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Habitat evaluation of two proposed extension areas to the Ginninderry reserve to provide improved ecological outcomes for *Varanus rosenbergi*.

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Executive Summary

This study used a multiple lines of evidence approach to assess the suitability of expanding the proposed Ginniderry conservation area at two specific areas (comprising a total of 11.1 ha) to support improved conservation outcomes for *Varanus rosenbergi*. We assessed the two areas based on the critical ecological needs of *V. rosenbergi* which include:

1. Termite mounds of *Nasutitermes exitiosus*. Without termite mounds, *V. rosenbergi* populations are unviable as there would be no recruitment of young (as hatchlings) into the population.
2. Refuge sites such as hollow logs, rock crevices, patches of thicket, and burrows are important because they provide shelter.
3. Adequate foraging areas are necessary for population sustainability.

The two areas (A and B) are ecologically degraded and do not contain habitat features that would improve the conservation outcomes of *V. rosenbergi*. Importantly, the two areas do not offer additional critical ecological resources (such as termite mounds and refuge sites) for *V. rosenbergi* that wouldn't otherwise be protected in the proposed conservation area and adjoining river corridor. Although we agree with the finding of Eco Logical (2016) that the two areas represent very poor habitat for *V. rosenbergi*, we disagree with their recommendation to include areas A and B in the reserve to improve conservation outcomes for *V. rosenbergi* as the rationale and logic underpinning their recommendation is unclear.

Background

The development.
The proposed Ginninderry urban development is a joint venture between the ACT Land Development Agency (LDA) and Riverview Developments, a propriety limited company. The urban development is expected to build 6,500 dwellings in the ACT and 5,000 dwellings in NSW. The development will house about 30,000 residents and will be developed progressively over the next 30-40 years. The proposed urban community is located to the west of Belconnen, near Kippax and will extend across the ACT/NSW border.

Proposed Ginninderry conservation area.
As part of the Ginninderry master plan, the Joint Venture proponents are proposing the establishment of a conservation area as part of their sustainability vision for the development. The conservation area will cover approximately 577 hectares from the southern side of Ginninderra Creek in NSW and south along the eastern bank of the Murrumbidgee River in NSW and the ACT to Stockdill Drive near Holt in the ACT. The proposed Conservation Area consists of undulating land, consisting of open woodland and native grasslands (TRC 2014), with the current predominant land use supporting pastoral activities.

A large number of environmental and ecological investigations have been commissioned by the proponents and interested stakeholders. The base studies, are available for view in the Reports Library of the Ginninderry Group – http://ginninderry.com/planning/reports-library. Many of the investigations identified values of conservation significance, including endangered box-gum woodlands, Pink-tailed Worm Lizard, and Golden Sun Moth as well as the Vulnerable Rosenberg's Goanna. There is no doubt that the proposed conservation corridor contains a variety of social, cultural, and environmental values. To this end, TRC (2014) assessed the suitability of the proposed conservation area as a protected area against best practice criteria and found that it was highly suitable for reserve classification. The proponents are canvasing appropriate management models,

one of which is management via an environmental trust to protect and maintain the values of the conservation area in perpetuity.

The proposed conservation area boundary line was derived based on a combination of inputs including the habitat needs of threatened species as well as numerous other social, recreational and cultural values. The habitat needs of the Pink-tailed Worm Lizard (listed as vulnerable – under federal legislation) and the Box-Gum woodlands (listed as endangered under federal legislation) were significant species used as inputs in delineating the proposed conservation area boundary line because of their high conservation value. However, *V. rosenbergi* is also known to occur within the reserve area but was not included the initial assessments. This prompted the proponents to commission their 2016 study into the habitat requirements of *V. rosenbergi* (listed as vulnerable under NSW legislation). The principle aim of that study was to understand whether the proposed conservation area would meet the needs of this goanna species. The proponents engaged Eco logical Pty Ltd to assess whether the area proposed for urban development contained significant number/distribution of habitat elements essential to the ongoing viability of the Rosenberg's Goanna population. Their study also listed actions to mitigate any potential impacts and to improve habitat values in areas to be managed for conservation outcomes.

