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Lists of Species

A list of reptiles and amphibians from Box Gum Grassy Woodlands in south-eastern Australia

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Abstract: A large-scale biodiversity monitoring program examining the response of herpetofauna to the Australian Government's Environmental Stewardship Program is taking place in south-eastern Australia within the critically endangered Box Gum Grassy Woodland vegetation community. Field surveys involve counting reptiles in areas under Environmental Stewardship management. These "Stewardship" areas have been matched with areas managed for primary production (domestic livestock grazing). We list reptiles recorded during surveys conducted between 2010 and 2012. We recorded sixty-nine species from ten families. The list will be useful for workers interested in the zoogeographical distribution of reptiles and amphibians in fragmented agricultural woodland ecosystems.

Introduction

Reptiles and amphibians have experienced unprecedented levels of population decline and extinction on a global scale (Alford and Richards 1999; Gibbons *et al.* 2000, Houlahan *et al.* 2000, Araujo *et al.* 2006). This trend has sparked widespread concern over the cause and effect of this global decline (Gibbons *et al.* 2000, Blaustein and Kiesecker 2002, Whitfield *et al.* 2007) and has led to the recognition that baseline distribution data are fundamental for resolution of this issue (McDiarmid *et al.* 2012). However, such data are lacking for many taxa (Foster *et al.* 2012), particularly on private-tenure land, and this is of major concern given the impact of agricultural practices on herpetofaunal diversity (Michael and Lindenmayer 2010).

Agricultural expansion, intensification and climate change are considered primary causes of reptile and amphibian declines worldwide (Fabricius *et al.* 2003, Driscoll 2004, Whitfield *et al.* 2007, Brown *et al.* 2008, Ribeiro *et al.* 2009, Sinervo *et al.* 2010). To address this issue, a number of agri-environment schemes (AES) have been developed around the world, whereby billions of dollars are spent annually (Donald and Evans 2006) in an attempt to integrate biodiversity conservation with production in agricultural landscapes (Kleijn and Sutherland 2003, Kleijn *et al.* 2006). However, many of these schemes have been criticised for their lack of rigorous assessment and monitoring to quantify their effectiveness for biodiversity (Kleijn and Sutherland 2003, Kleijn *et al.* 2006, Zammit *et al.* 2010). In recognition of the growing concern about biodiversity conservation issues in production landscapes, the Australian Federal Government established the Environmental Stewardship Program (ESP). This program aims to maintain and/or improve the condition and extent of targeted ecological communities of national environmental significance under the *Environment Protection and Biodiversity Conservation Act 1999*. The first target for the ESP was the Box Gum Grassy Woodland (BGGW) vegetation type, which is an endangered ecological community. This community extends from Queensland through New South Wales to Victoria (a region known as the wheat-sheep belt of south-eastern Australia) and has been reduced to less than four per cent of its original extent and occurs as remnants of varying condition on productive agricultural land (Zammit *et al.* 2010).

The ESP offers private land managers financial incentives to undertake prescriptive management interventions which may include reducing grazing intensity by domestic livestock, reducing fertilizer use, undertaking exotic plant management, and replanting of local provenance native species. Land managers in the ESP receive funds from the Australian Government once they have entered into a contractual agreement ranging from four to 15 years. To help evaluate the success of this program, The Australian National University was engaged to develop and implement a biodiversity monitoring program across the BGGW ecosystem. In this paper, we provide baseline data for reptiles and frogs recorded between 2010 and 2012 as part of the ESP BGGW project.

Materials and Methods

Study area

The study was undertaken within the critically endangered BGGW ecosystem in south-eastern Australia, covering five water catchments in New South Wales and two catchments in southern Queensland. These catchments were the Murrumbidgee (MCMA), Lachlan (LCMA), Central West (CWCMA), Namoi (NCMA), Border Rivers – Gwydir (BRCMA), Maranoa-Balonne (MBCMA) and Condamine (CCMA) (Figure 1). This area extends from Warwick in the north-east (28°1'32" S, 152°12'22" E) to Bredbo in the south (35°56'32" S, 149°9'32" E), and Leeton in the west (34°40'43"S, 146°16'48" E).

The annual average rainfall in the region ranges from 504mm in the south (Bredbo weather station, BOM) to

692mm in the north (Canning Downs weather station, BOM). The study area is characterised by a slightly wetter spring-summer period than autumn-winter period. The average minimum and maximum summer temperature ranges from 9°C – 27°C in the South (Cooma weather station, BOM) and 14.3°C – 29.4°C in the north (Killarney weather station, BOM). Average minimum and maximum winter temperatures range from -2.8°C – 13.4°C in the south (Cooma weather station, BOM) and 2.1°C – 18.7°C in the north (Killarney weather station, BOM).

