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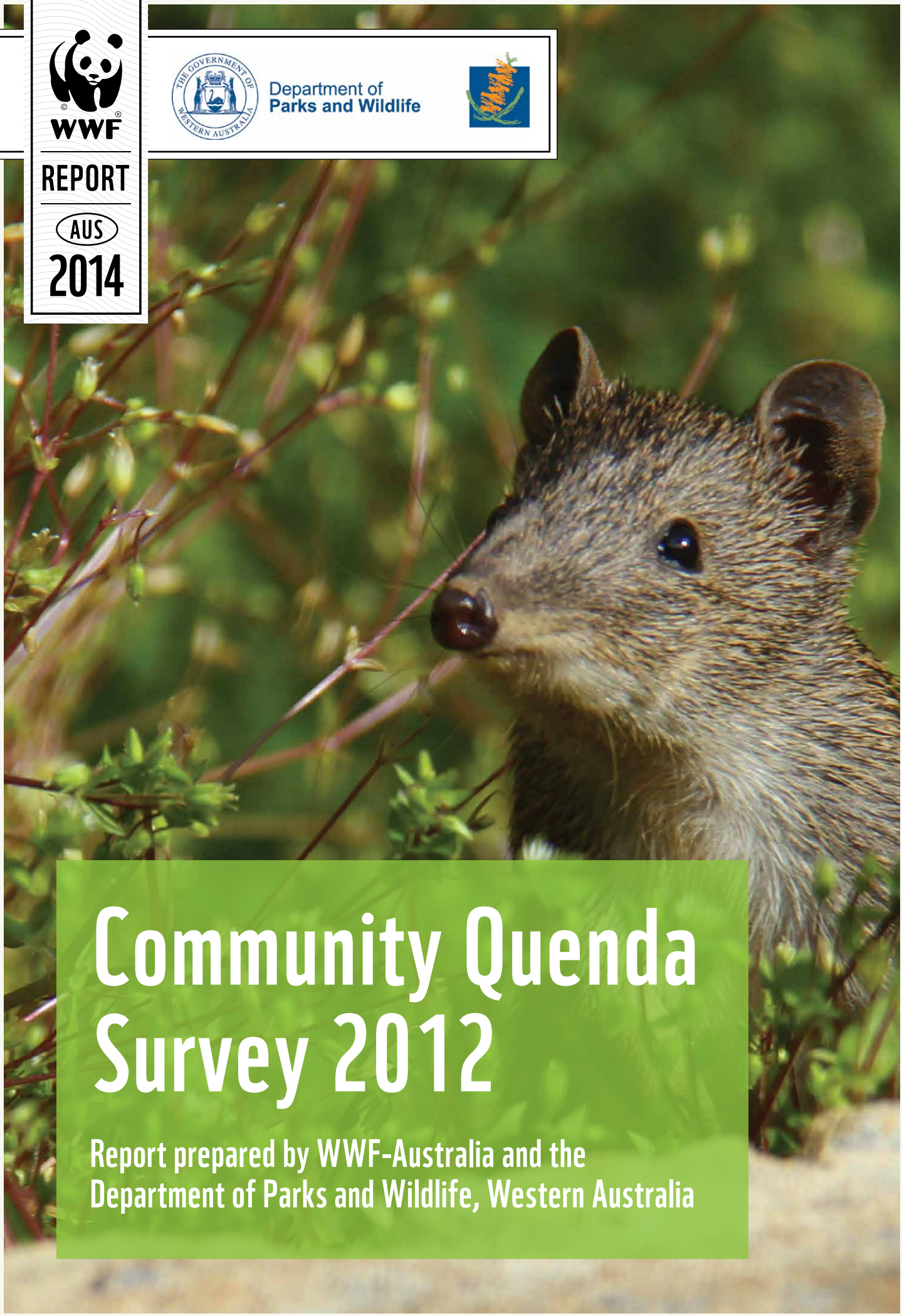

Community Quenda Survey 2012

Report prepared by WWF-Australia and the Department of Parks and Wildlife, Western Australia

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Cover image: Quenda in a Parkerville garden on the peri-urban fringe of Perth. © Simon Cherriman

In the interests of the environment, limited copies of this resource have been printed. Digital copies are available for download at wwf.org.au.

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Acknowledgements

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1. SUMMARY

- A total of 946 people participated in the 2012 Community Quenda Survey, reporting quendas at 1020 sites across the Perth and Peel Metropolitan Regions and other areas in Southwest Western Australia.
- Survey participants displayed a high level of accuracy in identifying quendas. Only 17 sighting reports were determined to be other species misidentified as quendas and removed from the dataset. Of the 213 participants who sent a photo to support their identification, 99% had correctly identified the species.
- The highest numbers of quenda sightings in 2012 were reported from established suburbs that have retained large areas of native vegetation and/or wetland or riparian habitat (*e.g.* Roleystone, Gooseberry Hill, Kalamunda, Mundaring).
- Almost no quenda sightings were reported from the inner and most urbanised suburbs of Perth where there is little native vegetation and the fragments that remain are highly isolated.
- A comparison between the 2012 and 1993 Community Quenda Surveys, made for a subset of the survey area where most sightings were reported, indicates that the number of quenda sightings declined in some suburbs south of the Swan River, particularly along the eastern peri-urban fringe; but increased in some areas of the Darling Ranges (*e.g.* Glen Forrest/Mundaring, Kalamunda and Kelmscott/Roleystone) over this period.
- In some newly urbanised areas where conversion of bushland for development has been very recent, there were no obvious patterns of change in quenda sightings between 1993 and 2012 but patchy increases (*e.g.* Wellard) or declines (*e.g.* Jandakot) were observed. It is likely that the full effects of recent habitat loss and fragmentation on resident quenda populations may take some years to be fully realised.
- Of 378 reported mortality events, vehicle strike was the most common known or suspected cause (44% of mortality events) followed by predation by cats, dogs or foxes (29%) and drowning (*e.g.* swimming pools; 16%).
- Quendas inhabiting suburban areas are supplementing their natural diet with human and pet food (provided and scavenged), as well as water from pools, sprinklers and water bowls. Survey participants reported either deliberate or inadvertent feeding of quendas at 35% (356) of all reported sites. Quendas were also reported to use artificial shelters (*e.g.* buildings and log piles) for refuge.
- There is a high public interest in quendas. The species is surprisingly well-known across the survey area and almost universally well-liked.
- The Perth and Peel Metropolitan Regions are rapidly changing landscapes. Quendas are at risk of losing more habitat to urban development, and to wetland degradation due to water harvesting and climate change. However the high numbers of quenda sightings in suburbs that have retained large areas of native vegetation indicate that it is possible to maintain small native mammals in the suburban and peri-urban environment. Improvements in planning and design which allow for greater retention and connectivity of native vegetation may be able to reduce the overall loss of quendas and biodiversity more generally.
- Quendas are important ecosystem engineers that contribute to better bushland health and a number of recommendations are provided to encourage the persistence of this species in the suburban and peri-urban environment.

A young quenda may sometimes be mistaken for a rat. Long ears, a long and very pointed nose, a short tail, a high, rounded rear and a bounding rather than a running gait are all good diagnostic features of quendas.

2. INTRODUCTION

The quenda (*Isoodon obesulus fusciventer*) is a subspecies of the southern brown bandicoot endemic to Southwest Western Australia.

It is found in higher-rainfall coastal and forest areas from Guilderton north of Perth, throughout the Swan Coastal Plain and adjacent forests, extending to east of Esperance; but has disappeared from the southern Wheatbelt where its habitat has been almost totally cleared (Friend 1990). They are ground-dwelling, medium-sized omnivorous marsupials. Males weigh between 500-1850g and females 400-1100g (Paull 2008), and as such they fall within the critical weight range (CWR) of mammals particularly susceptible to predation by the introduced red fox (*Vulpes vulpes*) and domestic or feral cat (*Felis catus*) (Johnson & Isaac 2009, Burbidge & McKenzie 1989).

Previously abundant across much of southern Australia, southern brown bandicoots are now much less common in New South Wales, Victoria and South Australia, where they persist only in small fragmented populations (Paull 2008). The eastern subspecies (*I. o. obesulus*) which occurs in New South Wales, Victoria and South Australia is listed as Endangered and the Nuyts Archipelago subspecies (*I. o. nauticus*) as Vulnerable under the national *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*.

The action plan for Australian mammals 2012 (Woinarksi *et al.* 2014) evaluated the conservation status of quenda as 'Least Concern', noted recent genetics research into the taxonomy of Isoodon species (Westerman *et al.* 2012) and merged *I. o. affinis* (Tasmania) and *I. o. nauticus* into *I. o. obesulus*, retaining *I. o. fusciventer* as a distinct subspecies. They noted that further research may lead to *I. o. fusciventer* being upgraded to a full species.

The quenda subspecies is not currently listed as threatened under the EPBC Act but is a protected species under the Western Australian *Wildlife Conservation Act 1950*. It is listed as 'Priority 5' on the WA Department of Parks and Wildlife (formerly Department of Environment and Conservation) Priority Fauna List (Department of Parks and Wildlife 2013). Priority 5 species are taxa for which conservation is dependent on ongoing management intervention. As such, it is also considered a significant fauna species by the WA Environmental Protection Authority to be taken into consideration during the land use planning and environmental impact assessment process (Environmental Protection Authority 2004).

Bandicoots as a group have undergone massive declines in both range and population in Western Australia, with three of the eight species formerly occurring in this state now extinct (Friend 1990). The quenda has declined significantly since the 1960s (Kitchener et al. 1978) but, to date, it has survived better than other bandicoot species in WA, at least in the uncleared parts of its range (Friend 1990) and it can still be found in the peri-urban fringe of the capital city of Perth in gardens and remnants of native vegetation. This ability to persist in some human-dominated landscapes may give the impression that quendas are common and their populations secure. However, little is known about where they occur across the Perth and Peel Metropolitan Regions, and whether their numbers are stable or declining. In this context, and with the aim of better understanding the current distribution of quendas in the Perth and Peel Metropolitan Regions, a partnership was formed between the Department of Parks and Wildlife (Parks and Wildlife) and WWF-Australia (WWF) to conduct a broad scale community-based quenda survey.

Access to areas of native bushland, damp soils such as wetlands and low, dense vegetation for foraging habitat and shelter from predators is critical to the survival of quendas (Bamford & Bamford 1994; Gibson *et al.* 2004; Wilson *et al.* 2010). Due to their general preference for damper soils, the quenda has been viewed as a 'flagship' or 'umbrella' species for the conservation and restoration of wetland and riparian areas, which are likely to become climatic refugia for a suite of other species in the context of a changing climate (Hughes & Banks 2010).

Additionally, the long-term health of remnant patches of suburban bushland may be at least partly dependent on the presence of quendas. It has been estimated that an individual quenda can turn over around 3.9 tonnes of soil each year (Valentine *et al.* 2012) as it digs for underground fungi, insect larvae, roots and tubers. Digging by native mammals plays an important role in Australian ecosystems. The resulting disturbance of the soil and leaf litter helps increase the breakdown of organic matter, facilitates water penetration and nutrient cycling, aerates the soil, increases seed germination and spreads beneficial soil fungi that is essential for plant growth (Eldridge & James 2009, Garkaklis *et al.* 1998, Valentine *et al.* 2012, Fleming *et al.* 2014).

The persistence of quendas in urban and peri-urban bushland areas should therefore be encouraged, not just for the conservation of this species, but also for the maintenance of broader bushland health and for the benefit of a suite of other species.

3. AIMS

The aims of the 2012 Community Quenda Survey were to:

- Collect spatially explicit data to improve current knowledge of quenda distribution in the Perth and Peel Metropolitan Regions and Southwest Western Australia;
- Compare the 2012 survey results with a similar community survey conducted in 1993 by Parks and Wildlife (Friend 1996), for an indication of possible changes in quenda distribution and abundance over the last 19 years;
- Collect data on quenda breeding and causes of quenda mortality;
- Raise the public profile of the quenda in the broader community;
- Collect data that can be used in future studies about quenda habitat preferences and distribution, quenda translocations, and land use planning and spatial conservation prioritisation in Southwest WA.

Below: A female quenda carrying pouch young.

4. SURVEY AREA

This survey primarily focused on the Perth and Peel Metropolitan Regions, but quenda sighting reports were accepted from anywhere in Southwest Western Australia (Figure 1). The recognised land use planning units of the Perth and Peel Metropolitan Regions, Local Government Areas (LGAs) and suburbs, have been used for much of the data analysis.

5. SURVEY METHODS

The 2012 Community Quenda Survey was designed to collect data for comparison with a community-based survey conducted in 1993 by the Department of Parks and Wildlife (Friend 1996).

Using an extensive media campaign, members of the public were asked to report quenda sightings to Parks and Wildlife (in 1993) and to either Parks and Wildlife or WWF (in 2012). The 2012 survey methods were comparable with the 1993 Parks and Wildlife survey (see section 5.4, below). Standardising and quantifying survey effort in a citizen science survey of this nature is difficult and no attempt was made to do so.

5.1 SURVEY PERIOD AND PROMOTION

5.1.1 Survey period

A pilot survey was undertaken in November 2011 by Parks and Wildlife via a call for quenda sightings in the Parks and Wildlife newsletter *Bushland News* (Department of Environment and Conservation 2011a).

This pilot survey generated 130 reports of quenda sightings dating back to the 1980s. The pilot survey also confirmed that there was a high level of public interest in the quenda and that the species frequently interacts with people in suburban settings. The main survey was subsequently launched on 14 May 2012 and ran for approximately three months over the winter period (May to August). The survey was formally closed on 31 July 2012, but sighting reports continued to be received and processed until the end of August 2012. Reports received after August 2012 were not included in this report but have been captured in the Parks and Wildlife Fauna Records database.