The Eco Logical (2016) study recommended varying the reserve boundary line at four discrete locations, extending the size of the reserve by approximately 13.4 ha; two of the locations were on property owned by Mr John Hyles (as two discrete areas of approximately 10.3ha and 0.8ha). This recommendation prompted the current investigation, as part of a due diligence process.

Purpose and Scope

Mr John Hyles commissioned the Institute of Applied Ecology at the University of Canberra to undertake the following studies:

- Evaluate the findings of Eco Logical Pty Ltd as documented in their 2016 report to Riverview – Habitat assessment of *Varanus rosenbergi.*
- Complete a field assessment of Area A and Area B (Figure 1) and evaluate the appropriateness of the two areas for improving the conservation outcomes for *Varanus rosenbergi* populations in the Ginninderra falls area.
- Prepare a report of findings which include an evaluation of the reports by the Ginninderra Catchment Group and Eco Logical and findings of the field assessment.
- Recommend whether the subset of proposed variation areas (known as Area A and B) should be included in the proposed Ginninderry conservation area.

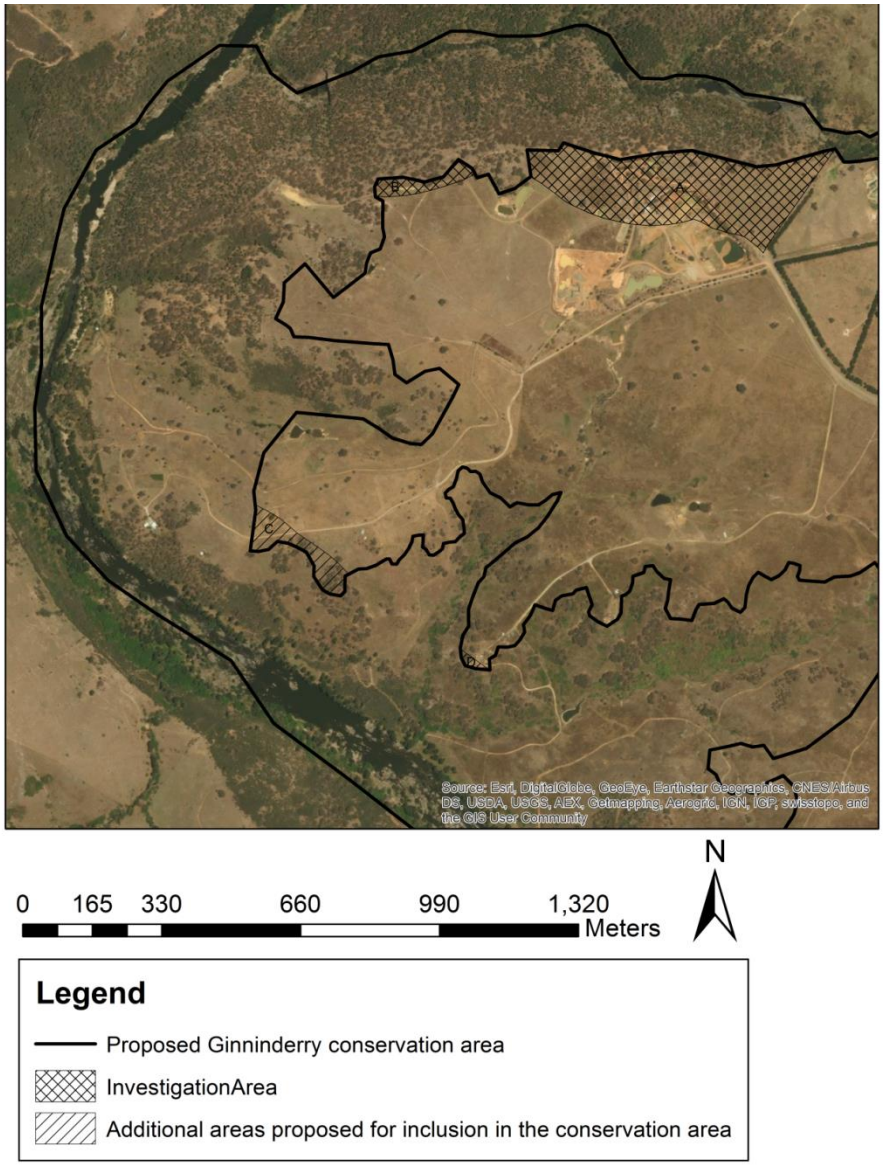

Figure 1. The proposed boundary line of the Ginninderry conservation area and the four areas recommended by Eco Logical to be included based on their interpretation of the habitat requirements of *V. rosenbergi* requirements. The cross hatched areas labelled (A) and (B) are the areas investigated.

Approach

This study has taken a multiple lines of evidence approach, including expert opinion, review of the literature regarding critical needs of *V. rosenbergi,* and field survey.

Expert opinion

The expert used in this study was Dr Brian Green because he is an expert Varanid ecologist, with over 40 years of cumulative research on the biology of *Varanus rosenbergi* and other species. Dr Brian Green completed his PhD at the Zoology Dept., University of Adelaide, with a thesis on water and electrolyte balance in Varanus gouldii/rosenbergi. He then worked for CSIRO Division of Wildlife and Ecology for over 25 years with a final rank of Senior Principal Research Scientist. He is presently a Professor (Adj) at the Institute for Applied Ecology, University of Canberra. Brian has published over 30 scientific papers on Varanids, including a book (King and Green, 1993) and has presented at

international and national scientific conferences on the biology and ecology of Varanids. He has numerous field observations on their biology, behaviour and ecology and is most likely Australia's preeminent expert on Varanid biology. Similarly, Brian has supervised numerous postgraduate student dissertations on the ecology, biology and zoology of varanid species.