The BGGW community comprises a diverse vegetation assemblage dominated by the overstorey species white box *Eucalyptus albens* (Benth 1867), yellow box *E. melliodora* (A.Cunn. ex Schauer sensu CHAH 2006), and Blakely's red gum *E. blakelyi* (Maiden 1917). Several additional overstorey species also co-occur in BGGW, including grey box *E. microcarpa* (Hook 1842), white cypress pine *Callitris glaucophylla* (Joy Thomps. and L.A.S.Johnson 1986), black cypress pine *C. endlicheri* ((Parl.) F.M.Bailey 1883), red box *E. polyanthemos* (Schauer 1843), red stringybark *E. macrorhyncha* (F.Muell ex Benth 1867), long-leaved box *E. goniocalyx* (F.Muell. ex Miq. 1856), apple box *E. bridgesiana* (Baker 1898), mugga ironbark *E. sideroxylon* (Woolls 1990), and kurrajong *Brachychiton populneus* (Schott and Endl. 1844). Different overstorey plant assemblages define sub-vegetation communities within the broader BGGW community as identified in the NSW Vegetation Classification and Assessment (VCA) scheme (NSW Office of Environment and Heritage, 2012).

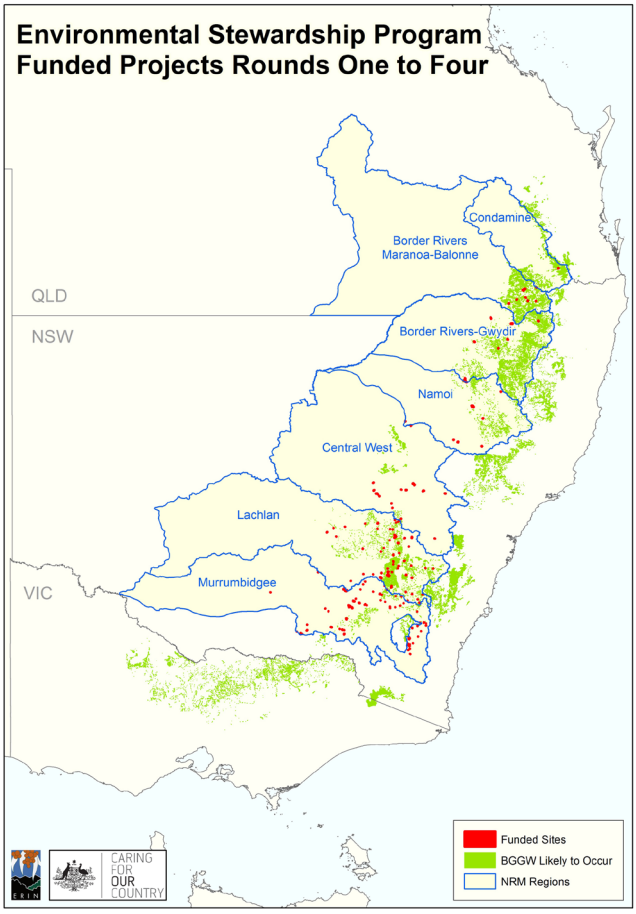

Figure 1. Box Gum Grassy Woodland Project study area and monitoring site locations (n=262) across seven catchment management zones. Maps produced by the Environmental Resources Information Network (ERIN), Department of Sustainability, Environment, Water, Population and Communities (SEWPAC).

The understorey of BGGW is typically dominated by perennial native grasses and forbs with few or no shrubs. Dominant grass species include kangaroo grass *Themeda australis* (R.Br.Stapf 1918), red-leg grass *Bothriochloa macra* (Blake 1969), wallaby grasses *Austrodanthonia* spp., and spear grasses *Austrostipa* spp. Included within the endangered BGGW community is a Derived Native Grasslands sub-community, which contains a largely intact assemblage of BGGW understorey flora but has experienced extensive removal of the dominant overstorey and midstorey species.