5.1.2 Survey promotion

A joint media release by WWF and Parks and Wildlife was distributed to all Perth metropolitan news outlets (Appendix A) including the State-wide newspaper *The West Australian* and all the free local newspapers in the greater Perth and Peel Metropolitan Regions. Prior to the 2012 survey there were few known records of quendas from the northern and southern fringes of the city, so the local newspapers of Mandurah, Joondalup, Wanneroo and surrounding suburbs were specifically targeted via follow up phone calls to their editors. Radio interviews with major Perth radio stations ABC and 6PR were solicited via phone calls to program producers.

Paid newspaper advertisements were considered but were not required as the survey was successfully promoted via articles in several media outlets across Perth and Western Australia. This unpaid advertising consisted of at least ten print articles, five radio broadcasts (three stations), five articles on online news sites and two Parks and Wildlife newsletters (for full list see Appendix B). The print news articles included a large story and photograph in *The West Australian* (circulation 200,000+), and stories in at least nine local newspapers that covered the north, south and eastern edges of the city.

The survey was further extensively promoted on the internet and social media, including the WWF website, Facebook page, blog and Twitter sites, and the Parks and Wildlife website, email network and Facebook page. Parks and Wildlife also promoted the survey via the *Bushland News* newsletter (distribution 1,980 people) (Department of Environment and Conservation 2011a, 2011b & 2012b).

We are therefore confident that good media coverage was achieved across most of the area covering the Perth and Peel Metropolitan Regions, both north and south of the Swan River.

5.2 DATA COLLECTION

Reports of quenda sightings were received via phone calls, emails, tweets and Facebook posts. People who responded via Facebook or Twitter were asked to email or call WWF or Parks and Wildlife project officers to provide details of the quenda sighting. All observers whose sighting reports were accepted for this analysis and report were contacted either via phone or email.

All survey participants were asked to provide the same information via a series of questions designed to collect accurate temporal and spatial information, provide insights into threatening processes and assess the observer's ability to correctly identify a quenda. Information on perceived threats was opportunistically collected as many participants volunteered comments on issues that they thought were affecting quenda numbers in their area, *e.g.* impending land development proposals, predation by dogs, foxes and cats, and effects of disease or poisoning.

The following questions were asked of each survey participant (not necessarily in order):

1. Can you describe the animal? (The survey project officers used the participant's description of the animal to determine if it had been accurately identified by checking for distinguishing characteristics *e.g.* long nose, short tail, hopping gait, bigger than a rat).
2. Could you provide a photograph? (To verify that the animal is a bandicoot).
3. What is the house/street address or road intersection of the reported sighting? Name of reserve or other site (*e.g.* school, golf course, business)?
4. What was the environmental context of the sighting location (*e.g.* suburban garden, roadside, bush block, golf course)?
5. Was the quenda dead or alive? If dead, what was the known or suspected cause of death?
6. How many bandicoots were there? (The survey methods were not designed to provide a formal 'count' but we wanted to know if only one or multiple bandicoots were seen.)
7. What time of day do you usually see them (*e.g.* morning, evening)?
8. How often do you see them? (This question was asked partly to determine the participant's ability to identify a quenda but also for information on regularity of sightings).
9. What was the date of the sighting?
10. Is there any evidence of breeding – do you see babies or small individuals, a family group?

11. Do you feed them, *i.e.* do you put food out especially for bandicoots, do they drink your pet's water, eat pet's food? (This question was not always asked directly but many participants volunteered this information. If participants provided information about feeding quendas, they were asked what food was provided to the animals.)

12. How did you find out about the bandicoot survey?

A contact phone number and/or email address was requested of each participant in case further information was required and for the later provision of feedback on the results of the survey.

5.3 DATA VETTING AND PROCESSING

The survey data were captured in Microsoft Excel spreadsheets which were then linked to a Microsoft Access database. Subsequent data vetting and processing were conducted by staff at both Parks and Wildlife and WWF, with all records being combined into a single database. Where a street address was provided as the location for the quenda sighting, latitude and longitude coordinates were generated using Google Maps.

5.3.1 Quenda identification

A photograph and a description of a quenda, including characteristics to distinguish the species from rats (long nose, short tail, hopping gait) were distributed with the media release. Most print and online news outlets that ran a story on the quenda survey had a photograph accompanying the article. Both WWF and Parks and Wildlife included photos of quendas on all web pages that referred to the quenda survey. The vast majority of people who learned of the survey from any source other than the radio or word of mouth would therefore have seen a photograph to aid their species identification.

The physical characteristics of quendas combined with a consideration of their habitat preferences and behaviour make them relatively easy to distinguish from other similar mammals such as rats or possums. The reliability of each sighting report was determined by the observer's ability to describe, or ideally provide a photograph of, a quenda. Verbal or email descriptions included the physical appearance, behaviour and habitat use of the animal seen by the observer.

Any reported sightings that were judged by the photograph or the description as definitely not or probably not quendas were eliminated from the analysis. For example, animals seen in roof spaces or on the tops of fences were eliminated as more likely to be rats or possums. In a small number of cases (fewer than ten, or <1% of sightings), where the observer was known to be familiar with the species (for example, Parks and Wildlife Officers), clear descriptions of digging activity were accepted as quenda records, in the absence of an actual sighting of the animal. These records have been identified in the database.

5.3.2 Quenda sites

When multiple reports were received from the same general location, a decision was made about whether to consider them as separate sites or a single site. This decision was based on the proximity of sightings to each other and likely habitat available (as assessed visually using Google Maps). Generally, if two sites were separated by open space without potential quenda habitat, they were considered to be separate sites with different quendas. If sightings were within a continuous patch of remnant vegetation and within 200 metres of each other, and the site description was the same, they were combined into the same site. As a consequence, there are some quenda sites with multiple observers. The observer information for each individual sighting was retained, regardless of the outcome of the decision regarding site allocation.

5.4 COMPARISON WITH THE 1993 SURVEY

The 2012 survey methods were comparable with the 1993 Parks and Wildlife survey, with media coverage, advertising effort and the instructions to participants all similar between the two surveys (J.A. Friend pers. comm.). One major difference in promotional effort between the two surveys could have been access to social media, available in 2012 but not in 1993; however social media did not ultimately contribute many useable sighting reports to the 2012 survey (see 6.7 Public response to quenda media campaign).

The 2012 survey occurred over a ten month period (November 2011 to August 2012) with a three month intensive period (May to August 2012). By comparison, the 1993 survey data were gathered over a longer time period (1991 to 1993), but this survey also had an intensive survey period (67% of sightings reported during the month of March 1993).

As such, for the area south of the Swan River for which the density comparison between the two surveys was made (see section 5.5), we are assuming that the survey effort was similar between 1993 and 2012. Notwithstanding this, we do acknowledge that apparent changes (declines or increases) in the number of quenda sightings in 2012 compared with 1993 in various suburbs may be due to differences in survey effort during the two periods.

5.5 DENSITY OF SIGHTINGS IN 2012 AND COMPARISON WITH THE 1993 SURVEY

The density of quenda sightings (number per km^2) in the 2012 community quenda survey was compared with that observed in the 1993 community quenda survey for a portion of the study area that received the bulk of the sighting reports in both years – the Perth suburbs south of the Swan River down to Serpentine and Jarrahdale (Figures 2, 4).

The density of quenda sightings in each year was calculated using ESRI's geographic information systems software ArcGIS 9.3 (2009), based on the number of sightings in a 1 kilometre radius around the centre of each cell of a 100 metre resolution grid, for each year (a standard density cloud mapping process in which each sighting is counted more than once). The difference between the two density layers was then calculated (sightings density in 2012 minus sightings density in 1993) and colour coded. Grid cells showing no difference in sightings density were coded grey, grids cells with a decrease in the number of sightings were coded red, and those with an increase in the number of sightings were coded green.

5.6 CHANGES IN REMNANT VEGETATION COVER AND BUILT-UP AREA EXTENT

To facilitate a better understanding of the spatial differences in quenda sightings density between the 2012 and 1993 surveys, the extent of remnant vegetation cover and built-up areas in each suburb was estimated for these two years (though note the constraints on data availability for 1993 as outlined below). Then, the area of remnant vegetation cleared and area of built-up land developed over the 19 year period between 1993 and 2012 in each Local Government Area was calculated.

Parks and Wildlife produced a remnant vegetation extent layer for 1995 for this study, as there were no aerial photographs or available data sets depicting the native vegetation extent in the study area in 1993. The 1995 remnant vegetation extent layer was produced based on the 2001 remnant vegetation extent layer provided by the WA Local Government Authority (WALGA), corrected through photo-interpretation of 1995 aerial photographs provided by Landgate.

A 2012 remnant vegetation extent layer was produced by updating the 2010 remnant vegetation layer provided by WALGA through photo-interpretation of 2012 aerial photographs provided by Landgate. In this way, we were able to account for new urban development and vegetation clearing that occurred between 2010 and 2012.

The extent of built-up areas was estimated using the spatial layers 'Street Smart – Perth Street Directory' from 1997 and 2012 provided by Landgate. In particular, the following urban classes were used: 'industrial or commercial areas', 'suburbia lawn parks', and 'medium high density residential areas'. The 1997 'Street Smart' dataset was the earliest one available.

6. RESULTS

A total of 946 people participated in the 2012 Community Quenda Survey, reporting quenda sightings at 1020 sites across Southwest Western Australia. (Several observers reported quendas from multiple sites, and some sites were reported by more than one observer.) The total of 1020 sites was obtained after elimination of duplicate sites and 17 sighting reports where the species identification was either questionable or confirmed as not being a quenda.

Of the 946 observers, 213 provided a photo to accompany their quenda sighting report. Of the 213 photos sent in, only two were not quendas: one was a black rat (*Rattus rattus*) and the other was a yellow-footed antechinus (*Antechinus flavipes*). Seventeen of the 1037 sighting reports (less than 2%) received during the survey period were eliminated from the analysis due to incorrect or questionable species identification, indicating that between 98 and 99% of all survey participants were able to accurately identify a quenda.

For sections *6.1.1 Comparison between Local Government Areas*; *6.1.2 Quendas and remnant vegetation*; and *6.2 Comparison of quenda sightings density between 2012 and 1993*; only 2012 quenda sightings within the Perth and Peel Metropolitan Regions were used. For all other analyses (number of participants and sightings, type of location where quendas seen, mortality, breeding, feeding, behaviour, and public response to the Community Quenda Survey), all quenda sighting records that were accepted to the 2012 survey were used (see Figure 1 for the location of these sighting records).

6.1 LOCATION OF QUENDA SIGHTINGS

Most sites where quendas were reported were in the Perth and Peel Metropolitan Regions (953 out of 1020). Quenda sightings were also reported from as far afield as Cervantes, Margaret River, Manjimup and Albany (Figure 1). See Appendix C for a complete list of suburbs for which quenda sightings were reported.

Most of the 2012 quenda sightings were from areas of human habitation, including bush blocks and rural zones on the fringes of the city and small suburban gardens, though these were usually in close proximity to areas of native vegetation, including riparian and wetland habitats. Quendas were also reported from other partially-developed areas such as industrial estates, golf courses and roadsides. Only 9% of the quenda sightings received in this survey were reported from bushland or wetland areas such as regional or national parks, wetlands, lake reserves or beach fronts (Table 1).

Table 1. Number and proportion of quenda sighting reports across Southwest Western Australia by location types (total 1020).

Location of quenda sightings	Number (and %) of sightings
Residential areas: suburban gardens, semi-rural, rural, bush blocks	776 (76.1%)
Bushland reserves, wetlands, lake reserves or beachfronts	90 (8.8%)
Other partially-developed sites: universities, schools, industrial areas, airports, golf courses, caravan parks	77 (7.5%)
Roadsides, cycle paths, road reserves or nature strips	77 (7.5%)

FIGURE 1

Location of all quenda sightings reported to the 2012 Community Quenda Survey.

