Monitoring bilby (*Macrotis lagotis*) at Matuwa (Lorna Glen) using observers on horseback

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Summary
The distribution of bilbies on the Australian continent has contracted significantly since European settlement and they are thought to be extinct from the Gascoyne-Murchison region. The species is listed 'Vulnerable' under the Wildlife Conservation Act (WA) and the Environment Protection and Biodiversity Conservation Act (Commonwealth). As part of Rangelands Restoration and following aerial baiting using Eradicat®, 128 captive-bred bilbies were reintroduced to Matuwa (Lorna Glen) over the period 2007 to 2009. Matuwa is near the southern extent of the contemporary range of the species, but they were locally extinct on Matuwa prior to their reintroduction. Monitoring the bilbies is essential to evaluate the success of the reintroduction. Following a large scale survey of signs of their activity by 6 volunteer observers on horseback in May 2012, a second survey was carried out over the period 13-17 July 2015. A total of 443.6 horse km was ridden in four surveys cells, or paddocks, each 8,000-9,000 ha. Over four days, observers visually inspected ~1,242 ha of ground, and recorded a total of 196 discrete observations of bilby burrows and diggings.

The key findings are that bilbies are persisting at Matuwa and their range has expanded since their reintroduction some eight years ago. Based on a number of assumptions explicit in this report, we estimate the bilby population on Matuwa to be about 312 animals but it could range from 234 to 390 animals. As noted in the 2012 survey, further research is needed to link activity, especially number of burrows, with population to provide a more accurate population estimate using this survey technique (burrows). It is encouraging that since the reintroductions, and based on some assumptions, the free ranging population of bilbies has more than doubled. In suitable habitat (especially Bullimore, Lorna and Sodary land systems) the total density of burrows (fresh and old) is consistently around 1 burrow ~25 ha^{-1} , and a fresh burrow every ~42 ha. On Matuwa, there are about ~106,000 ha of suitable bilby habitat which, if fully occupied and in the absence of excessive predation, we estimate could sustain a potential population of about 500 animals.

Aside from improved visibility after fire, it was noticeable that bilby digging activity was highest in recently burnt areas (Gravel cell), suggesting high food availability following post-fire vegetation regrowth. Together with introduced predator control, maintaining a patch-burn mosaic is likely to be beneficial for bilby populations.

Background
Rangelands Restoration is a long term program to restore biodiversity and ecosystem health and function to former pastoral leases in the northern Goldfields. The program is currently focused on the ex-pastoral lease Lorna Glen (Matuwa), which is owned by the Wiluna Martu Aboriginal Community and managed in partnership with the Department of Parks and Wildlife. The re-introduction of bilbies to Matuwa is part of a long term program to re-establish 11 locally extinct native mammals. Over the period 2007-2009, some 128 captive-bred bilbies were re-introduced to various locations on Lorna Glen (see Pertuisel 2010). According to the Translocation Proposal (TP), criteria for successful reintroduction of bilbies are as follows:

- Better than 60% survival by 30 November 2007.
- Body weight of survivors has been maintained or increased by 30 November 2007.
- The appearance of pouch young known to have been conceived at Lorna Glen by March 2008.
- The appearance of new, unmarked Bilbies in the population.
- The successful expansion of Bilbies into large areas of suitable habitat after 18 months.
- An estimated population > 200 by August 2010.

In order to determine whether these criteria are satisfied, and to determine the fate of bilbies on Matuwa, it has been, and continues to be, necessary to carry out systematic surveys. Initially, monitoring by radio-tagging and some associated trapping provided some information against some of the success criteria. However, animals are no longer being radio-tagged and they are difficult to trap. Recently, DNA extracted from scats is being used to estimate the bilby population.

In order to comply with the TP and to know whether or not success criteria are met, it is essential that bilbies continue to be monitored. Basically, it is necessary to know whether their numbers are trending up, down, or are stable, and where they have dispersed to. Because of their mostly solitary nature, low density and high mobility (so-called 'nomadic' habit), monitoring their numbers and distribution is problematic. Trapping is time consuming and ineffective unless we know exactly where the animals are and which burrows they are in, so monitoring will depend on indirect measures, such as recording tracks, burrows, scats and diggings, and DNA analysis.

A small trial using observers on horseback was carried out in March 2011 (Burrows *et al*. 2012) when some 25 km of transect was assessed in the immediate vicinity of the original bilby release site. This trial demonstrated that using horses as a means of transport to survey for bilbies offered many advantages over other techniques. These included:

- Horses are much softer and quieter on country than ATVs (quad bikes) or 4WDs – machines which, to varying degrees, damage / crush the vegetation and the soil, damaging the important cryptogamic crusts. On fragile arid zone soils, just one pass by a machine leaves tracks / impressions that are visible for decades. Repeated surveys along the same transects by quads will result in significant environmental damage as well as visual scarring. Horse tracks virtually obliterate after a downpour of rain.
- Horses can go where quads and other machines can't – for example, through thick scrub and spinifex, dense mulga groves, areas of dead and downed timber, steep creek crossings, steep and scrubby sand dunes and across recently burnt spinifex. It is perilous (and damaging) taking quads (and other vehicles) across recently burnt spinifex for fear of puncturing tyres. Horses can push through scrub whereas quad bikes need to make often long detours.
- Horses are faster and more durable than people on foot – they can walk almost twice the speed of a person and can walk considerably longer distances and for a longer time.
- A horseback observer can pay attention to observing, rather than driving a machine to avoid obstacles. Horses pick their way through, over and around obstacles.
- Horses provide an excellent observation platform; an observer on horseback is considerably higher than one on foot or on a quad bike. For example, the eye-level of a person on an average sized horse (15hh) is ~2.4m above ground, compared with ~1.2m for a person on a quad bike or ~1.6m for a person on foot. Above ground observation height is particularly important in thick scrub and spinifex with tall, dense seed heads.