Survey design

We established a single monitoring site within discrete areas of remnant vegetation on 153 farms funded under the ESP. These sites, which are subject to management intervention, are termed 'treatments'. In addition, we established a monitoring site on the same property within an area of remnant vegetation managed for agricultural production (i.e. not funded under ESP). These sites in areas not funded under ESP served as matched external spatial reference areas and are termed 'controls'. Because it was not possible to find matched controls on 44 farms (either because suitable remnant vegetation did not exist or the same vegetation community was not present) we established 109 control sites in the final design, giving 263 sites in total. The establishment of spatial controls was important to determine if changes in vegetation condition or biodiversity are due to management intervention and not climatic factors or local population fluctuations. Table 1 provides the number of sites in each management class, which span seven regional catchment management areas (CMA's).

Reptile Surveys

We established a permanent 200 m transect on all stewardship and control sites. Along each transect we placed two arrays of cover objects 100 m apart. Each array consisted of four roof tiles (32 cm x 42 cm), two sheets of corrugated iron (1 m x 1 m) stacked on top of each other and four wooden sleepers (1.2 m long). At each site, we conducted a 20-minute active search for reptiles by inspecting exfoliating bark, fallen timber, surface rocks, leaf litter and arrays of artificial refuges (ARs) within a 1 ha search area (200 m x 50 m). These methods are effective for surveying a broad range of herptofauna in temperate woodland ecosystems (Michael *et al.* 2012).

The same group of experienced field ecologists from The Australian National University conducted all surveys. We surveyed all sites over the 2-year baseline period (2010-2011) in spring (September-October) using active searches and inspection of AR's. Extensive rain in 2010 prevented all sites in the northern catchments (NCMA, BRGCMA, BRMB CMA and CCMA) from being surveyed. All sites were again surveyed by inspection of AR's only during the summer/autumn (February-April) of 2012.

We conducted all surveys between 09:00 h – 16:00 h on clear days with minimal wind. We identified species using keys and descriptions in Cogger (2000), Wilson and Swan (2010) and Tyler and Knight (2011), and individuals were released once recorded. We conducted surveys under the Department of Environment and Climate Change scientific license number 13174 and Queensland

Government Environmental Protection Agency scientific licence number WISP08460910. Individual animals were only recorded without any specimens being taken. Where identification was difficult the animal was hand-captured and released to the same location it was caught after approximately a 1 minute handling time.

Statistical analyses

Herpetofaunal species richness recorded in each of the stewardship and control treatments was analysed using a paired t-test using the package GenStat14 (VSN International 2011). Differences in species richness between catchments, between stewardship and control sites within catchments and their interaction were investigated further by fitting generalised linear models with an over dispersed Poisson distribution and a log-link function. Significance of effects was assessed from deviance ratios represented as F statistics.

Results and Discussion

Table 1 contains a list of reptiles and amphibians recorded during field surveys between 2010 and 2012. We recorded 69 species from ten families. This total represents 61.9% of species expected or known to occur in the study area based on the literature and wildlife atlas databases (Atlas of Living Australia 2012, Robinson 1998, Wilson and Swan 2010). Notable absences from our list of recorded species include the Spotted Python *Antaresia maculosa* (Kluge 1993), Carpet Python *Morelia spilota* (Barker and Barker 1994), Green Tree Snake *Dendrelaphis punctulata* (Gray 1827) and Common Death Adder *Acanthophis antarcticus* (Shaw and Nodder 1802).

Over the entire region, we found that overall herpetofaunal species richness was significantly different between catchments ($F_{6,241}$=10.10; P<0.001). The northern Namoi, Border Rivers-Gwydir and Maranoa-Balonne catchments contained higher average herpetofaunal richness per site than those in the south. The Condamine catchment represented an exception to this trend, however this catchment also had the least number of surveys and greatest error (Table 2). Our results follow a common pattern of higher species richness with decreasing latitude – a well-known result for species richness patterns (Gaston and Spicer 2004). Furthermore, species richness within certain genera appeared to correlate with latitude, with *Ctenotus* and *Lymnodynastes* having greater diversity at higher latitudes and *Amalosia, Amphibolurus*, *Carlia*, *Cryptoblepharus* and *Delma* diversity being higher at lower latitudes. This latitudinal gradient of within-genera diversity is of importance for large-scale (State or Federal) conservation managers because the northern and southern catchments exhibit marked differences in the composition of herpetofaunal assemblages despite having similar levels of overall herpetofaunal species richness.

We found high spatial variation in species detected across the study area, with distinct assemblages associated with elevation and sub-vegetation communities. *Hemiergis decresiensis* and *Lampropholis guichenoti* were commonly found in association with *Eucalyptus viminalis* (Labill. 1956) communities at mid-elevations and moist drainage lines. These associations highlight the importance of some kinds of vegetation remnants on agricultural land, which can be relatively species-rich in this highly fragmented and critically endangered BGGW ecosystem.