Critical needs of Varanus rosenbergi.

Termitaria

The termitaria of *Nasutitermes exitiosus* remain the most vital ecological resource for the survival of *Varanus rosenbergi* populations.

The termite mounds of *Nasutitermes exitiosus* provide a reliable microclimate for the incubation of *V. rosenbergi* eggs. Rismiller et al, (2007) report that temperatures within the termite mounds exhibit a seasonal cycle, with maximum temperatures of around 37^0C recorded during summer months and minimum temperatures of around 23^0C during winter. Temperatures during spring and autumn were intermediate to these values. The daily maximum and minimum temperatures within mounds never differed by more than 2^0C. In comparison, ambient air temperatures on Kangaroo Island ranged from as high as 42^0C in summer and as low as 8^0C in winter. Ambient minima in winter in the ACT/NSW local area are even lower, with -5^0C being quite common.

Termite mounds also provide a high humidity micro-environment that also assists egg incubation, with relative humidity recordings of between 95 and 100% throughout the year (King and Green 1993 a, b; Rismiller et al, 2007). *V. rosenbergi* eggs are extremely porous and lose moisture rapidly when exposed to dry air.

Laboratory experiments show that the development time of *V. rosenbergi* eggs is temperature dependent (Andrews et al, 2017). At 26^0C the time from laying to hatching is 220 days, whereas at 35^0 C it is 165 days. Incubation length (IL) as a function of temperature (T^0) is described by the following regressions;

Linear: $IL = 355.4 - 5.56T$ ($F_{1,42}=72.3$, $P<0.0001$, $R^2=0.62$)

Non-linear: $Log10IL = 3.62 - 0.91Log10T$ ($F_{1,42}=82.6$, $P<0.0001$, $R^2=0.65$)

In addition, there was no survival of *V. rosenbergi* eggs below 26^0C or above 35^0C (Andrews et al, 2017).

Termitaria are also important refuges for hatchling *V. rosenbergi* (Green et al, 1999); the young use the termite mound for overnight refuge for up to 2 months post-hatching. An additional benefit the mounds provide for the young is that the body temperatures of the young are already at an elevated level in the morning, thus reducing the time needed for basking and the time exposed to predation.

Thus, termitaria provide an excellent micro-environment for egg incubation over the extensive development period common to Varanid lizards and also provide some protection from predators during the early months after hatching.

