sp., Jacksonia aculeata, Trianthema sp.*	< 2 years, cool	0	1	?
K27	-	-	Low woodland	713	*Corymbia zygophylla, Acacia sp., Triodia sp., Acacia adoxa*	< 3 years	0	1	1
K28	Red sand	Swale/dune edge	Low woodland	713	*Corymbia zygophylla, Jacksonia aculeta, Corchorus sp., Erythrophleum chlorostachys, Triodia sp., Crotalaria cunninghammi*	< 3 years	0	0	0
K29	Red sand	Swale	Low woodland	713	*Owenia reticulata, Corymbia zygophylla, Acacia sp., Erythrophleum chlorostachys, Grevillea wickhami, Triodia sp.*	< 3 years	0	1	0
K30	Sandy clay loam	-	Tall shrubland	713	*Acacia monticola, Acacia colei, Grevillea refracta, Gardenia pyriformis, Acacia hilliana, Triodia sp.*	> 3 years	0	0	0
K31	Red sand	Swale/plain	Low open-woodland	713	*Owenia reticulata, Gardenia pyriformis, Acacia sp., Triodia sp.*	> 3 years	0	0	0
K32	Red sand	Swale	Tall shrubland	713	*Corymbia zygophylla, Acacia sp., Acacia monticola, Eriachne sp., Acacia adoxa, Triodia sp.*	< 1 year	0	0	0
K33	Red sand	Swale	Tall open-shrubland	713	*Erythrophleum chlorostachys, Grevillea wickhamii, Gardenia pyriformis, Calytrix exstipulata, Trianthema sp., Triodia sp., Eragrostis*	< 1 year	0	0	0

Site	Soil type	Land type	Vegetation Specht (1970)	Vegetation Shepherd *et al.* (2002)	Dominant species	Fire history	Weeds	*Keraudrenia* spp. Present	*Keraudrenia* spp. Flowering
					sp.				
K34	Red sand	Swale	Tall shrubland	713	*Corymbia zygophylla, Owenia reticulata, Erythrophleum chlorostachys, Grevillea wickhammi, Acacia sp., Triodia sp., Indigofera sp., Trianthema sp.*	< 1 year	0	0	0
K35	Sandy clay loam	Salt lake edge	Low open-woodland	1271	*Owenia reticulata, Melaleuca lasiandra, Acacia colei, Portulaca sp., Triodia sp., Tecticornia sp.,*	> 2 years	0	0	0
K36	Red sand	Dune blow-out	Low open-shrubland	713	*Erythrophleum chlorostachys, Gardenia pyrifromis, Gardenia pyriformis, Crotalaria cunninghammi, Triodia sp.*	< 3 years	0	0	0
K37	Red sand	Swale	Low open-woodland	713	*Corymbia zygophylla, Owenia reticulata, Acacia sp., Grevillea wickhammi, Erythrophleum chlorostachys, Calytrix exstipulata, Triodia sp.*	> 3 years	0	1	1
K38	Red sand	Swale	Low woodland	713	*Gardenia pyriformis, Corymbia zygophylla, Acacia sp., Grevillea wickhammi, Grevillea eriostachya, Triodia sp., Solanum sp., Jacksonia aculeata*	< 1 year	0	0	0
K39	-	-	Low open-woodland	713	*Owenia reticulata, Corymbia zygophylla, Acacia sp., Gardenia pyriformis, Clerodendrum floribundom, Triodia sp., Trianthema sp., Eriachne sp.*	< 1 year	0	1	1
K40	Red sand		Low open-woodland	699	*Corymbia zygophylla, Acacia adoxa, Acacia colei, Gardenia pyriformis, Triodia sp., Stackhousia intermedia, Trianthema sp.*	< 1 year	0	0	0
K41	Red sand	Plain	Tall shrubland	699	*Acacia colei, Gardenia pyriformis, Acacia sp., Acacia wickhammi, Triodia sp., Jacksonia sp., Acacia hilliana*	> 3 years	0	0	0
K42	Red sand	Plain	Low open-woodland	699	*Corymbia zygophylla, Gardenia pyriformis, Acacia sp., Calytrix exstipulata, Triodia sp., Solanum sp., Jacksonia aculeata*	< 1 year	0	0	0
K43	Red sand	Swale	Low woodland	713	*Corymbia zygophylla, Acacia sp., Erythrophleum chlorostachys, Triodia sp., Trianthema sp., Acacia adoxa, Aristida inequiglumis*	> 3 years	0	1	0
K44	Red sand	Swale	Low open-woodland	713	*Corymbia zygophylla, Acacia colei, Gardenia pyriformis, Grevillea refracta, Triodia sp., Acacia adoxa*	-	0	0	0
K45	Red sand	Swale	Tall open-shrubland	713	*Gardenia pyriformis, Triodia sp., Trianthema sp.*	> 3 years	0	0	0
K46	Sandy clay loam		Tall shrubland	1271	*Owenia reticulata, Acacia ampliceps, Melaleuca lasiandra, Acacia colei, Eragrostis sp., Eriachne obtusa, Triodia spp., Tecticornia sp.*	> 3 years	0	0	0
K47	Red sand	Swale/dune edge	Low open-woodland	713	*Owenia reticulata, Corymbia zygophylla, Melaleuca lasiandra, Acacia translucens, Acacia colei, Triodia sp.*	> 3 years	0	0	0
K48	Red sand	Swale/dune edge	Tall shrubland	713	*Corymbia zygophylla, Owenia reticulata, Grevillea wickhammi, Gardenia pyriformis, Grevillea refracta, Calytrix exstipulata, Triodia sp., Jacksonia aculeta, Aristida inequiglumis*	-	0	0	0
K49	Red sand	Swale/dune edge	Low open-woodland	713	*Corymbia zygophylla, Erythrophleum chlorostachys, Corchorus sidoides, Acacia sp., Triodia sp., Aristida sp., Eriachne obtusa*	> 3 years	0	0	0
K50	Red sand	Swale/dune edge	Low open-woodland	713	*Corymbia zygophylla, Owenia reticulata, Acacia adoxa, Acacia tumida, Gardenia pyriformis, Jacksonia aculeata, Triodia sp., Calytrix exstipulata*	< 2 years	0	0	0
K51	Red	Plain	Tall	713	*Owenia reticulata, Corymbia zygophylla, Acacia sp., Gardenia*	-	0	0	0