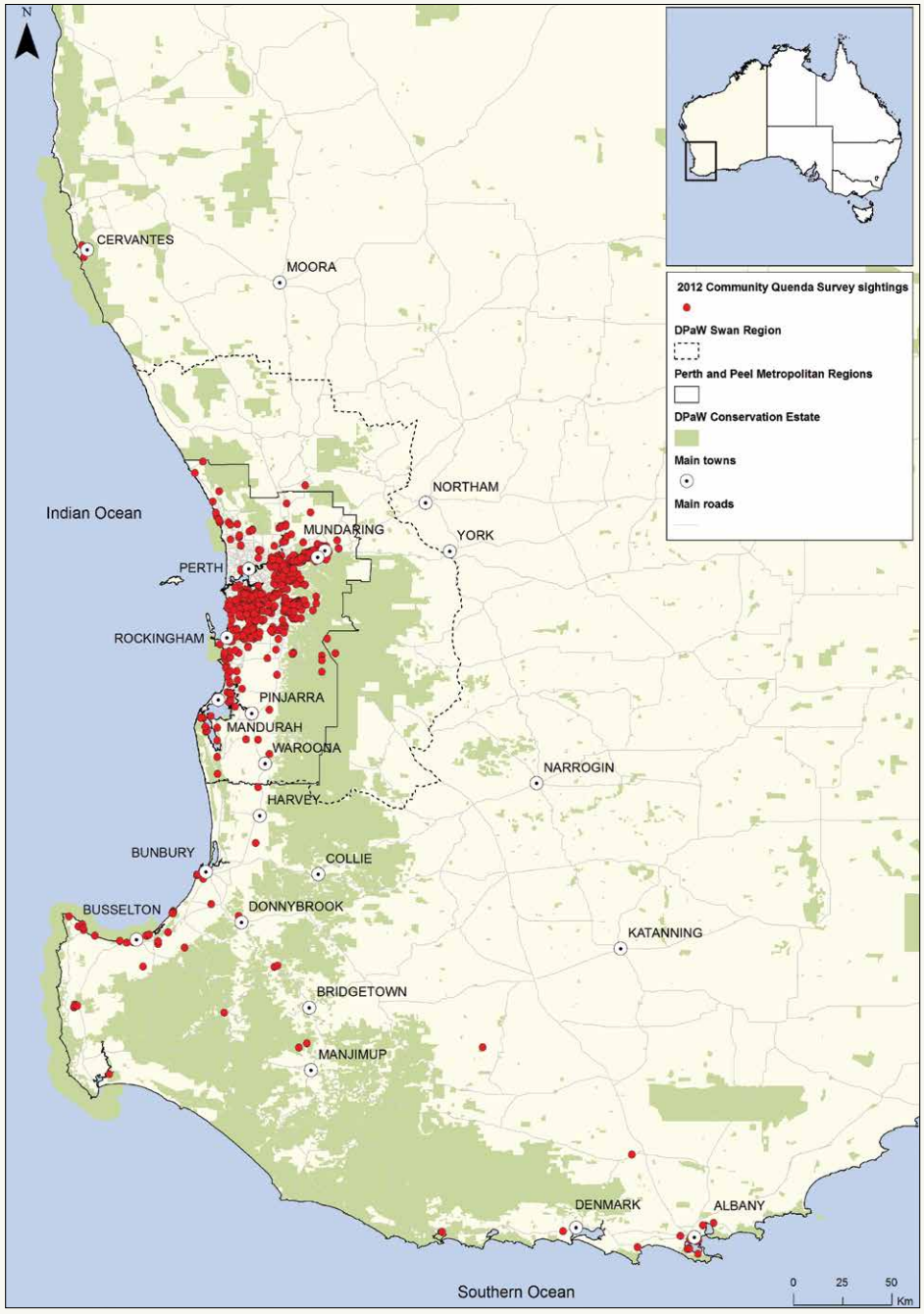
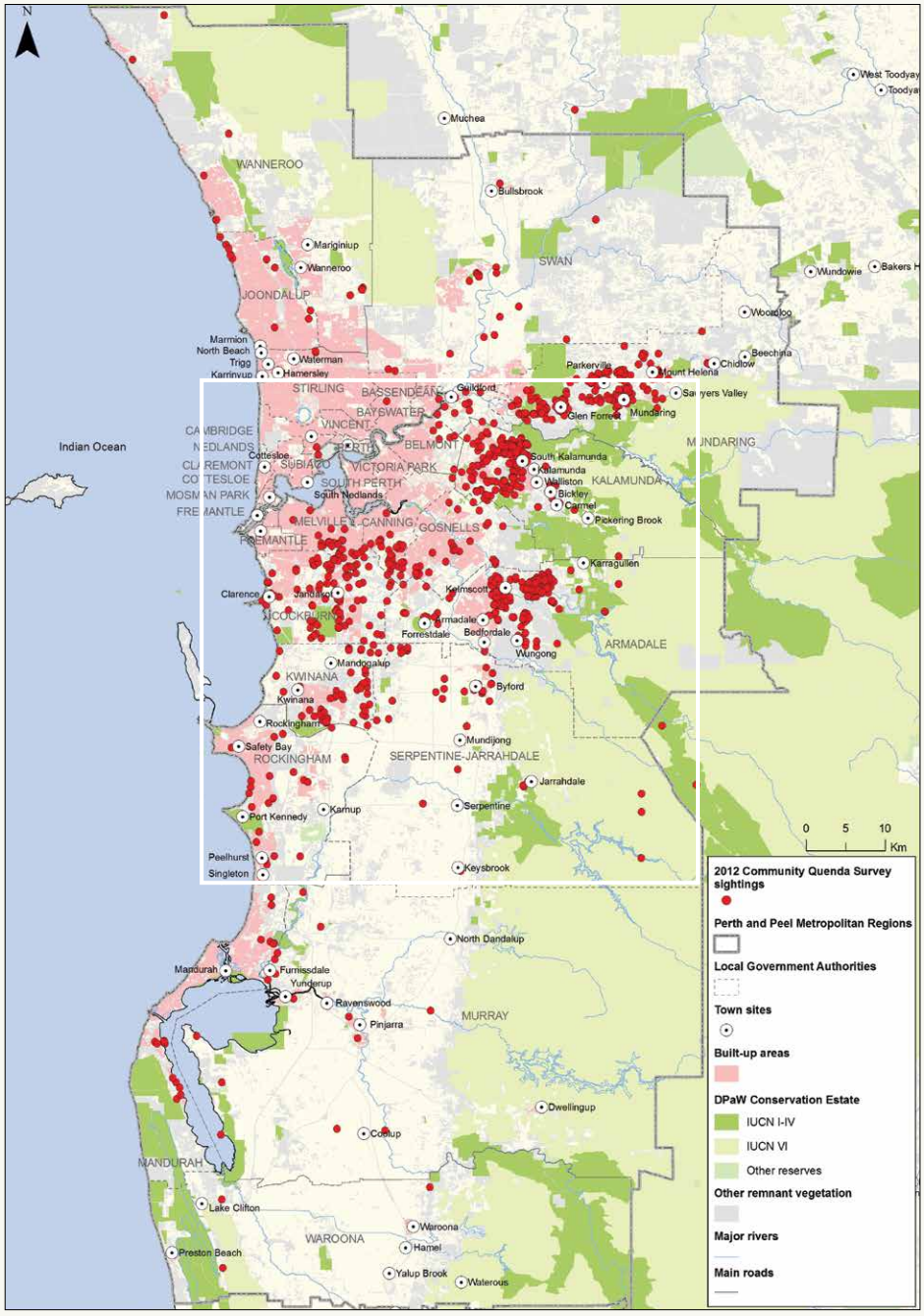


FIGURE 2

Location of the quenda sightings reported to the 2012 Community Quenda Survey in the Perth and Peel Metropolitan Regions. The white square indicates the area used for comparison between the 2012 and 1993 Community Quenda Surveys.



6.1.1 Comparison between Local Government Areas

The number of quenda sightings was mapped by Local Government Area (LGA) within the Perth and Peel Metropolitan Regions (Figures 2 and 4, Table 2) as these are easily recognisable administrative units, although we recognise that the area and human population of LGAs varies greatly. We further acknowledge that although media exposure and therefore survey awareness would have been similar across the region, survey effort is variable and accurate quenda population estimates from a survey of this nature are not possible. However, by comparing results for LGAs with different extents of remnant native vegetation and built up areas, broad trends can be observed.

Within the Perth and Peel Metropolitan Regions, the majority of quenda sightings (almost 60%) were located in three LGAs along the Darling Scarp: Mundaring, Kalamunda, and Armadale (Figures 2 and 4; Table 2). These LGAs all retain more that 65% of their pre-European vegetation extent. On the Swan Coastal Plain portion of the study area, most quenda sightings were reported from south of the Swan River, largely in the City of Cockburn and the Town of Kwinana LGAs (28% and 38% vegetated, respectively) (Figure 2).

In general, quendas were largely unreported from the most urbanised and established suburbs north of the Swan River and south of Reid Highway, and are very likely to be absent from these suburbs given the paucity of suitable habitat.

Sparse sightings were reported from some middle and outer Perth suburbs undergoing quite recent conversion of bushland for urban development; *e.g.* Burns Beach and Wellard. Recent development may result in quendas being displaced into gardens, local parks and roadsides, where they are more easily observed. Quendas were also reported from sites along major roads such as the Kwinana Freeway shared cycle path and the Roe Highway.

Local Government Areas with less than 25% remaining native vegetation almost consistently returned zero or almost no quenda sighting reports (0-6), with the exception of the Cities of Canning, Melville and Joondalup. Sighting reports were still sparse from the City of Joondalup (11 in total) with most reported from a strip of coastal vegetation from Burns Beach to the Iluka Foreshore. Quenda sightings within the City of Canning were almost all within the suburb of Canning Vale, which is immediately adjacent to large areas of banksia woodland at Jandakot Airport and Jandakot Regional Park. Quenda sightings in the City of Melville were clustered mostly around the Murdoch University's South Street Campus, which contains two Conservation Category wetlands, an area of banksia woodland, a dense human population and various food outlets which may all be supporting the quenda population.

The City of Cambridge retains around 25% of its pre-European vegetation and received no quenda sightings, but the total area of this LGA is relatively small and most of the 25% vegetated area is accounted for by Bold Park and Perry Lakes Reserve. Despite the availability of apparently suitable habitat, quendas were not reported from either of these reserves, or from nearby Herdsman Lake Regional Park (City of Stirling). Bold Park contains 437 hectares of native bushland (Botanic Gardens and Parks Authority, 2011), but it is quite isolated, surrounded on most sides by busy roads and long-established suburbs. Herdsman Lake was extensively cleared and modified in the past, and while it now contains areas of low, dense vegetation due to ongoing revegetation works, suitable quenda habitat was limited at the site for many years (M. Bamford pers. comm.) and indeed quendas have not been recorded at this site since the 1960s (White 1984).

Quendas were sighted in Kings Park during the 2012 survey, which may indicate a recent unauthorised translocation, given that the species is not thought to exist there and was not recorded from the park in 1993. The single, isolated sighting in Shenton Park (City of Subiaco) is also unlikely to indicate a resident population.

There were only a small number of quenda sightings reported from the Shire of Waroona at the southern extremity of the Peel Metropolitan Region, where large areas of native vegetation persist.

6.1.2 Quendas and remnant vegetation

Most quenda sightings in the Perth and Peel Metropolitan Regions were located in suburbs that retain a large proportion of remnant vegetation and/or wetland or riparian habitat. As shown in Figure 3 and Table 2, there was a significant positive correlation between the number of quenda sightings and the 2010 percentage of pre-European vegetation remaining in each LGA (Pearson correlation coefficient = 0.75). Note though, that this correlation decreases to 0.46 if the City of Armadale and the Shires of Kalamunda and Mundaring (top right, Figure 3) are not considered - these LGAs have the highest percentage of pre-European vegetation remaining and also the highest number of quenda sightings in 2012.

FIGURE 3

Relationship between the number of quenda sightings in each Perth and Peel Local Government Area during the 2012 Community Quenda Survey and the percentage of pre-European vegetation extent remaining in that LGA (2010).

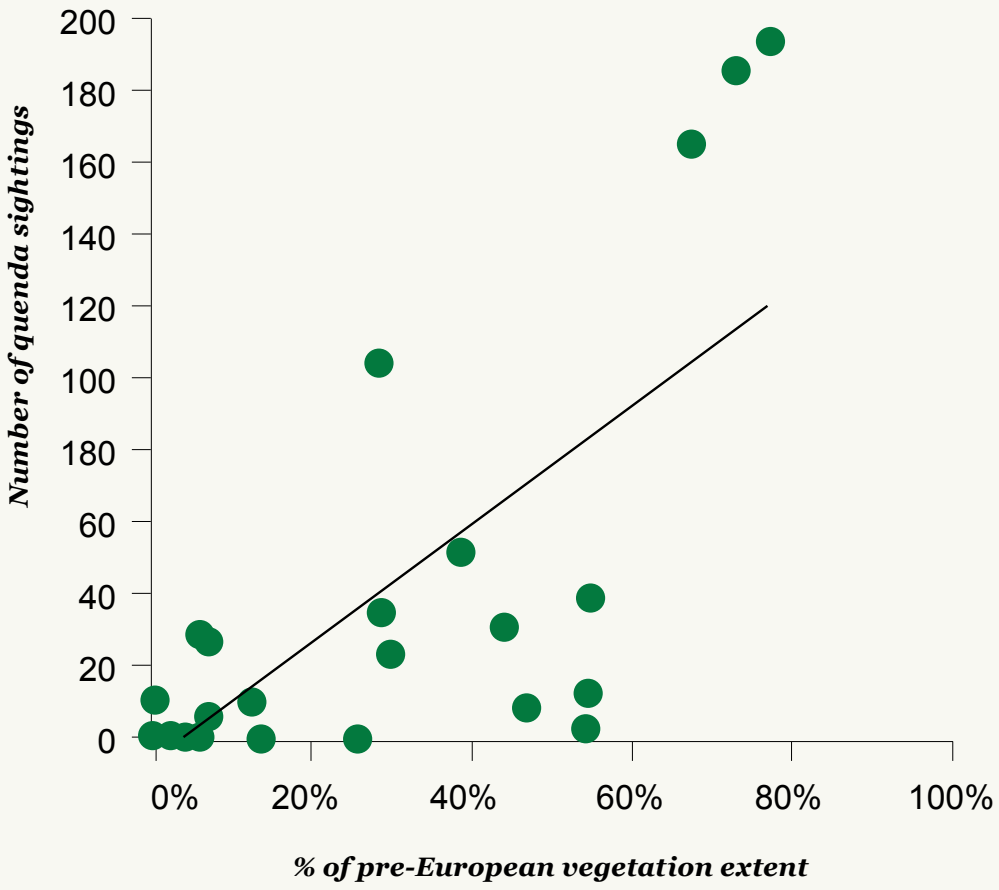


Table 2. Quenda sightings (total of 953) and remaining native vegetation extent by LGA in the Perth and Peel Metropolitan Regions.