Across the range of *V. rosenbergi* it is highly improbable that eggs could survive and complete embryonic development if laid in any situation that could not provide a minimum temperature of 26^0C and a high humidity across the whole incubation period. The reliance of the Eco Logical report on unpublished observations on alternative nesting sites for *V. rosenbergi* in order to challenge the demonstrated absolute requirement of termitaria for successful incubation, is unwarranted.

Varanus rosenbergi populations are totally reliant on termite mounds for incubating their eggs and as a refuge for the newly emergent young, especially so in areas subject to cold winter conditions. Without this critical element, it is certain that populations of *V.rosenbergi* would be unable to sustain a local population with recruitment of young and would be totally reliant on immigration.

Home range and habitat needs

Refuge sites used by *Varanus rosenbergi* include hollow logs, burrows, rock crevices, and thick vegetation.

Home range is the area that bounds the movements of an animal and is generally presented on a two-dimensional plan. In the Eco Logical report the criticism is made that the long term studies of *V. rosenbergi* populations on Kangaroo Island are "somewhat atypical" and provide extremely large home ranges, although the 1500 ha estimate referred to relates to life-long home range.

On Kangaroo Island, the mean home ranges of *V.rosenbergi* adults over several years were 96 + 4 hectares for females and 257 + 21 hectares for males (Rismiller et al, 2007). The terrain in which these data were obtained is generally flat with slight undulations. In contrast, unpublished home range estimates for *V. rosenbergi* in the course of one year around Googong Dam, NSW were approximately 170 ha (Smith, pers. comm.). However, the terrain around Googong is highly dissected with steep hillsides and valleys. Thus the "plan" area for home range is much smaller than the surface area actually covered by animals in such terrain. Thus the difference in home range estimates for *V. rosenbergi* at Kangaroo Island and Googong are probably not as great as might appear at first glance.

Home ranges for Varanids include focal areas which contain refuges which avoid predation, for resting and for thermoregulation. Typical refuges used by *V.rosenbergi* include hollow logs, burrows, rock crevices and at times tree hollows. These micro- habitat features will vary depending on the overall macro- habitat condition.

Field survey

This study focused its investigations on the two areas recommended for inclusion in the proposed Ginninderry conservation area. Figure 1, shows the extent of the two areas. The size of Area A is 10.3 ha (700m X 200m) approximately, whilst the size of Area B is approximately 0.8 ha (240m X 45m). Details on the date and timing of the surveys are outlined in Table 1. A total of 22 person hours were allocated to the two investigation areas.

Table 1. Survey type, dates and effort allocated to the 11.1ha study area.

Survey Date	Method	Number of Surveyors	Approximate time	Effort (person hours)
07/02/2017	Vegetation assessment- Walk transect	1	Four evenly spaced transects	5
17/02/2017	Visual encounter survey – termite mounds; species detection	2	0730 - 1230	10
24/02/2017	Visual encounter survey– termite mounds; species detection	2	0830 - 1200	7

Vegetation assessment

The vegetation survey involved walking four evenly distributed transects which spanned both investigation areas. The surveyed transects were rapid in approach, with the surveyor noting new species as encountered. The vegetation community and condition was also assessed.

Visual encounter surveys

The aims of the visual encounter surveys were two- fold. Firstly, the surveys were conducted to detect the extent and frequency of occurrence of termite mounds within the two study areas. Termite mounds of the *Nasutitermes exitiosus* species were chosen as the principle survey target, as they present the critical need of *V. rosenbergi* (see Termitaria section – This Report). Secondly, the surveys aimed to detect direct and indirect signs of *V. rosenbergi* activity, which included: (a) sighting individuals, (b) scratching/excavation at termite mounds, (c) tracks – including tail drags and foot prints and (d) scats.

A systematic sampling design using visual encounter surveys was used for this study. The visual encounter surveys were conducted by two Ecologists; both of which walked parallel at approximately 10m apart (distance expanded and contracted depending upon visibility through vegetation). 36 transects were surveyed; they varied in length from 19m to 768m (Figure 2). Overall, 7431m were walked across the two study areas, including the buffer zone (within the conservation area).