Site	Soil type	Land type	Vegetation Specht (1970)	Vegetation Shepherd *et al.* (2002)	Dominant species	Fire history	Weeds	*Keraudrenia* spp. Present	*Keraudrenia* spp. Flowering
	sand		shrubland		*pyriformis, Erythrophleum chlorostachys, Triodia sp.*				
K52	Red sand	Plain	Low open-woodland	713	*Owenia reticulata, Acacia sp., Codonocarpus cotinifolius, Triodia sp., Newcastelia cladotricha, Solanum sp.*	< 2 years	0	0	0
K53	Sandy clay loam		Low open-shrubland	713	*Grevillea refracta, Acacia translucens, Grevillea wickhammi, Triodia sp., Stackhousia intermedia, Melaleuca lasiandra*	< 3 years	0	0	0
K54	Red sand		Tall shrubland	699	*Melaleuca lasiandra, Acacia sp., Hakea sp., Jacksonia aculeata, Grevillea refracta, Triodia sp.,*	> 3 years	0	0	0
K55	Red sand	Swale/dune edge	Low open-woodland	699	*Melaleuca lasiandra, Grevillea striata, Triodia sp., Trianthema sp., Ptilotus sp., Chrysopogon sp.*	< 2 years	0	1	1
K56	Sandy clay loam		Tall open-shrubland	104	*Gardenia pyriformis, Melaleuca lasiandra, Acacia colei, Hakea sp., Triodia sp., Chrysopogon sp., Eriachne obtusa*	-	0	0	0
K57	Clay loam		-	104	*Bauhinia cunninghammi, Eucalyptus dichromophloia, Acacia monticola, Acacia colei, Gossypium australa, Carissa lanceolata, Chrysopogon sp., Triodia sp., Acacia hilliana*	> 3 years	0	0	0
K58	Red sand	Swale/dune edge	-	699	*Corymbia zygophylla, Grevillea eriostachya, Crotalaria cunninghammi, Gardenia pyriformis, Triodia sp., Acacia sp., Acacia adoxa*	< 2 years	0	0	0
K59	Red sand		Tall open-shrubland	699	*Eucalyptus dichromophloia, Melaleuca lasiandra, Grevillea refracta, Acacia colei, Acacia hilliana, Triodia sp., Jacksonia aculeata, Newcastelia cladotricha*	> 3 years	0	0	0
K60	Red sand		Tall open-shrubland	699	*Grevillea refracta, Triodia sp.*	< 1 year	0	0	0
K61	Red sand	Swale	Tall open-shrubland	713	*Melaleuca lasiandra, Acacia adoxa, Corchorus sidoides, Grevillea eriostachya, Triodia sp., Ptilotus sp., Senna sp., Trianthema sp.*	< 3 years	0	0	0
K62	Red sand	Dune crest	Tall shrubland	713	*Corymbia zygophylla, Calytrix exstipulata, Triodia sp., Sida arenicola, Trianthema sp., Spermococoe sp., Eragrostis sp., Goodenia sepalosa*	< 2 years	0	1	1
K63	Red sand	Dune crest	Low open-woodland	713	*Owenia reticulata, Corymbia zygophylla, Jacksonia aculeata, Acacia sp., Calytrix exstipulata, Sida arenicola, Triodia sp., Acacia adoxa*	> 3 years	0	0	0
K64	Red sand	Swale/dune edge	Tall open-shrubland	713	*Corymbia zygophylla, Grevillea refracta, Gardenia pyriformis, Acacia sp., Triodia sp., Acacia hilliana, Erichachne obtusa*	> 3 years	0	0	0

APPENDIX 2: HELICOPTER LOG