These initial findings from the ESP BGGW project revealed no significant difference in herpetofaunal species richness between stewardship and control sites (*t*=0.1, P=0.91). This result is expected given the early stage of this study and the rigorous site matching process pairing sites on the basis of vegetation type, vegetation condition and other characteristics such as landform, patch size and patch connectivity. However, ongoing surveys are required to evaluate the effectiveness of ESP management intervention over time.

The detection of threatened species (specifically *Aprasia parapulchella* and *Amalosia rhombifer*) at a number of sites emphasizes the value of conducting baseline surveys on private land for assessing status of species of conservation significance. Detection of *A. parapulchella* at a number of previously unknown sites highlights the limited knowledge about the distribution and habitat of this enigmatic species (Wong *et al.* 2011). Ongoing surveys are needed to provide a better understanding of the extent of its occurrence on private land. Further, detection of *A. parapulchella* outside of ESP managed areas emphasizes the significant need for sensitive management of remnant vegetation on private land for all woodland taxa.

The list we present in Table 1 provides the first quantitative set of baseline data for reptiles and amphibians found throughout the endangered BGGW system. As such it provides an important baseline resource for future BGGW policy and planning. The list should also be of broad interest to many groups, including natural resource managers, workers interested in the zoogeographical distribution of reptiles and frogs in temperate zone woodlands, and those interested in studying biodiversity in fragmented agricultural landscapes. Field surveys of reptiles in BBGW are on-going. Major re-survey of sites will recommence in coming years to monitor and compare changes in vegetation condition between stewardship and control sites.

Table 1. Reptile and amphibian species detected between 2010 and 2012 in seven catchment areas in south-eastern Australia, classified by management type (C = control, S = stewardship). The seven Catchment Management Areas (CMA) surveyed include Murrumbidgee (MCMA), Lachlan (LCMA), Central West (CWCMA), Namoi (NCMA), Border Rivers – Gwydir (BRGCMA), Border Rivers Maranoa-Balonne (BRMBCMA) and Condamine (CCMA). Codes are absent (-), S = sparse (detected at < 5% sites), R = rare (detected at 5 – 25% of sites), U = uncommon (detected at 26-50% of sites), C = common (detected at > 51 % of sites). Listed vulnerable (*) and threatened (**) taxa listed in bold. Nomenclature follows Wilson and Swan (2010) and AROD (2012).