Approximately, 1.7 ha within Area A was excluded from the visual encounter surveys as it included the gravel pit and quarrying operations of the Tharwa Sand operator, deemed inappropriate for survey due to its highly modified state.

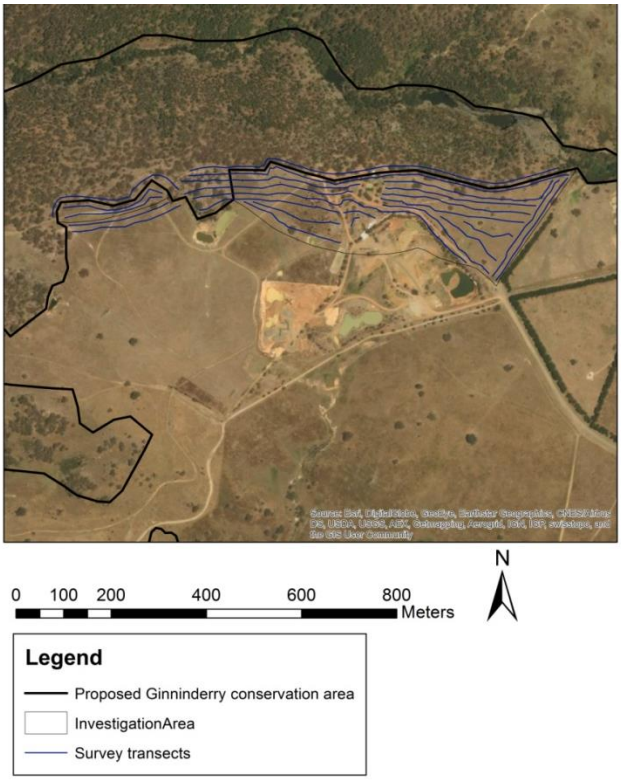

Figure 2. The location of Visual encounter transects completed on 17/2/17 and 24/2/17. The transects involved two individuals walking parallel, approximately 10m apart.

Results

Visual encounter surveys

Over the course of the two survey days, two *Nasutitermes exitiosus* termite mounds were located on the boundary of the conservation reserve within area A. One of the mounds was classified as active, whilst the other was classified as moribund (Figure 3). Within the main areas of both sites no Termite mounds were observed (Figure 3). Similarly, no indirect signs of *V. rosenbergi* were observed within either area (indirect signs included tail drags, foot prints or scats).