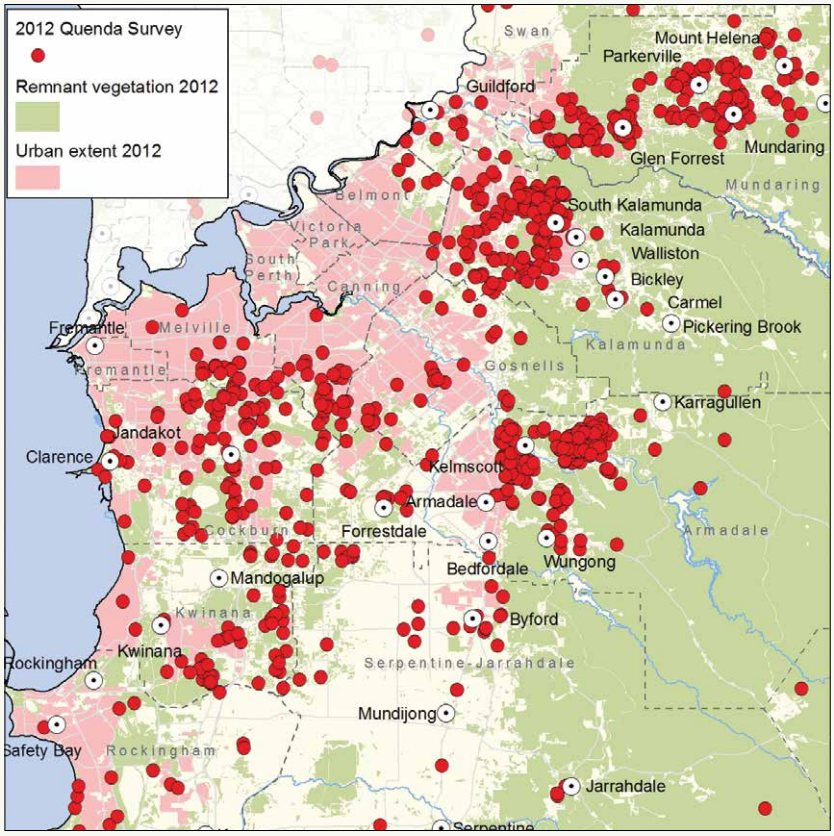
Local Government Areas (LGAs) of Perth and Peel Metropolitan Regions	Quenda sightings 2012	% Quenda sightings 2012	Remaining vegetation extent 2010 (ha)*	Remaining vegetation (2010) as % of pre-European extent*
City of Armadale	194	20.4%	43002.54	77.1%
Shire of Kalamunda	190	19.9%	23585.43	72.9%
Shire of Mundaring	174	18.3%	43468.2	67.5%
City of Cockburn	98	10.3%	4138.4	28.0%
City of Kwinana	53	5.6%	4593.65	38.4%
Shire of Serpentine-Jarrahdale	38	4.0%	49433.16	54.9%
City of Gosnells	31	3.3%	3672.24	28.7%
City of Swan	31	3.3%	45551.82	43.7%
City of Canning	27	2.8%	458	7.1%
City of Melville	26	2.7%	309.11	6.0%
City of Rockingham	23	2.4%	7267.83	29.8%
City of Mandurah	19	2.0%	8196.55	49.6%
Shire of Murray	13	1.4%	92181.34	54.2%
City of Joondalup	11	1.2%	1203.82	12.3%
City of Wanneroo	11	1.2%	32059.01	46.9%
City of Belmont	6	0.6%	405.51	7.1%
Shire of Waroona	3	0.3%	45065.68	54.2%
City of Stirling	2	0.2%	638.32	6.1%
City of Bayswater	1	0.1%	42.57	1.3%
Town of Bassendean	1	0.1%	27.45	2.7%
City of Subiaco	1	0.1%	0.76	0.1%
Town of Cambridge	0	0.0%	558.93	25.6%
City of Nedlands	0	0.0%	268.42	13.6%
City of South Perth	0	0.0%	50.14	2.6%
City of Fremantle	0	0.0%	32.74	1.8%
Town of Mosman Park	0	0.0%	18.8	4.7%
Town of Victoria Park	0	0.0%	15.35	0.9%
Town of Cottesloe	0	0.0%	11.2	0.0%
Town of Claremont	0	0.0%	4.01	0.8%
Town of East Fremantle	0	0.0%	2.71	0.8%
Shire of Peppermint Grove	0	0.0%	1.7	1.7%
Town of Vincent	0	0.0%	0.04	0.0%
City of Perth	0	0.0%	0	0.0%

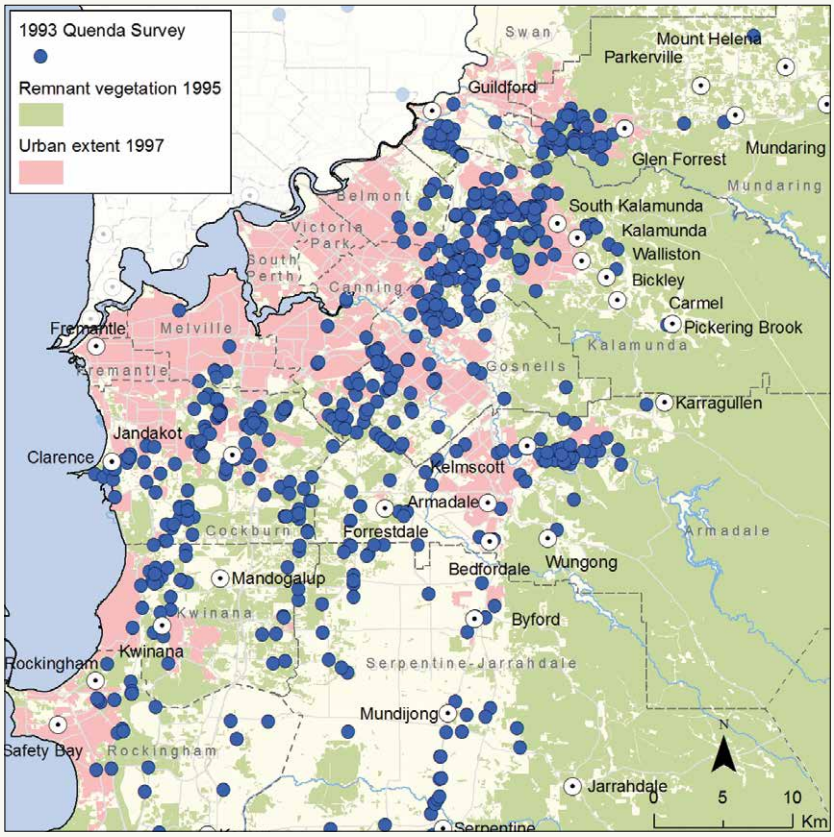
* Remaining vegetation extent and remaining vegetation extent as a percentage of the pre-European extent data were sourced from the 2010 Addendum to Chapter 16 of the Local Biodiversity Planning Guidelines (Perth Biodiversity Project, 2011).

Some Perth suburbs are shared between two or more LGAs. Where this is the case, ArcGIS was used to identify which quenda sightings 'belonged' to each LGA.

FIGURE 4

Location of the majority of the quenda sightings reported during the 2012 and 1993 Community Quenda Surveys. This area was used for the direct comparison of sightings density between the two surveys (Figure 5).





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6.2 COMPARISON OF QUENDA SIGHTINGS DENSITY IN 2012 AND 1993

The density of quenda sightings in 2012 and 1993 was directly compared for a portion of the survey area that extended from the Swan River south to the LGAs of Serpentine-Jarrahdale and Rockingham. High numbers of quenda sightings were recorded in this area during both surveys, with more quenda locations reported during 2012 than 1993 (873 and 664, respectively).

The distribution of sightings in this area was similar in both surveys, with almost no sightings reported in the most urbanised areas immediately south of the Swan River; and a relatively high density of sightings (up to 16 and 9 sightings per km^2 in 2012 and 1993, respectively) reported in areas that retain considerable areas of remnant vegetation (Figure 4, Table 3).

Changes in sightings density are explored in more detail below but overall, these results seem to indicate that between 1993 and 2012:

a) the number of quenda sightings was already low and has declined further in the most consolidated suburbs since 1993, particularly in the City of Gosnells, the rapidly growing suburbs in the foothills of the Shire of Kalamunda, and certain suburbs of the Cities of Swan, Cockburn and Kwinana;

b) the number of quenda sightings has increased on the Darling Scarp, in certain suburbs of the City of Armadale and the Shires of Mundaring and Kalamunda; and

c) in some areas, there is no obvious pattern but there are patches of both increased and decreased quenda sightings. These include some suburbs that have undergone recent vegetation clearing and conversion from rural to residential urban.

Table 3 and Figure 5 present the difference in sightings density between 1993 and 2012.

Table 3. Number of quenda sightings reported during the 2012 and 1993 Community Quenda Surveys in selected LGAs.

Local Government Area	2012	1993	Difference	
City of Armadale	194	73	121	↑
Shire of Mundaring	174	65	109	↑
Shire of Kalamunda	190	145	45	↑
City of Melville	26	6	20	↑
City of Kwinana	53	34	19	↑
City of Mandurah*	19	1	18	↑
City of Joondalup*	11	1	10	↑
City of Canning	27	20	7	↑
City of Wanneroo*	11	4	7	↑
City of Swan†	31	31	0	–
Town of Bassendean	1	1	0	–
City of Belmont	6	10	-4	↓
City of Rockingham†	23	35	-12	↓
Shire of Serpentine-Jarrahdale†	38	56	-18	↓
City of Cockburn	98	121	-23	↓
City of Gosnells	31	88	-57	↓

*LGAs outside of the area selected for direct comparison mapped in Figures 4 and 5.

†LGAs with boundaries that extend beyond the area selected for direct comparison mapped Figures 4 and 5.

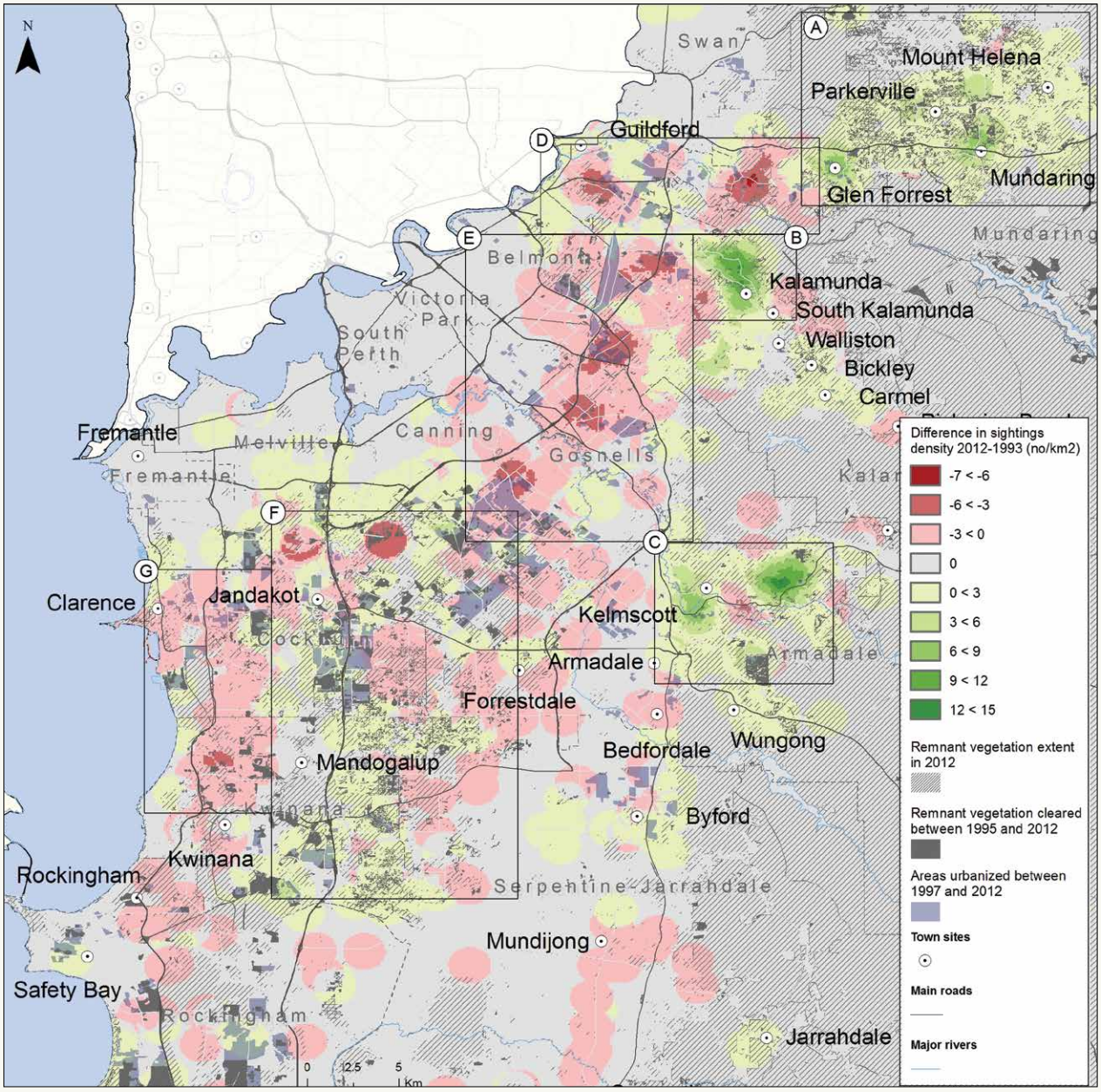


FIGURE 5

Difference between sightings density in the 2012 and 1993 Community Quenda Surveys, south of the Swan River. Green shades indicate an increase in the number of sightings per km² from 1993 to 2012, whereas red shades indicate a decrease in the number of quenda sightings per km². The figure also presents the extent of remnant vegetation in 2012; the areas of remnant vegetation that were cleared between 1995 and 2012; and the areas urbanised between 1997 and 2012.