	MCMA		LCMA		CWCMA		NCMA		BRG CMA		BRMB CMA		CCMA		Tot
	C	S	C	S	C	S	C	S	C	S	C	S	C	S	
	Number of sites														
Scientific Name	42	57	36	56	17	16	5	6	4	7	7	8	1	1	*263*
AGAMIDAE															
Amphibolurus burnsi (Wells and Wellington, 1985)	-	-	-	-	-	-	-	-	R	R	-	-	-	-	*2*
Amphibolurus muricatus (White, 1790)	-	S	S	S	-	-	-	-	-	-	R	R	-	-	*8*
Diporiphora nobbi (Witten, 1972)	-	-	-	-	-	-	-	-	-	U	U	-	-	-	*5*
Physignathus lesueurii (Gray, 1831)	-	-	-	-	-	-	-	-	-	R	-	-	-	-	*1*
Pogona barbata (Cuvier, 1829)	S	R	R	S	R	R	R	R	R	-	-	-	-	-	*12*
CHELIDAE															
Chelodina longicollis (Shaw, 1794)	-	-	-	S	-	-	-	-	-	-	-	-	-	-	*1*
ELAPIDAE															
Demansia psammophis (Schlegel, 1837)	-	-	S	-	-	-	-	R	U	U	U	-	-	-	*9*
Furina diadema (Schlegel, 1837)	-	-	-	-	-	-	R	-	-	-	-	R	-	-	*2*
Parasuta dwyeri (Worrell, 1956)	S	-	R	S	R	R	-	-	-	-	C	-	-	-	*11*
Pseudechis guttatus (De Vis, 1905)	-	-	-	S	-	-	-	-	-	-	-	-	-	-	*1*
Pseudechis porphyriacus (Shaw, 1794)	-	S	-	-	-	-	-	-	-	-	-	-	-	-	*1*
Pseudonaja textilis (Duméril, Bibron and Duméril, 1854)	-	R	R	R	R	R	-	-	-	R	-	R	-	-	*20*
Cryptophis nigrescens (Günther, 1862)	-	-	-	-	-	-	-	-	-	-	-	-	-	C	*1*
Suta suta (Peters, 1863)	-	-	-	-	-	-	-	-	-	R	-	-	-	-	*1*
Vermicella annulata (Gray, 1841)	-	-	-	-	-	-	-	-	-	-	R	-	-	-	*1*
GEKKONIDAE															
Amalosia rhombifer (Gray, 1845)	-	-	-	-	-	-	-	-	R	-	-	-	-	-	*1*
Amalosia tryoni (De Vis, 1884)	-	-	-	-	-	-	-	R	R	-	-	-	-	-	*2*
Christinus marmoratus (Gray, 1845)	R	R	U	R	-	-	-	-	-	-	-	-	-	-	*30*
Diplodactylus vittatus (Gray, 1832)	S	R	R	R	R	-	-	-	-	-	-	R	-	-	*18*
Gehyra variegata (Duméril and Bibron, 1836)	-	S	R	S	R	R	-	-	-	-	-	U	-	-	*9*
Heteronotia binoei (Gray, 1845)	-	-	-	-	-	-	-	-	-	U	C	C	-	-	*15*
Lucasium steindachneri (Boulenger, 1885)	-	-	-	-	-	-	-	-	-	-	R	-	-	-	*1*
Nebulifera robusta (Boulenger, 1885)	-	-	-	-	-	-	-	-	-	-	-	R	C	-	*3*
Strophurus intermedius (Ogilby, 1892)	-	-	S	-	-	-	-	-	-	-	-	-	-	-	*1*
Underwoodisaurus milii (Bory de Saint-Vincent, 1825)	-	S	-	-	-	-	-	-	-	-	-	-	-	-	*2*
HYLIDAE															
Litoria caerulea (White, 1790)	-	R	R	R	-	-	C	-	-	C	U	R	-	C	*24*
Litoria latopalmata (Gunther, 1867)	S	-	R	-	-	-	-	R	-	-	U	R	-	-	*10*
Litoria peronii (Tschudi, 1838)	S	S	C	R	R	R	-	-	-	R	-	-	-	-	*37*
Litoria rubella (Gray, 1842)	-	-	-	-	-	-	-	-	R	R	R	-	-	-	*3*
MYOBATRACHIDAE															
Crinia parinsignifera (Main, 1957)	R	-	-	S	-	-	-	-	-	-	-	R	-	-	*6*
Crinia signifera (Girard, 1853)	-	S	R	R	-	-	-	-	C	C	-	-	-	-	*16*
Limnodynastes dumerilii (Peters, 1863)	-	-	-	S	-	-	-	-	-	-	-	-	-	-	*1*
Limnodynastes fletcheri (Boulenger, 1888)	-	-	S	-	-	-	-	-	-	-	-	-	-	-	*1*
Limnodynastes interioris (Fry, 1913)	-	S	R	-	R	R	-	-	-	-	-	-	-	-	*5*
Limnodynastes peronii (Duméril and Bibron, 1841)	S	S	R	S	-	-	-	-	R	-	-	-	-	-	*7*
Limnodynastes tasmaniensis (Günther, 1858)	C	U	C	C	R	-	-	R	-	U	-	R	C	-	*161*
Notaden bennettii (Günther, 1873)	-	-	-	S	-	-	-	-	-	-	-	-	-	-	*1*
Pseudophryne bibronii (Günther, 1873)	-	-	-	-	-	-	-	R	-	-	-	-	-	-	*1*
Uperoleia laevigata (Keferstein, 1867)	U	U	R	U	-	-	-	-	R	-	R	R	-	-	*64*
Uperoleia rugosa (Andersson, 1916)	-	-	-	-	-	-	-	-	-	-	-	U	-	-	*4*
PYGOPODIDAE															
Aprasia parapulchella (Kluge, 1974)	S	R	R	S	-	-	-	-	-	-	-	-	-	-	*14*
Delma inornata (Kluge, 1974)	R	S	R	S	-	-	U	-	-	R	-	-	-	-	*12*
Delma plebeia (De Vis, 1888)	-	-	-	-	-	-	-	R	-	R	U	R	-	-	*6*
Delma tincta (De Vis, 1888)	-	-	-	-	-	-	-	-	-	R	-	-	-	-	*1*
SCINCIDAE															
Acritoscincus platynota (Peters, 1881)	-	R	-	-	-	-	-	-	-	-	-	-	-	-	*3*