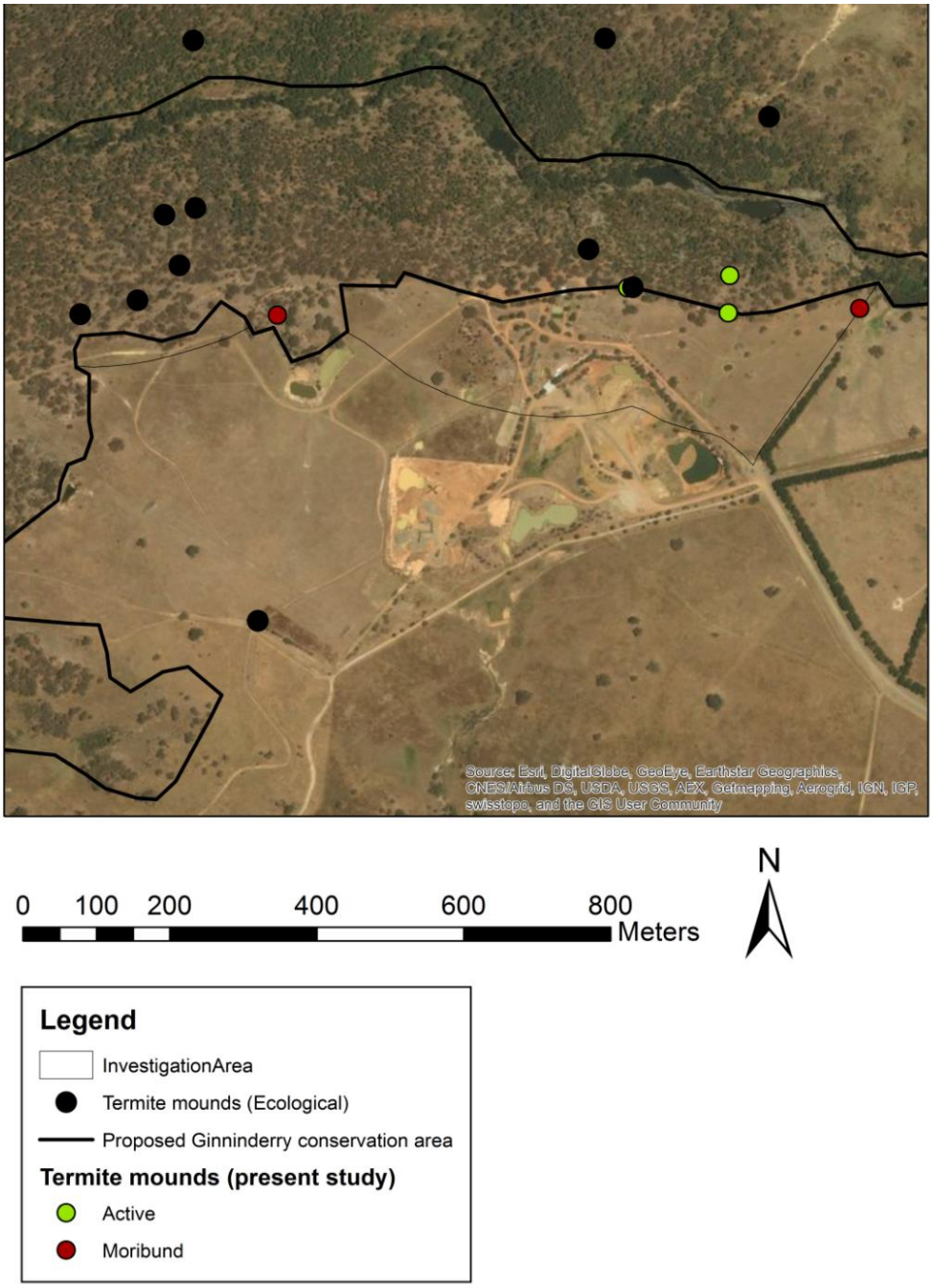

Figure 3. Location of termite mounds observed in the present study and those observed by the Eco logical (2016). Termites located in the present study were classified as active or moribund.

Vegetation condition

Area A

The native and non-native plant species observed in Area A are shown in Table 2 and Table 3 respectively. Thirty-five native species were identified whilst 18 non-native species were identified. Area A, is an area of land in varied condition and supporting varied vegetation. The majority of Area A is a temperate grassland community, fringing on Lowland Woodlands. There are pockets of high quality temperate grassland dominated by *Themeda triandra* and these areas contain a high diversity of grassland species. There are large parts of Area A where the vegetation is in poor or very poor condition. These areas contain a large number of non-native species. The current vegetation condition is in part a result of past and current land management, foremost through the operation of the quarry, previous exploration, livestock grazing and the development of infrastructure (such as the construction of dams, roads, carparks and trenches for pipes). The vegetation in the area of the quarry is in very poor condition as is to be expected.

Area A contains sporadic large standing trees, one standing dead tree and very few widely interspersed fallen logs which contain hollows. Many of the trees in Area A are not remnant and have been planted by the landowner.

The list of species out-lined in Table (2 and 3), lists the species observed at the time of survey (Table 1). The surveyor attempted to note all species present, some species (such as short lived spring blooming annuals), may be present on site and missed in the survey and this should be acknowledged. The list outlines a diverse array of grassland and grassy woodland species. None of these species are listed individually as threatened or endangered in the ACT or NSW, but the ecological community Natural Temperate Grasslands are listed as an endangered community in the ACT. There are sections of *Themeda* grassland occurring predominantly in the lower areas of Area A in good condition. There is a small section of *Stipa* grassland in the higher elevated area (toward the quarries office), this is dominated by *Stipa bigeniculata*.