6.2.1 Areas of decreased density in quenda sightings

To facilitate the interpretation of Figure 5, the figure has been subdivided into smaller regions labelled A-G.

Areas where the density of quenda sightings decreased between 1993 and 2012 include a stretch of suburbs around 12 kilometres from the city centre. These areas were already quite developed and any remaining vegetation very fragmented in the early 1990s, and have been further urbanised in the last two decades:

- Zone D, including the suburbs of South Guildford (City of Swan) and Boya (Shire of Mundaring);
- Zone E, including the suburbs of Canning Vale, Thornlie, Kenwick (City of Gosnells), Wattle Grove, Forrestfield and Maida Vale (Shire of Kalamunda) and Perth Airport (City of Swan) (Figure 5).

There was a patchy decline in quenda sightings in:

- Zone F, including noticeable declines in quenda sightings in the suburbs of Jandakot, Bibra Lake and Yangebup (City of Cockburn);
- Zone G, particularly the suburbs of Hope Valley (City of Kwinana) and Wattleup (City of Cockburn) east of Rockingham Road.

Zones E, F and G of Figure 5 have experienced considerable urbanisation and fragmentation between 1993 and 2012.

6.2.2 Areas of increased density in quenda sightings

Areas where the density of quenda sightings has increased between 1993 and 2012 include the following locations along the Darling Scarp (Figure 5):

- Zone A, including some suburbs along the Great Eastern Highway: Glen Forrest, Mundaring, Stoneville, and Parkerville;
- Zone B, including the suburbs of Kalamunda and Gooseberry Hill;
- Zone C, including the suburbs of Kelmscott and Roleystone.

These are generally semi-rural or special rural residential areas (except Kelmscott, which is urban residential) that are largely surrounded by major areas of remnant vegetation, including Parks and Wildlife-managed Conservation Estate and local government conservation areas, and where individual private properties (often five acre or approximately two hectare blocks) retain some remnant vegetation. For example, Zone A includes part of the John Forrest National Park, Beelu National Park and Strettle Road Reserve, and Zone B is surrounded to the east by Kalamunda and Beelu National Park. Kelmscott, in Zone C, is the only suburb of these three zones that is urban residential. Nevertheless, Zone C is crossed by the Canning River and its riparian corridor, and is close to Korung National Park and Darling Range Regional Park, as well as the rural residential area of Roleystone. Despite some vegetation clearing and minor urbanisation (in Zones A and C, Figure 5), there was an increase in quenda sightings density in these three zones.

There was a patchy increase in quenda sightings in:

- Zone F, *e.g.* along the Kwinana Freeway in suburbs that have experienced recent vegetation clearing and urbanisation, such as Wellard and Casuarina (City of Kwinana).

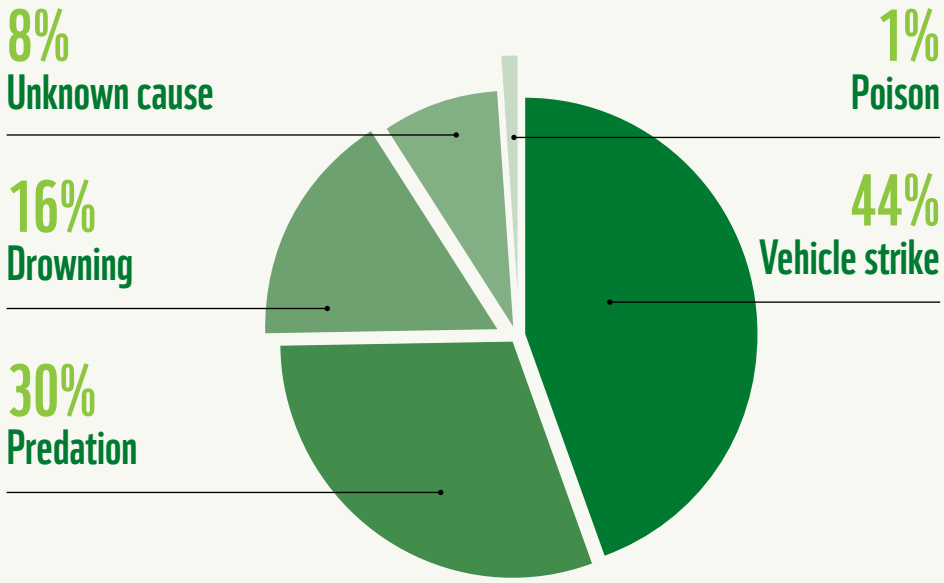
6.3 MORTALITY AND PERCEIVED THREATS

All quenda sightings from across Southwest WA (Figure 1) that included information on mortality or perceived threats were included in the following results, not just those from the Perth and Peel Metropolitan Regions. When examining these results it should be noted that the frequency with which a particular cause of mortality is reported by the general public will be heavily influenced by how visible it is. Animals killed by vehicle strike are highly visible, as are animals drowned in pools, whereas predated or poisoned animals or those that die from illness or old age are much less likely to be seen by people.

Survey participants reported 378 mortality events that had occurred over a number of years, prior to and during the formal survey period. The earliest recorded death in a swimming pool dated back to the 1980s, however, most recorded deaths were post 2011 (370 recorded deaths were from 2011 or 2012).

FIGURE 6

Reported causes of quenda mortality to the 2012 Community Quenda Survey.



The most commonly reported cause of death was vehicle strike (168 reports, or 44% of mortality events, Figure 6), including three quendas killed by bicycles.

Predation by cats, dogs, foxes or birds accounted for 113 reported quenda deaths (30% of mortality events). The majority of reported predation events (111) were from introduced mammals (cats, dogs or foxes); but one observer reported two cases of predation by whistling kites (*Haliastur sphenurus*). In 46% of cases the observer was confident of the species of predator, but for the balance of reported predation events the identity of the predator was assumed or guessed based on the nature of the kill and/or whether cats, dogs or foxes were regularly seen in the area.

Drowning emerged as a significant cause of mortality, with 62 quendas (16% of mortality events) reported as drowned in swimming pools, fish ponds or drainpipes. Although only two incidents of poisoning were reported (1% of mortality events), one of these from snail baits, there were a significant number of deaths by unknown cause (8%), where there were no obvious signs of predation or vehicle strike. Some of these may have been attributable to toxins. Most commercially available snail and rat baits are toxic to quendas, as is Pindone, a poison sometimes used to control rabbits near built-up areas.

Although not solicited, information on perceived threats was opportunistically collected as many observers volunteered information on issues they believed to be impacting on quenda numbers in their area. Commonly reported perceived threats (in order of frequency) included cats, land clearing for urban development, foxes, traffic and dogs; infrequently reported perceived threats included disease, poison baiting and fire.

6.4 BREEDING

Survey participants reported many instances of breeding. Females with pouch young, young individuals or family groups were reported at 423 of the 1020 sites across the entire survey area of Southwest WA (41%). This does not necessarily indicate a lack of breeding at other sites, as many of the reports were one-off sightings or mortality events such as vehicle strike, where regular observations of the same individuals are not possible. The survey did not canvass whether participants noticed breeding activity outside the formal survey period.

6.5 FEEDING QUENDAS

In about a third (35% or 356) of the sighting reports across the entire Southwest WA survey area, survey participants reported that either they actively fed quendas, or that quendas were seen scavenging non-natural food (dropped food scraps or pet food from bowls).

Unsurprisingly the sites where quendas were either provided with or scavenged non-natural food were almost exclusively in residential or industrial areas, although one observer reported feeding quendas at a bushland site (Ginger Creek Campsite on the Bibbulmun Track). Food provided to quendas included fruit, oats, nuts, pet food, meat, food scraps, and occasionally bread, biscuits and cake. This attraction for quendas may account for the high level of records in residential areas where observers and food availability would facilitate the sighting of quendas that may occur in the general area (see also sections 7.1 and 7.6).

6.6 QUENDA BEHAVIOUR

Information on quenda behaviour was not specifically requested but was frequently volunteered. Observers responding to the survey regularly confirmed others' findings that southern brown bandicoots are frequently active during the day, as well as at night (Paull 2008). Some participants reported quendas living and sometimes even feeding side-by-side with resident cats and dogs. Quendas were frequently reported as stealing pet food from bowls, sometimes even in the presence of the pet.

6.7 PUBLIC RESPONSE TO QUENDA MEDIA CAMPAIGN

The news article in *The West Australian* newspaper (Appendix B) generated by far the most sighting reports for this survey, and local newspapers were the next best way of engaging participants (Table 4). At least 200 observers called to report quenda sightings in the first two days after *The West Australian* article was printed. This newspaper dedicated over a quarter of a page to the story including a large, high quality photo, which in no doubt had considerable influence on the number of responses received and therefore the success of the survey.

Just over a quarter of the participants did not provide any information on where they had heard about the survey, or gave a generalised answer such as 'newspaper' or 'recent ad campaign' that could not be identified to a specific source. Very few survey participants stated that they had heard about the survey via social media.

Demographic information about survey participants was not collected so we cannot identify from this survey which media outlets are more useful for targeting any particular age or social group.

Table 4. Sources of information about the 2012 Community Quenda Survey that led participants to report sightings of quenda.

Where did you hear about the 2012 Community Quenda Survey? (total number = 946)	**Proportion of participants**
The West Australian	41%
Local newspapers	12%
Word of mouth	6%
News websites	5%
Radio interviews	3%
Parks and Wildlife's *Bushland News* newsletter	2%
Unspecified internet sources	2%
Social media (Facebook, Twitter)	1%
Not specified	28%

Online media articles, Facebook posts and Tweets relating to the quenda survey all attracted numerous online responses. Anyone who responded to the survey via Facebook or Twitter, or who responded to online news articles or blogs via the Comments section was asked to provide more information and their contact details to either WWF or Parks and Wildlife via email. Unfortunately very few people then took this additional step, and without this direct contact, these online reports contained insufficient information for the purposes of this study and were not used.

Quendas have frequently been observed feeding from pet food bowls left on the ground. This resourceful animal even managed to gain access to bin of dog food without any assistance.

7. DISCUSSION

The 2012 Community Quenda Survey was highly successful and demonstrated a high level of public interest in this species, with nearly a thousand people contributing to this citizen science exercise. Quenda sighting reports continue to be received by both WWF and Parks and Wildlife at the time of publication. The survey aimed to raise the profile of the quenda in the broader community, and the extensive media coverage it received has no doubt contributed to this end. However, for a small, usually shy and frequently nocturnal mammal, we found that this species was already surprisingly well-known, as evidenced by the huge number of observers who took part. This high level of awareness may have been at least partly created or improved by previous promotional campaigns, including the 1993 survey. The high response rate to both surveys indicates that the quenda is undoubtedly a species of high public interest.

7.1 QUENDA DISTRIBUTION

In both the 2012 and 1993 surveys, quendas were entirely unreported and therefore almost certainly absent from the most established and older suburbs surrounding the city centre. Quenda sightings were also much scarcer in the middle-ring suburbs north of the river compared to south of the river.

The presence of suitable habitat is clearly critical and it is not surprising that quendas are absent from the city centre and innermost suburbs where little or no native vegetation remains. However, in the older parts of the city, quendas have disappeared even from many urban bushland or wetland reserves where suitable habitat persists - including large (but isolated) reserves such as Bold Park, Kings Park and Herdsman Lake. Isolation of populations has been found to be a major threat to medium-sized (body weight 100g – 5000g) mammals such as bandicoots (Friend 1987; Brown & Main 2010). Multiple factors such as predation, fire, loss of habitat quality and vehicle strike may have a synergistic effect on isolated populations, which experience no immigration and ultimately may be driven to local extinction (How & Dell 2000, Abbott 2008, Fitzgibbon *et al.* 2011).

In 2012, quendas were persisting in peri-urban environments where large areas of remnant vegetation and/or wetland or riparian areas were still present and well-connected in the landscape. This is consistent with other studies (*e.g.* Bamford & Bamford 1994; Reaveley 2009). The current study found a significant correlation between high numbers of quenda sightings and the remaining proportion of pre-European native vegetation. Although most quenda sighting reports were received from areas of human habitation, strong habitat connectivity, with abundant native vegetation in the landscape matrix, seems to be a key feature of the landscapes where quendas occur. Areas of natural habitat may be acting as important 'source' populations, from which quendas can re-colonise areas of suitable habitat following local extinction events.

An opportunistic sightings survey of this nature is expected to return more data from places of human habitation or frequent visitation than the less accessible centres of large bushland areas and that was certainly the case with this study. The greater frequency of quenda sightings in gardens, workplaces or on roadsides compared to nature reserves and remnant parks is therefore partially attributed to the fact that people spend more time in these environments. Also, quendas that have become habituated to human company may be more easily observed (especially when accessing artificial food and water sources) than those living in more natural areas. However, it seems probable that where suitable refuge habitat enables quendas to persist in residential and partially-developed industrial areas, the increased food resources and water supplied by gardens and sympathetic human residents are also enabling quendas to live at artificially high densities.

Infrequent sightings in some rural areas where large sections of native vegetation persist (*e.g.* the Shire of Waroona) may indicate a low density of quendas, but may also reflect a lower human population density, and thus fewer potential observers (and lower artificial resource subsidies) in these regions. Limitation of quenda numbers through predation by foxes is also likely to be more important in rural than in built-up areas.