Table 1. ***Continued.***

	MCMA		LCMA		CWCMA		NCMA		BRG CMA		BRMB CMA		CCMA		Tot
	C	S	C	S	C	S	C	S	C	S	C	S	C	S	
	Number of sites														
Anomalopus leuckartii (Weinland, 1862)	-	-	-	-	R	R	-	R	U	U	R	R	-	-	*7*
Carlia tetradactyla (O'Shaughnessy, 1879)	U	U	C	R	R	-	-	R	-	-	U	U	-	-	*83*
Carlia vivax (De Vis, 1884)	-	-	-	-	-	-	-	-	-	-	U	R	-	-	*3*
Cryptoblepharus pannosus (Horner, 2007)	R	U	R	R	R	R	R	-	R	R	-	R	-	-	*45*
Cryptoblepharus pulcher (Sternfeld, 1918)	-	-	-	-	-	-	C	U	-	C	R	U	-	-	*14*
Ctenotus orientalis (Storr, 1971)	S	S	S	-	-	-	-	-	-	-	-	-	-	-	*3*
Ctenotus robustus (Storr, 1970)	C	U	C	R	C	U	C	C	C	C	U	R	-	-	*163*
Ctenotus taeniolatus (White, 1790)	S	R	R	R	-	-	-	-	-	-	-	-	-	-	*23*
Egernia cunninghami (Gray, 1832)	R	R	R	S	R	-	-	-	-	-	-	R	-	-	*13*
Egernia striolata (Peters, 1870)	R	S	R	S	-	R	R	R	-	U	U	C	-	-	*26*
Eulamprus quoyii (Quoy and Gaimard, 1824)	-	-	-	-	-	-	-	-	-	R	-	-	-	-	*1*
Hemiergis decresiensis (Cuvier, 1829)	R	U	C	U	R	-	U	U	C	C	-	-	-	-	*106*
Lampropholis delicata (De Vis, 1888)	R	U	U	R	-	-	-	-	C	C	R	-	-	-	*69*
Lampropholis guichenoti (Duméril and Bibron, 1839)	-	S	S	S	-	-	-	-	C	C	-	-	-	-	*12*
Lerista bougainvillii (Gray, 1839)	-	-	R	R	R	-	-	R	-	-	-	-	-	-	*17*
Lerista timida (De Vis, 1888)	-	-	-	S	-	R	-	-	-	-	C	R	-	-	*9*
Lygisaurus foliorum (De Vis, 1884)	-	-	-	-	-	-	-	-	R	-	C	C	-	C	*17*
Menetia greyii (Gray, 1845)	-	R	-	-	-	-	-	-	-	C	R	-	-	-	*9*
Morethia boulengeri (Ogilby, 1890)	C	C	C	C	R	U	R	C	U	C	C	C	-	-	*276*
Tiliqua rugosa (Gray, 1825)	S	-	R	R	-	-	-	-	-	-	-	-	-	-	*17*
Tiliqua scincoides (Gray, 1825)	-	S	R	R	-	-	R	U	-	-	-	-	-	-	*11*
TYPHLOPIDAE															
Ramphotyphlops nigrescens (Gray, 1845)	-	-	R	S	R	-	-	-	-	-	-	R	-	-	*5*
Ramphotyphlops wiedii (Peters, 1867)	-	-	-	-	-	-	-	R	U	R	-	R	C	C	*8*
VARANIDAE															
Varanus varius (White, 1790)	-	-	-	S	-	-	-	-	-	-	-	-	-	-	*2*
	23	*31*	*35*	*36*	*17*	*12*	*11*	*17*	*18*	*28*	*23*	*27*	*3*	*4*	*70*

Table 2. Average reptile species richness for both control (c) and stewardship (S) management treatments in each of the seven Catchment Management Area's surveyed, including (in decreasing latitude) Murrumbidgee (MCMA), Lachlan (LCMA), Central West (CWCMA), Namoi (NCMA), Border Rivers – Gwydir (BRGCMA), Border Rivers Maranoa-Balonne (BRMBCMA) and Condamine (CCMA).

CATCHMENT	NUMBER OF SURVEYS	MEAN RICHNESS PER SITE	STANDARD ERROR
MCMA	283	1.80	0.12
LCMA	288	1.72	0.12
CWCMA	92	1.19	0.17
NCMA	38	2.22	0.39
BRGCMA	45	2.90	0.44
BRMBCMA	8	3.10	0.42
CCMA	5	1.26	0.60

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