Area A has some confined areas of intact grassland communities, these areas are relatively high in species diversity and low in non-native species. There are some remnant and planted trees which provide habitat for wildlife on site. Despite this, Area A exhibits mainly degraded sections affording little ecological value.

Area B

The native and non-native plant species observed in Area B are shown in Table 4 and Table 5 respectively. Twelve native species were observed (Table 4), whilst nine non-natives were observed (Table 5). Area B is an area of land that borders on a Lowland Woodland Community to the north and agricultural land to the south. Area B contains a few large trees, but overall the area is absent of mid-storey and canopy vegetation**.** Area B has poor vegetation condition containing non-native mid-storey species (such as blackberries and Rosehip). There is some evidence of seedling recruitment of *Eucalyptus* species present on site.

In regards to habitat for *V. rosenbergi*, no dead standing or fallen trees were observed, and the few remnant trees did not contain hollows. The rocky outcrop in Area B would provide some potential habitat. Overall Area B contains a grassland community with a high density of non-native species, and very little habitat in the way of hollows. The only value Area B may provide is a potential connection between adjacent high quality woodland habitats.

Conclusion and recommendations

Based on extensive visual encounter surveys, expert opinion and collective knowledge and published scientific literature on the biology of *V. rosenbergi* we have classified Areas A and B as not containing critical habitat components essential for maintaining a viable, sustainable population of *V. rosenbergi.* This qualitative classification is based on the following principles:

1. A general absence of active termite mounds.
2. A general lack of essential refuge habitat and vegetation cover.
3. The additional areas only provide marginal foraging opportunities.

Approximately one-third of area A, included the quarry site, and progressive rehabilitated areas areas with virgin excavated natural material. The area also included offices as well as remnant infrastructure associated with the legacy Ginninderra Falls tourist park (office, residence, carpark and roads). As expected these collective areas are ecologically degraded. Notwithstanding the degraded areas, the small size of each proposed area, the poor vegetation structure and low habitat quality provide additional support for discounting the areas as necessary for inclusion in the Ginninderry reserve as they are unlikely to improve the conservation outcomes of *V. rosenbergi* in their current state.

There is no evidence in the scientific literature supporting the notion that degraded grasslands support populations *V. rosenbergi.* This is supported by the habitat classification completed by Eco Logical (2016) whom classified the habitat quality of the grassland areas as very low quality for *V. rosenbergi* (Area A-92%; Area B-61%). However, it is important to note that their classifications were based entirely on extrapolation as they did not assess habitat within either area A or area B.

Varanus rosenbergi is known to occur in conservation areas within the ACT, and some of these reserves (e.g. Mt Ainslie) have low density dwellings which adjoin the reserve. Both *V. rosenbergi* and *V. varius* are able to utilise fringe areas to some extent, as has also been indicated in the Eco Logical (2016) report.

Numerous areas to the north of Ginninderra Creek and along the Murrumbidgee River may contain habitat which is likely to contain high quality values for *V. rosenbergi* and we recommend those areas be prioritised for consideration (if needed) and augmentation to the proposed reserve instead of low quality, convenient areas such as the two areas proposed (Area A and Area B; Figure 1). Although, this study has not assessed the overall size and condition of the proposed Ginninderry conservation reserve as the scope was limited to the two areas (Figure 1), it is clear that the two proposed areas do not contain habitat elements suitable for supporting a viable population of *V. rosenbergi* nor do they represent a comprehensive buffer to the reserve.

Issue of note - Population genetics

Section 5.4 and Appendix A of the Eco Logical report propose that further genetic research is required to ascertain if *V. rosenbergi* is a complex of two or more species, despite acknowledging Smith *et al.* (2007) in the reference list. Smith *et al.* (2007) clearly reports that genetic differences across the whole distribution of *V. rosenbergi* do not support the existence of multiple species. Instead, Smith et al, (2007) propose that the extent of genetic differences represents the existence of five Evolutionary Significant Units; WA, ACT/NSW, mainland SA, Kangaroo Island, and the Sir Joseph Banks Islands in SA.

Table 2. Native plant species observed within Area A. Asterisk denote species which have been actively planted by the landholder.