Vegetated road reserves and cycle paths such as those along the Kwinana Freeway and Roe Highway are currently providing quendas with refuge habitat, and may also be enabling them to move between other habitat patches and to access suburban gardens (Chambers & Bencini 2013). The values and concomitant risks of linear corridors to a particular species can be difficult to determine; quendas living

alongside busy roads are obviously at risk from vehicle strike, and narrow strips of vegetation (particularly if degraded or poorly vegetated) may also act as population sinks (poor quality habitat where immigrating animals fail to survive for long) and may facilitate the movement of foxes (Simberloff & Cox 1987, Noss 1987, Saunders & Hobbs 1991). Cats, however, can move easily throughout the urban landscape regardless of the presence of vegetated corridors. For vegetated corridors to be of benefit to quendas, the presence of low, dense vegetation or other refuge habitat is no doubt as critical as it is elsewhere.

7.2 COMPARISON OF QUENDA SIGHTINGS DENSITY IN 2012 AND 1993

As very few quenda sightings were received for the suburbs north of the Swan River in either 2012 or 1993, the density of quenda sightings in 2012 and 1993 was only directly compared for a portion of the survey area that included the suburbs south of the Swan River, down to the LGAs of Serpentine-Jarrahdale and Rockingham.

The spatial patterns in the changes in quenda sighting density between 1993 and 2012 are complex and patchy. Interpretation of the results is limited by differences in survey effort and timing between the two surveys, and by the nature of the data itself (*i.e.* opportunistic sightings largely in the urban and peri-urban environment rather than systematic surveys across a set of different habitats). With these caveats, we believe that the two surveys are still broadly comparable for the area south of the Swan River chosen for direct comparison.

Within this area, two main patterns seem to emerge.

First, quendas appear to have declined in the suburbs southeast of the Perth CBD on the Swan Coastal Plan and foothills of the Darling Scarp, in areas that were already reasonably developed and very fragmented in the early 1990s, and that have been further urbanised in the last two decades. Increasing isolation of habitat patches in these suburbs may have reduced quenda population numbers. These suburbs include Canning Vale, Thornlie and Kenwick (City of Gosnells), Wattle Grove, Forrestfield and Maida Vale (Shire of Kalamunda), Perth Airport and South Guildford (City of Swan) and Boya (Shire of Mundaring).

There were also noticeable declines in quenda sightings in the suburbs of Jandakot, Bibra Lake and Yangebup (City of Cockburn), Hope Valley (City of Kwinana) and Wattleup (City of Cockburn) east of Rockingham Road; where areas of ideal wetland habitat remain but where there has also been considerable clearing and urban residential or industrial development.

Second, quenda sightings have increased between 1993 and 2012 in several suburbs in the Darling Ranges near the Great Eastern Highway – Glen Forrest, Mundaring, Stoneville, and Parkerville – and also in Kalamunda, Gooseberry Hill, Kelmscott and Roleystone. These are generally semi-rural or special rural residential areas that are largely surrounded by native bushland.

Increased numbers of sightings in these hills suburbs may be indicative of two, possibly interacting, scenarios – either quenda abundance has increased and/or human-quenda interaction has increased. Human population density has increased in these escarpment suburbs in the last two decades, without major additional clearing of native vegetation, increasing the number of people available to observe any resident wildlife. It is also possible that human demographics in the hills

suburbs may have changed, resulting in a higher proportion of residents interested in responding to this survey. However, quendas are also taking advantage of artificial feeding, irrigated lawns and gardens, and dense, low vegetation cover and physical structures where they can hide from predators, which may allow them to reach artificially high densities in some suburban environments (Fitzgibbon *et al.* 2011; Hughes and Banks 2010). It is also worth noting that populations of quendas and other medium-sized mammals have recovered (sometimes temporarily) in reserves that receive regular 1080 fox baiting under Parks and Wildlife's Western Shield Program (Orell 2004, Burrows & Christensen 2002, Wayne *et al.* 2011, Morris et al. 2003). Regular 1080 baiting does take place in reserves in the Perth Hills but given the wide buffers between baited areas and residential zones, it is difficult to say whether the Western Shield baiting program has contributed to the apparent quenda population increases in suburban areas indicated by this survey.

By contrast, some areas where there has been significant urbanisation, industrialisation and fragmentation between 1993 and 2012, such as across large parts of the Cities of Cockburn and Kwinana, exhibit no clear pattern, showing minor patchy areas of both increased and decreased quenda sightings over that period. Again, the difficulty of achieving comprehensive survey coverage of a large region via opportunistic sightings-based surveys must be taken into account. However, seemingly paradoxical increases in quenda sightings in areas of recent development and consequent habitat loss may again be due to an increased human population available to observe them. Also, the immediate impacts of habitat loss and fragmentation will result in more animals being seen crossing roads and seeking new habitat after having been displaced from recently cleared habitat. The full impact of the loss and fragmentation of habitat may take time to be revealed (Ewers & Didham 2006) and quendas may disappear from these suburbs in coming years.

Historically considered to be "Still plentiful even near Perth if environment is suitable" (Glauert 1933, p. 22), the quenda's range across what is now the Perth and Peel regions has contracted, particularly on the northern Swan Coastal Plain (Kitchener *et al.* 1978; Friend 1987; How & Dell 2000). It is likely that the quenda will continue to experience local extinctions as urban development continues to replace native bushland across the region.

7.3 MORTALITY AND PERCEIVED THREATS

The Draft National Recovery Plan for the eastern subspecies of the Southern Brown Bandicoot lists the major threats to this species as "continued habitat loss or modification, inappropriate fire regimes, introduced predators, and isolation of populations" (Brown & Main 2010, p. 1).

The survey designers expected vehicle strike and predation from cats, dogs and foxes to be the causes of quenda mortality most frequently reported to this survey of bandicoots in the urban environment, and such was indeed the case. However, the reported causes of mortality do not necessarily indicate the frequency of actual causes of mortality. Animals killed by vehicle strike are far more visible than animals dying from most other causes and it is not surprising that this was the most commonly reported cause of quenda mortality; but it does not necessarily follow that vehicles actually kill more quendas than any other cause of death. It should also be noted that causes of individual mortality are not necessarily threats to the species as a whole. However the high number of quenda road kill events (168) reported to this survey is still concerning.

Many observers reported quendas regularly stealing pet food from bowls and co-existing in gardens with either pet dogs or cats. Nevertheless, predation by cats and dogs (and foxes) was the second most commonly reported cause of quenda mortality. At least one dog owner reported their own pet as having killed more than one quenda. Some of this incongruity may be attributed to differing personalities and prey preferences of individual pets. However, it may be possible for quendas to persist in the presence of introduced predators if there is sufficient low, dense vegetation to provide shelter and refuge (Bamford & Bamford 1994). It must also be remembered that for more than half (54%) of the reported predation events, the identity of the predator was only guessed or suspected based on the visible presence of cats or foxes in the area (in the case of most reported dog predation events, the observer had either witnessed the kill or was confident that the kill had been made by a dog).

Only a small number of quendas were reported to have been poisoned by snail baits or unknown substances. This may be an under-representation of the significance of this threat to quendas as such deaths may have been reported as 'unknown cause', or poisoned animals may seek shelter and die out of sight of humans.

An unexpected finding was that drowning in swimming pools and other artificial structures containing water emerged as a significant cause of quenda deaths. Although quendas are capable of swimming, a smooth-sided pool wall provides no foothold for escape. Encouragingly, some of the survey participants who found drowned quendas took action to prevent it from happening again, by either covering their pool or fencing it with chicken wire; providing a shallow dish of water as an alternative water source; or placing a brick on the top step to allow quendas to climb out to safety.

Along with predation by exotic species, habitat loss is among the ultimate threats to quenda populations because when an area of native bushland is cleared, most resident animals perish (Australian State of the Environment Committee 2006, Johnson *et. al.* 2007, Caughley & Gunn 1996). However it often does not present as the proximate cause of mortality and it is not surprising that it was not reported as such by any survey participants. Nonetheless, many observers voiced concern about impending land clearing for development proposals and the likely impact on the resident quendas in their area. Habitat destruction has been described as probably "the single most important factor in the decline of this species" (Courtenay 1996, p. 14) and the removal of native vegetation for urban development is clearly a major threat to quendas. Between 2002 and 2009, over 10,000 hectares of native vegetation was cleared within the Swan Coastal Plan and Jarrah Forest bioregions of the Perth Metropolitan Region (Perth Biodiversity Project 2010) and more than half of the Local Government Areas of Perth and Peel have less than 10% of their pre-European extent of native vegetation remaining (Perth Biodiversity Project 2011). Habitat fragmentation due to urban developments or roads is also likely to increase fauna exposure to vehicle strike and introduced predators.

Given this species' preference for damp soils and wetland areas, there is an additional threat posed by the expected loss of wetlands due to water abstraction for urban use, a changing climate and predicted ongoing declines in rainfall (Indian Ocean Climate Initiative 2012).

7.4 BREEDING

Breeding was commonly reported during the survey at most sites where quendas were seen regularly (*i.e.* not in 'one off' sightings or mortality incidents). This high frequency with which young were observed is consistent with bandicoots' known high potential reproductive rate, and consequent ability for populations to increase quickly (Paull 2008, Fitzgibbon *et al.* 2011, Bamford & Bamford 1994). This ability may facilitate re-colonisation of unoccupied sites under favourable conditions and given sufficient habitat connectivity, or following a reintroduction.

7.5 PUBLIC ATTITUDES TOWARD QUENDAS

Observers were not asked whether they liked or cared about quendas or why they took part in the survey, but most volunteered an opinion about the species. Apart from a very small handful of observers who complained about quendas digging holes in their lawn ("making a mess"), survey participants' views on quendas were almost universally positive.

Whether or not supplying food to wildlife is beneficial (see section 7.6), the large number of respondents who stated that they feed or supply water to quendas is another clear indication of a positive attitude towards this species and native fauna in general (many observers also supplied food and water to birds and/or other animals).

These results echo those of a 2006 survey of Brisbane residents regarding attitudes to wildlife including bandicoots, in which 85% of residents indicated that they were or would be pleased to know that bandicoots survived near them (Fitzgibbon and Jones 2006).

The survey revealed that some members of the public are undertaking unauthorised quenda translocations. At least two observers volunteered the information that they had caught and moved quendas that they perceived to be a nuisance. There is a need to raise public awareness of the risks of moving animals, particularly as the recipient site may contain unsuitable habitat or be fully occupied. There is also the possibility of fines that may accompany compliance action against unauthorised translocations under WA's *Wildlife Conservation Act 1950*. The Department of Parks and Wildlife has produced a set of translocation guidelines for quendas (Department of Parks and Wildlife, in prep.), providing standard operating procedures for trapping, relocating and the ongoing monitoring of translocated quendas but this is only intended to inform approved translocations by suitably qualified individuals.

7.6 FEEDING QUENDAS

A large number of people are either actively or unintentionally feeding quendas across the survey area, with feeding reported from 35% (356) of all reported sites across Southwest WA.

It appears that quendas living close to humans are frequently supplementing their natural diet with additional food, whether supplied intentionally or unintentionally by people. Access to irrigated lawns and easily available water from pools, sprinklers and water bowls provide additional resources. Dense garden beds and artificial

structures such as sheds, buildings, and wood piles are also serving as shelter and refuge. These resource subsidies may be allowing quenda populations to exist at higher densities in and around urban bushland fragments than in more rural or natural bushland sites; and may be a key factor in enabling this species to persist at all in these highly modified environments. However, living in higher densities may lead to increased parasite loads, and contact with domestic animals can result in quendas acquiring domestic animal parasites that are not otherwise endemic in quenda populations (Dr A. Hillman pers. comm.) though this does not necessarily result in ill-health for either species.

The practice of feeding wildlife is popular and widespread in the general public though often controversial, particularly in Australia (Jones 2011). Artificial feeding of wild animals is regularly associated with both positive impacts (*e.g.* enhanced survival, more frequent breeding, encouraging human empathy for nature) and negative impacts (*e.g.* inappropriate nutrition, increased human/wildlife conflict, creating 'dependency' on handouts). However many claims of either harm or benefit are insufficiently supported by empirical evidence (Orams 2002, Jones & Reynolds 2008). The WA Department of Parks and Wildlife recommends against feeding wildlife and in particular points out that an artificially high density of quendas in one place may lead to more frequent aggressive interactions between these mostly solitary animals (Department of Parks and Wildlife 2013). WWF-Australia does not currently have a specific policy on feeding wild animals. A more detailed examination of the possible negative and positive impacts of feeding quendas and the differences between fed and unfed quenda populations is beyond the scope of this survey but certainly worthy of further investigation.

For the purposes of this survey, feeding quendas was neither actively encouraged nor discouraged, except when observers reported feeding animals with raw meat. Raw meat can be a source of the parasitic protozoan *Toxoplasma gondii* (Dr A. Hillman pers. comm.) and providing it to any wildlife is discouraged. If observers asked what could be done to encourage or support resident quendas, they were advised to maintain low dense vegetation, perhaps provide a shallow dish of drinking water and to consider keeping their cats inside or erecting fencing to contain their dogs. Some additional recommendations for encouraging the persistence of quendas in the urban and peri-urban environment are provided in section 8.2 Management Recommendations.

7.7 USES FOR THE 2012 COMMUNITY QUENDA SURVEY DATA

The GIS shape files produced from the 2012 Community Quenda Survey can be provided on request, and have been made available to the relevant Government agencies involved in land use planning in Western Australia. The data are also available through the Parks and Wildlife NatureMap website (naturemap.dpaw.wa.gov.au) which also includes sightings reported outside of these two survey periods. The incorporation of this data layer can be used to identify and protect areas where quendas are known to occur, and provide guidance on the protection of other bushland areas.