Area A: Native Species list	
Tree Species	**Common Name**
Callitris endlicheri	Black Cypress Pine
*Casuarina cunninghamiana**	River Sheoak
*Eucalyptus cinerea**	Argyle Apple
Eucalyptus macrorhyncha	Red Stringybark
Eucalyptus mannifera	Brittle Gum
Eucalyptus melliodora	Yellow Box
*Eucalyptus polyanthemos**	Red Box
Eucalyptus rossii	Scribbly Gum
*Eucalyptus sideroxylon**	Mugga Ironbark
Shrub Species	
Acacia baileyana	Cootamundra Wattle
Acacia dealbata	Silver Wattle
Acacia implexa	Hickory Wattle
Acacia pravissima	Ovens Wattle
Dodonaea viscosa	Sticky Hop-bush
Grevillea rosmarinifolia	Rosemary Grevillea
*Hakea salicifolia**	Willow-leaved Hakea
Leptospermum brevipes	Grey Tea-tree
Grasses:	**Common name**
Aristida ramosa	Purple Wiregrass
Austrostipa scabra	Spear-grass
Bothriochloa macra	Red-leg Grass
Chloris truncata	Windmill-grass
Dichelachne crinita	Longhair Plumegrass
Microlaena stipoides	Weeping Grass
Panicum effusum	Hairy Panic-grass
Rytidosperma sp.	Wallaby Grass
Themeda triandra	Kangaroo Grass
Wildflowers:	
Cassinia quinquefaria	Long-leaved Cassinia
Chrysocephalum semipapposum	Clustered Everlasting
Vittadinia cuneata	Fuzzy New Holland Daisy
Vittadinia muelleri	Narrow-leaf New Holland Daisy
Other species	
Cheilanthes sieberi	Rock Fern
Cyperus sp.	Sedge
Dianella revoluta	Blue Flax-Lily
Lomandra multiflora	Many-flowered Mat-rush
Rumex brownii	Swamp Dock

Table 3. Non-native species observed in Area A.

Area A Non-native Species	
Avena sp.	Oats
Briza maxima	Quaking Grass
Briza minor	Shivery Grass
Echium plantagineum	Paterson's Curse
Eragrostis curvula	African Love-grass
Euphorbia oblongata	Egg-leaf Spurge
Hypericum perforatum	St. John's Wort
Onopordum acanthium	Scotch Thistle
Paspalum dilatatum	Paspalum
Phalaris aquatica	Phalaris
Plantago lanceolata	Lamb's Tongues
Polygonum aviculare	Wireweed
Rosa canina	Rosehip
Rubus fruticosus	Blackberry
Sisymbrium sp.	NA
Taraxacum officinale	Dandelion
Verbascum thapsus	Great Mullein
Vulpia myuros	Rat's Tail Fescue

Table 4. Native species observed in Area B.

Area B: Native Species List	
Tree Species	**Common Name**
Eucalyptus macrorhyncha	Red Stringybark
Eucalyptus melliodora	Yellow Box
Grasses, forbs & other understorey species	**Common Name**
Bothriochloa macra	Red-leg Grass
Cassinia quinquefaria	Long-leaved Cassinia
Cheilanthes sieberi	Rock Fern
Chrysocephalum semipapposum	Clustered Everlasting
Dichelachne crinita	Longhair Plumegrass
Lomandra multiflora	Many-flowered Mat-rush
Panicum effusum	Hairy Panic-grass
Rumex brownii	Swamp Dock
Rytidosperma sp.	Wallaby Grass
Themeda triandra	Kangaroo Grass
Vittadinia cuneata	Fuzzy New Holland Daisy

Table 5. Non- native species observed in Area B.

Non-native Species	
Avena sp.	Oats
Briza minor	Shivery Grass
Conyza sp.	Fleabane
Echium plantagineum	Paterson's Curse
Hypericum perforatum	St. John's Wort
Paspalum dilatatum	Paspalum
Rosa canina	Rosehip
Rubus fruticosus	Blackberry
Taraxacum officinale	Dandelion

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