8. RECOMMENDATIONS

8.1 RECOMMENDATIONS FOR FUTURE SURVEYS

The 2012 and 1993 Community Quenda Surveys were effective at collecting information from which broad trends in quenda abundance, distribution and threats to their survival can be obtained. Some recommendations for building on the results of this survey are made below.

In this survey, participants were not asked to actively seek for quendas, but just to report their opportunistic sightings. Future surveys could ask interested, trained individuals to actively search for signs of quendas in under-reported areas, including those suburbs that appear to have experienced a decline in quendas over the last twenty years, and in larger bushland areas. Remote sensor camera traps could be used to confirm quenda presence or otherwise at sites where the animals themselves have not been seen.

A community-based quenda count, similar to the BirdLife Australia Great Cocky Count (*e.g.* Kabat *et al.* 2013), could be set up, allowing for a more rigorous, quantifiable and repeatable method of counting quendas from year to year. WWF and Parks and Wildlife have initiated such a survey, with the first Spring Quenda Count being carried out in 2013 (WWF-Australia and Parks and Wildlife unpublished data).

Future surveys could build on the information collected opportunistically in this survey and address more specific questions regarding perceived threats, quenda behaviour (including interaction with other quendas, pets and people), and community attitudes toward and interactions with quendas and other urban wildlife.

As the main 2012 survey period was over winter, a future survey which focuses on the spring-summer period might yield additional information on behaviour and distribution (although it should also be noted that the southwest of Western Australia experienced below average rainfall in the winter of 2012, including the driest July on record (Bureau of Meteorology 2012)).

A collection of demographic data and information on the motivations of survey participants for taking part might yield useful information to guide the design and communication of future citizen science surveys.

This survey did not attempt to use smartphone applications to collect information, a tool that is becoming popular in citizen science, but did make extensive use of social and online media for publicising the survey. These outlets have become a part of daily life and as such are useful tools for sharing environmental messages with the general public. However, the amount and quality of data that was obtained via these mechanisms was very limited; in fact the majority of responses received via Facebook, Twitter and online news outlets contained insufficient information to be accepted by this survey. For the purposes of this survey, the mainstream print media (and to a lesser extent, radio) was far more effective at generating useable data than social media. This may indicate that an older generation who still buys newspapers may be more likely to take part in a survey of this nature, or it may be a function of the fleeting nature of interactions on social media. Either way, at this point in time the mainstream media is an important tool in the citizen science kit.

8.2 MANAGEMENT RECOMMENDATIONS

Habitat loss for urbanisation and introduced predators are likely to be major drivers of quenda decline in suburban and peri-urban areas (*e.g.* Reaveley 2009). Climate change, water abstraction for urban supply and the consequent transformation and loss of wetland areas are also likely to represent a major future threat for quenda.

Frequent quenda sightings and the quenda's opportunistic approach to living in suburban gardens may create a false sense of security regarding the species' ability to persist in human-dominated landscapes. However, the absence and/or scarcity of sightings in the most consolidated and older suburbs, even in large reserves such as Bold Park and Kings Park, indicate that that the quenda's persistence over time in much of the survey area is not guaranteed.

Some recommendations for state and local governments, developers and residents are provided here to encourage the persistence of quendas in the suburban and peri-urban environment. See also the Victorian *Sub-regional Species Strategy for the Southern Brown Bandicoot (Draft for public consultation)* (Department of Sustainability and Environment 2011) and *Wildlife Notes No. 5: Encouraging Quendas* (Bramwell 1998) for additional recommendations.

State and local governments and land developers

- Wherever possible, retain and protect native vegetation and quenda habitat when making land use planning decisions. Areas suitable for quendas are likely to also support a broader suite of plants and animals, particularly wetland–dependent species, and are likely to become refugia for native species as our climate continues to dry.
- Consider the legislative and social obligations to protect wetland habitat and other groundwater-dependent ecosystems when allocating water abstraction licences.
- Wherever possible, maintain native habitat connectivity. Avoid planning new roads or road upgrades through or adjacent to quenda habitat. Provide fauna underpasses on busy roads such as underground culverts that allow quenda movement between habitat areas. Underpasses should be kept as short as possible and entrances well-vegetated to provide cover. See *Fauna Sensitive Road Design Volume 2 – Preferred Practices* (Queensland Department of Main Roads 2010), and *The Factors Affecting the Use of Fauna Underpasses by Quenda and Bobtail Lizards* (Chambers & Bencini 2013) for more detailed recommendations for best practice fauna crossing design.
- Place conditions on habitat clearing approvals to mitigate the impacts on quendas, and relocate any displaced quendas to an approved alternative location. Parks and Wildlife is in the process of producing guidelines for the relocation of quendas (Department of Parks and Wildlife, in prep.).
- Consider ways to strengthen the Western Australian *Cat Act 2011* to provide improved protection to wildlife. Options could include requiring the confinement of cats to the owner's property or using local government laws to create 24 hour cat curfews or cat-free zones around areas of quenda habitat.

- Work with Parks and Wildlife and local governments to increase and coordinate fox and feral cat control actions in suburban bushland. Consider protecting areas of quenda habitat with ring-lock fencing that allows quendas to pass through but provides protection from domestic dogs.
- Reduce vehicle speed limits and install fauna warning signs on roads exhibiting high numbers of fauna road kill incidents, including quendas, macropods, birds etc.
- Maintain low, dense vegetation in state and local government managed parks and reserves. Manage fire to conserve quenda habitat.
- Increase broad community education about the legal protection of native fauna in Western Australia and the necessity to have a permit to move them.
- Continue broad community education about the benefits of having native fauna, including quendas, in your garden, and the threats to native fauna associated with suburban landscapes.

Residents

- Wherever possible, retain or plant low, dense vegetation to provide shelter for quendas and other ground-dwelling fauna.
- Try to reduce the access of pet dogs and cats to quendas and other wildlife. Some pets don't harass wildlife, but others do. To encourage wildlife, consider ways to keep wild animals safe from your pets such as: keep cats indoors (day and night); if possible, restrict access of dogs and stock to potential habitat areas; and don't allow dogs to run unleashed through bushland or wetland areas.
- Use pool covers to reduce quenda drowning incidents (and evaporative water loss). Place a brick or ramp on the top step to allow quendas to escape from pools or ponds, or exclude them from the pool area altogether using chicken wire or similar to 'quenda-proof' the bottom edge of the pool fence. Provide an alternative source of water such as a shallow dish to encourage quendas to drink more safely.
- Irrigated lawns and exotic weed cover have been found to be attractive to bandicoots (Fitzgibbon *et al.* 2011). Quenda diggings are beneficial to the soil, but if small holes in lawns are considered aesthetically undesirable, try reducing irrigation to the lawn to see if this deters digging, or install low fencing to prevent quendas from accessing the lawn.
- Before removing large areas of weed cover such as watsonia species and veldt grass (*Ehrharta* spp.) from sites where quendas are present, ensure that there is alternative, adjacent low, dense habitat into which the quendas can move.
- Exercise caution when using snail or rat poison, or other toxins around the garden. If quendas are observed in the area, place rat baits at least a metre off the ground. There are Iron EDTA complex-based snail baits that are marketed as 'eco-friendly' and thought to be of lower toxicity to pets and wildlife than the more commonly used methiocarb-based baits, but poisoning is still possible if sufficient baits are consumed. Avoid using snail baits and instead allow the quendas to act as natural snail control agents. If snail baits must be used, try placing baits in cages that will allow access by snails and slugs but not quendas.

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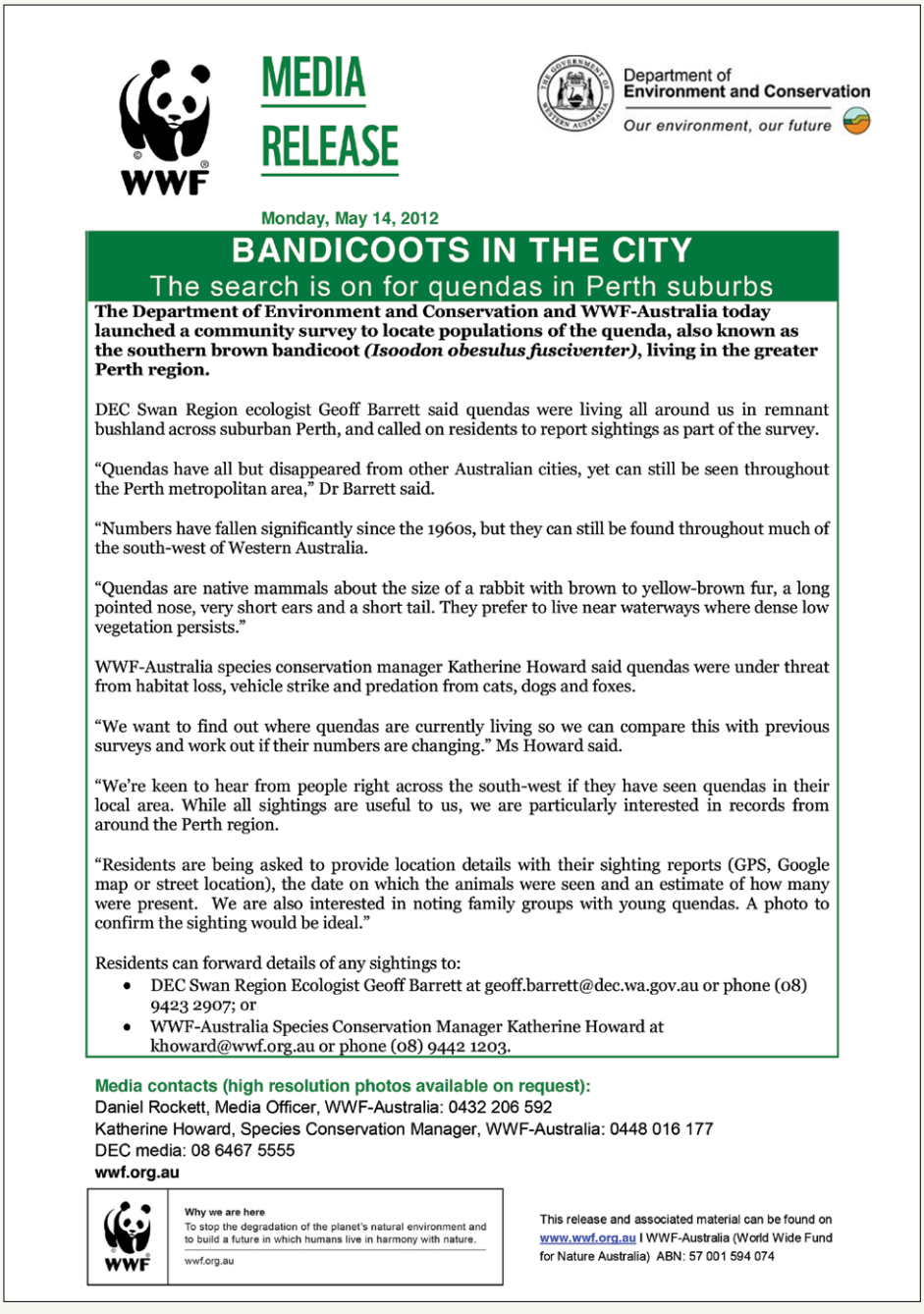
APPENDIX A:

SURVEY LAUNCH MEDIA RELEASE



WWF

MEDIA RELEASE

Department of Environment and Conservation
Our environment, our future

Monday, May 14, 2012

BANDICOOTS IN THE CITY

The search is on for quendas in Perth suburbs

The Department of Environment and Conservation and WWF-Australia today launched a community survey to locate populations of the quenda, also known as the southern brown bandicoot *(Isoodon obesulus fusciventer)*, living in the greater Perth region.

DEC Swan Region ecologist Geoff Barrett said quendas were living all around us in remnant bushland across suburban Perth, and called on residents to report sightings as part of the survey.

"Quendas have all but disappeared from other Australian cities, yet can still be seen throughout the Perth metropolitan area," Dr Barrett said.

"Numbers have fallen significantly since the 1960s, but they can still be found throughout much of the south-west of Western Australia.

"Quendas are native mammals about the size of a rabbit with brown to yellow-brown fur, a long pointed nose, very short ears and a short tail. They prefer to live near waterways where dense low vegetation persists."

WWF-Australia species conservation manager Katherine Howard said quendas were under threat from habitat loss, vehicle strike and predation from cats, dogs and foxes.

"We want to find out where quendas are currently living so we can compare this with previous surveys and work out if their numbers are changing." Ms Howard said.

"We're keen to hear from people right across the south-west if they have seen quendas in their local area. While all sightings are useful to us, we are particularly interested in records from around the Perth region.

"Residents are being asked to provide location details with their sighting reports (GPS, Google map or street location), the date on which the animals were seen and an estimate of how many were present. We are also interested in noting family groups with young quendas. A photo to confirm the sighting would be ideal."

Residents can forward details of any sightings to:

- DEC Swan Region Ecologist Geoff Barrett at geoff.barrett@dec.wa.gov.au or phone (08) 9423 2907; or
- WWF-Australia Species Conservation Manager Katherine Howard at khoward@wwf.org.au or phone (08) 9442 1203.

Media contacts (high resolution photos available on request):
Daniel Rockett, Media Officer, WWF-Australia: 0432 206 592
Katherine Howard, Species Conservation Manager, WWF-Australia: 0448 016 177
DEC media: 08 6467 5555
wwf.org.au

WWF
Why we are here
To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.
wwf.org.au

This release and associated material can be found on www.wwf.org.au I WWF-Australia (World Wide Fund for Nature Australia) ABN: 57 001 594 074

APPENDIX B:

MEDIA COVERAGE OF THE 2012 COMMUNITY QUENDA SURVEY

The 2012 Community Quenda Survey was promoted via articles and interviews in the following outlets. The survey was further extensively promoted on the internet and social media, including the WWF website, Facebook page, blog and Twitter sites, and the Department of Parks and Wildlife website, email network and Facebook page.

Print media

- *The West Australian* article 'Fears for bandicoots as Perth grows' 15.05.12
- *Wanneroo Weekender* editorial 'Keep a lookout for quendas' 31.05.12
- *Joondalup Weekender* editorial 'Keep a lookout for quendas' 31.05.12
- *Stirling Times* article 'Keep a lookout for quendas' 31.05.12
- *Hills Gazette In My Community* online article 'Keep a lookout for quendas' 31.05.12
- *Weekend Courier* (Rockingham) article 'Watch for quendas' 25.05.12
- *Mandurah Coastal Times* article 'Survey launched to determine quenda numbers, locations' 23.05.12
- *Gosnells Examiner* article 'Help DEC with a bandicoot head count' 17.05.12
- *Armidale Examiner* article 'Help DEC with a bandicoot head count' 17.05.12
- *The Echo* (Swan, Mundaring and Kalamunda) article 'Bandicoot sightings flood in' 07.07.12
- Survey respondents also reported seeing a survey-related article in other local newspapers including the *Ellenbrook Advocate*, the *Roleystone Courier*, the *Valley Reporter* and the *Comet*, but these articles were subsequently unable to be found online.

Radio

- 6PR Breakfast program interview 14.05.12
- ABC 720 Radio (Perth) News and Afternoon program 14.05.12
- ABC Radio Northwest (Karratha) News 14.05.12
- ABC Radio South Coast (Albany) interview with Conservation Council of WA representative mentioned the Parks and Wildlife/WWF Quenda Survey 15.05.12
- Curtin FM interview 01.06.12

Online media

- *The West Australian* online article 'Fears for bandicoots as Perth grows' 15.05.12
- Perth Now online article 'Search on for city-dwelling bandicoots' 14.05.12
- news.com.au reproduced Perth Now online article 'Search on for city-dwelling bandicoots' 14.05.12
- ABC online article 'Public asked to report sightings of the quenda' 14.05.12
- Yahoo! News Australia online reproduced ABC online article 'Public asked to report sightings of the quenda' 14.05.12

Newsletters

- *Bushland News,* Department of Environment and Conservation (DEC) Urban Nature program, articles in Issues 79 (Spring 2011), 80 (Summer 2011-2012), and 82 (Winter 2012).
- *Bushland News* articles were also published to provide feedback on results to survey participants after the close of the Community Quenda Survey in Issues 83 (Spring 2012) and 84 (Summer 2012-2013).
- *Quenda News* newsletter to provide feedback on results to survey participants produced by WWF and the Department of Environment and Conservation and distributed to all Community Quenda Survey participants, Issue 1 (January 2013).

West Australian, Perth
15 May 2012, by Daniel Mercer

General News, page 17 - 279.69 cm²
Capital City Daily - circulation 206,776 (MTWTF--)

ID 145992703

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At risk: The southern brown bandicoot population is thought to have declined across Perth. Picture: Ian Munro

Fears for bandicoots as Perth grows

■ **Daniel Mercer**

WA's main environmental agency has launched a survey to track the number of bandicoots living in Perth amid questions over whether the city's growth is reducing their population.

The Department of Environment and Conservation is staging the survey in conjunction with World Wildlife Fund-Australia as part of moves to protect the marsupial.

DEC Swan region ecologist Geoff Barrett said bandicoots, or quendas, had once been prevalent across many parts of Australia but their numbers were thought to be rapidly declining.

Cats were an acute threat to the animals, while urban encroachment was also a significant problem.

WWF species conservation manager Katherine Howard said the survey would compare the results of previous work to see whether there had been changes in the bandicoot population and distribution. "We're keen to hear from people right across the south-west if they have seen quendas in their local area," she said.

Margaret Robinson, the hospital manager at the Kanyana Wildlife Rehabilitation Centre, said it was crucial that authorities knew about the state of the bandicoot population. She said there had been examples in the past where numbers of a native species had declined dramatically.

Anyone who sees one of the animals should call 9442 1203 or email khoward@wwf.org.au.

APPENDIX C:

QUENDA SIGHTINGS BY SUBURB

Lists all sightings reported to this survey, including those outside the Perth and Peel Metropolitan Region that have not been included in some of the detailed analyses.

Table C1: Quenda sightings by suburb – alphabetical

Suburb	No of Sites
Acton Park	1
Albany	8
Anketell	3
Armadale	5
Ashendon	2
Attadale	1
Atwell	2
Baldivis	6
Balingup	2
Banjup	8
Bassendean	1
Bateman	3
Beckenham	1
Bedfordale	24
Beeliar	4
Benger	1
Bertram	4
Bibra Lake	19
Bickley	3
Big Grove	1
Birchmont	1
Bouvard	5
Boya	6
Boyanup	1
Broadwater	1
Bullsbrook	1
Bunbury	5
Bunkers Bay	1
Burns Beach	5
Busselton	4
Byford	11
Canning Vale	26
Capel	2

Suburb	No of Sites
Carabooda	1
Cardup	3
Carmel	5
Casuarina	10
Cervantes	2
Champion Lakes	2
Chidlow	3
Coogee	6
Cooloongup	2
Coolup	2
Darling Downs	1
Darlington	25
Dawesville	6
Dayton	1
Denmark	1
Donnybrook	1
Duncraig	1
Dunsborough	4
Forrestdale	7
Forrestfield	18
Furnissdale	2
Geographe	1
Gidgegannup	1
Glen Forrest	29
Glen Iris	1
Gnangara	4
Golden Bay	3
Gooseberry Hill	50
Gosnells	7
Greenfields	4
Greenmount	5
Guildford	1
Hamersley	2

Table C1: Quenda sightings by suburb – alphabetical (continued)

Suburb	No of Sites
Hammond Park	5
Harrisdale	3
Hazelmere	6
Helena Valley	2
Herne Hill	2
High Wycombe	9
Hovea	5
Huntingdale	2
Iluka	1
Jandakot	16
Jarrahdale	6
Jindalee	1
Joondalup	2
Kalamunda	47
Kalgan	1
Kardinya	2
Karnup	1
Karragullen	3
Kelmscott	40
Kenwick	3
Kewdale	1
Keysbrook	1
Kings Park	1
Kingsley	2
Koongamia	1
Kronkup	1
Kwinana	2
Kwinana Beach	1
Lake Clifton	2
Lakelands	2
Leda	2
Leeming	8
Lesmurdie	28
Little Grove (near Albany)	1
Lower Chittering	1
Lower King	1
Ludlow	1
Maddington	1
Mahogany Creek	4
Maida Vale	15

Suburb	No of Sites
Mandurah	2
Manjimup	3
Mardella	1
Margaret River	5
Martin	3
Medina	2
Melville	2
Midland	1
Millendon	2
Mindarie	2
Molloy Island	1
Morley	1
Mount Barker	1
Mount Bouchon	1
Mount Cooke	2
Mount Helena	11
Mount Nasura	11
Mount Richon	1
Mundaring	41
Mundijong	2
Munster	6
Murdoch	11
Nambeelup	1
Nannup	1
Naval Base	1
Nirimba	1
Noranda	2
North Lake	4
Oakford	9
Oldbury	3
Orange Grove	6
Palmyra	1
Parkerville	18
Parmelia	3
Peppermint Grove Beach	3
Perth Airport	4
Piara Waters	1
Pickering Brook	2
Pinjarra	3
Point Grey	1

Table C1: Quenda sightings by suburb – alphabetical (continued)

Suburb	No of Sites
Port Albany	1
Port Geographe	1
Port Kennedy	4
Quindalup	1
Red Hill	1
Redcliffe	1
Roleystone	96
Ruabon	2
Safety Bay	1
Sawyers Valley	7
Secret Harbour	2
Serpentine	1
Shenton Park	1
Singleton	1
South Guildford	3
South Lake	3
South Yunderup	1
Southern River	5
Spearwood	3
Stake Hill	1
Stoneville	17
Success	9

Suburb	No of Sites
Swan View	2
The Vines	6
Thornlie	1
Two Rocks	1
Upper Swan	2
Walpole	1
Wandi	6
Wanneroo	1
Warnbro	3
Waroona	1
Wattle Grove	8
Wattleup	6
Wellard	18
Welshpool	1
Willetton	4
Winthrop	1
Wonnerup	1
Woodbridge	1
Yanchep	1
Yangebup	4
Yarloop	1
Total	**1020**

Note: Appendix C tabulates the quenda sighting reports against the suburbs as they were named by the observers. Subsequent GIS analysis indicated that a small number of sites were actually within the boundaries of adjacent suburbs and/or Local Government Areas.

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Access to additional food and water in suburban and peri-urban environments may allow quendas to exist at unusually high densities.

Table C2: Quenda sightings by suburb – most to least sightings

Suburb	No of Sites
Roleystone	96
Gooseberry Hill	50
Kalamunda	47
Mundaring	41
Kelmscott	40
Glen Forrest	29
Lesmurdie	28
Canning Vale	26
Darlington	25
Bedfordale	24
Bibra Lake	19
Forrestfield	18
Parkerville	18
Wellard	18
Stoneville	17

Suburb	No of Sites
Jandakot	16
Maida Vale	15
Byford	11
Mount Helena	11
Mount Nasura	11
Murdoch	11
Casuarina	10
High Wycombe	9
Oakford	9
Success	9
Albany	8
Banjup	8
Leeming	8
Wattle Grove	8
Forrestdale	7

Table C2: Quenda sightings by suburb – most to least sightings (continued)

Suburb	No of Sites
Gosnells	7
Sawyers Valley	7
Baldivis	6
Boya	6
Coogee	6
Dawesville	6
Hazelmere	6
Jarrahdale	6
Munster	6
Orange Grove	6
The Vines	6
Wandi	6
Wattleup	6
Armadale	5
Bouvard	5
Bunbury	5
Burns Beach	5
Carmel	5
Greenmount	5
Hammond Park	5
Hovea	5
Margaret River	5
Southern River	5
Beeliar	4
Bertram	4
Busselton	4
Dunsborough	4
Gnangara	4
Greenfields	4
Mahogany Creek	4
North Lake	4
Perth Airport	4
Port Kennedy	4
Willetton	4
Yangebup	4
Anketell	3

Suburb	No of Sites
Bateman	3
Bickley	3
Cardup	3
Chidlow	3
Golden Bay	3
Harrisdale	3
Karragullen	3
Kenwick	3
Manjimup	3
Martin	3
Oldbury	3
Parmelia	3
Peppermint Grove Beach	3
Pinjarra	3
South Guildford	3
South Lake	3
Spearwood	3
Warnbro	3
Ashendon	2
Atwell	2
Balingup	2
Capel	2
Cervantes	2
Champion Lakes	2
Cooloongup	2
Coolup	2
Furnissdale	2
Hamersley	2
Helena Valley	2
Herne Hill	2
Huntingdale	2
Joondalup	2
Kardinya	2
Kingsley	2
Kwinana	2
Lake Clifton	2

Table C2: Quenda sightings by suburb – most to least sightings (continued)

Suburb	No of Sites
Lakelands	2
Leda	2
Mandurah	2
Medina	2
Melville	2
Millendon	2
Mindarie	2
Mount Cooke	2
Mundijong	2
Noranda	2
Pickering Brook	2
Ruabon	2
Secret Harbour	2
Swan View	2
Upper Swan	2
Acton Park	1
Attadale	1
Bassendean	1
Beckenham	1
Benger	1
Big Grove	1
Birchmont	1
Boyanup	1
Broadwater	1
Bullsbrook	1
Bunkers Bay	1
Carabooda	1
Darling Downs	1
Dayton	1
Denmark	1
Donnybrook	1
Duncraig	1
Geographe	1
Gidgegannup	1
Glen Iris	1
Guildford	1

Suburb	No of Sites
Iluka	1
Jindalee	1
Kalgan	1
Karnup	1
Kewdale	1
Keysbrook	1
Kings Park	1
Koongamia	1
Kronkup	1
Kwinana Beach	1
Little Grove (near Albany)	1
Lower Chittering	1
Lower King	1
Ludlow	1
Maddington	1
Mardella	1
Midland	1
Molloy Island	1
Morley	1
Mount Barker	1
Mount Bouchon	1
Mount Richon	1
Nambeelup	1
Nannup	1
Naval Base	1
Nirimba	1
Palmyra	1
Piara Waters	1
Point Grey	1
Port Albany	1
Port Geographe	1
Quindalup	1
Red Hill	1
Redcliffe	1
Safety Bay	1
Serpentine	1

Table C2: Quenda sightings by suburb – most to least sightings (continued)

Suburb	No of Sites
Shenton Park	1
Singleton	1
South Yunderup	1
Stake Hill	1
Thornlie	1
Two Rocks	1
Walpole	1
Wanneroo	1
Waroona	1
Welshpool	1
Winthrop	1
Wonnerup	1
Woodbridge	1
Yanchep	1
Yarloop	1
Total	**1020**

Note: Appendix C tabulates the quenda sighting reports against the suburbs as they were named by the observers. Subsequent GIS analysis indicated that a small number of sites were actually within the boundaries of adjacent suburbs and/or Local Government Areas.

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