Following the trial in 2011, a full scale survey was carried out in May 2012. See Burrows *et al*. (2012) for details, but in summary, 6 volunteer observers on horseback covered a total of 545 horse km in four surveys cells/paddocks, each ~9,000 ha. Over four days, observers visually inspected 1,576 ha of ground, and recorded a total of 247 observations of burrows, and diggings, including 74 bilby burrows. With some modification (see below) the survey was repeated in July 2015.

Method

Six horses were floated to Matuwa specifically for the survey and were stabled in the old cattle yards near the homestead. All of the accompanying riders and a logistics support person (Errol Thoomes) were DPaW registered volunteers. Prior to the commencement of the survey, observers were briefed on the project, the purpose of the survey and on safety

including scheduled radio calls. Line 1 (Gravel cell) was used as a training exercise to ensure observes were able to consistently recognize bilby burrows and digs, echidna digs, and cat and dog and footprints. Each team of two observers carried a first aid kit, GPS, spare batteries, compass, maps, food and water and a VHF radio. A SAR watch was established and observers radioed a base station once they had reached predetermined points along the transects.

Four large cells, or paddocks, each about 9,000 ha (~10 km x 9 km) were identified for the 2015 survey (Figure 1). Two of these cells (Bucktin and Desert) were surveyed in 2012 but rather than re-survey Christmas Creek and Spinifex cells, cells further to the west and north-west of the original release sites were chosen for the 2015 survey being Gravel and Lasseter (Figure 1). It was known that bilbies were persisting in the Christmas Creek and Spinifex cells (the reintroduction area being in Spinifex cell) but it was important to see if a) they were still present in Bucktin and Desert cells and b) if they had spread west and north to Gravel and Lasseter cells, both of which comprised mostly of the Bullimore landsystem (sand plains and occasional dune fields). In a separate survey, the Christmas Creek cell was surveyed using quad bikes in 2015 (Colleen Sims) and these data have been included in this report.

In 2012, six line transects in each of 4 cells were surveyed, but for the 2015 survey, only 4 line transects per cell were surveyed (except for Gravel; three lines surveyed). Lines that were unlikely to contain bilby habitat, in particular lines dominated by open hard stony country, were dropped from the survey as previous experience had revealed a low likelihood of detecting bilby activity on these substrates. Instead, additional effort by way of an additional observer on horseback was placed on surveying potential bilby habitat (softer/sandy substrates). As with the 2012 survey, each transect was about 8.5-9 km long and about 1.43 km apart. For each cell, two teams of three observers traversed two transects by riding 8.5-9 km off a base line track into the bush along the first transect, then turning 90^{o} and riding for ~1.43 km, before turning 90^{o} and riding out along the second transect and back to the baseline track. The start and finish points of the transects were pre-loaded as weigh points into a wrist-mounted Garmin ForeTrex GPS, which was used to navigate along the transects and record the actual travel route, distance, speed and travel time. While the straight-line distance of each transect was 8.5-9 km, observers rode up to 11% further due to the need to avoid obstacles and to ride off heading to inspect a burrow or a track. It was also noted by observers that occasionally the electronic compass was not particularly stable, resulting in deviations and corrections *en route.* On the first day of the survey, only three horses and riders were on site (others arrived the following day), so two observers on quad bikes were used to complement the survey of this cell (Gravel). Line 1 of Gravel cell was also used as a 'training line', with three horse-mounted observers and two observers on quad bikes working together to ensure standardised recording of observations.

Three horse-back observers making up a team rode about ~20 m apart and recorded observations ~20 m either side of each observer, giving a total visual sample swathe of about 80 m per team. Perfect formation could not be held by the team due to obstacles that had to be detoured etc., but over-all, this sample width was about the average. This gave an average visual sample swathe of ~80,000 m^2 km^{-1} of transect or ~72 ha of land area visually inspected per transect. While the main target was signs of bilby activity (burrows, digs, foot prints, scats), signs of activity of other animals, including cat, dog, echidna and rabbit were also recorded.

These data were supplemented by data collected by Colleen Sims and Mark Blythman who carried out a survey in the Christmas Creek cell in 2015.

Bilby digs and burrows were categorized as fresh (recently used), or old (not recently used). Approximating the time since a burrow was last used requires interpreting and making a judgement on the 'freshness' of signs of tracks in the soil and sometimes scats and diggings

(digs) in and around the burrow entrance. Fresh foot prints in red sandy loam soil are sharp, crisp and clear and the surface soil colour of a track is often slightly lighter or 'glossier' than the surrounding undisturbed soil. The soil of fresh tracks is usually more friable or looser than that of older tracks. Older tracks loose detail and clarity, or appear blurred, and soil colour and consistency of the track is similar to the surrounding undisturbed soil. The rate of 'weathering' of animal tracks and digs is a function of time and of elements such as wind and rain. Very recent, or fresh tracks and very old, weathered tracks are usually obvious to most observers, but only experienced observers are able to reliably estimate the age of tracks (in days).

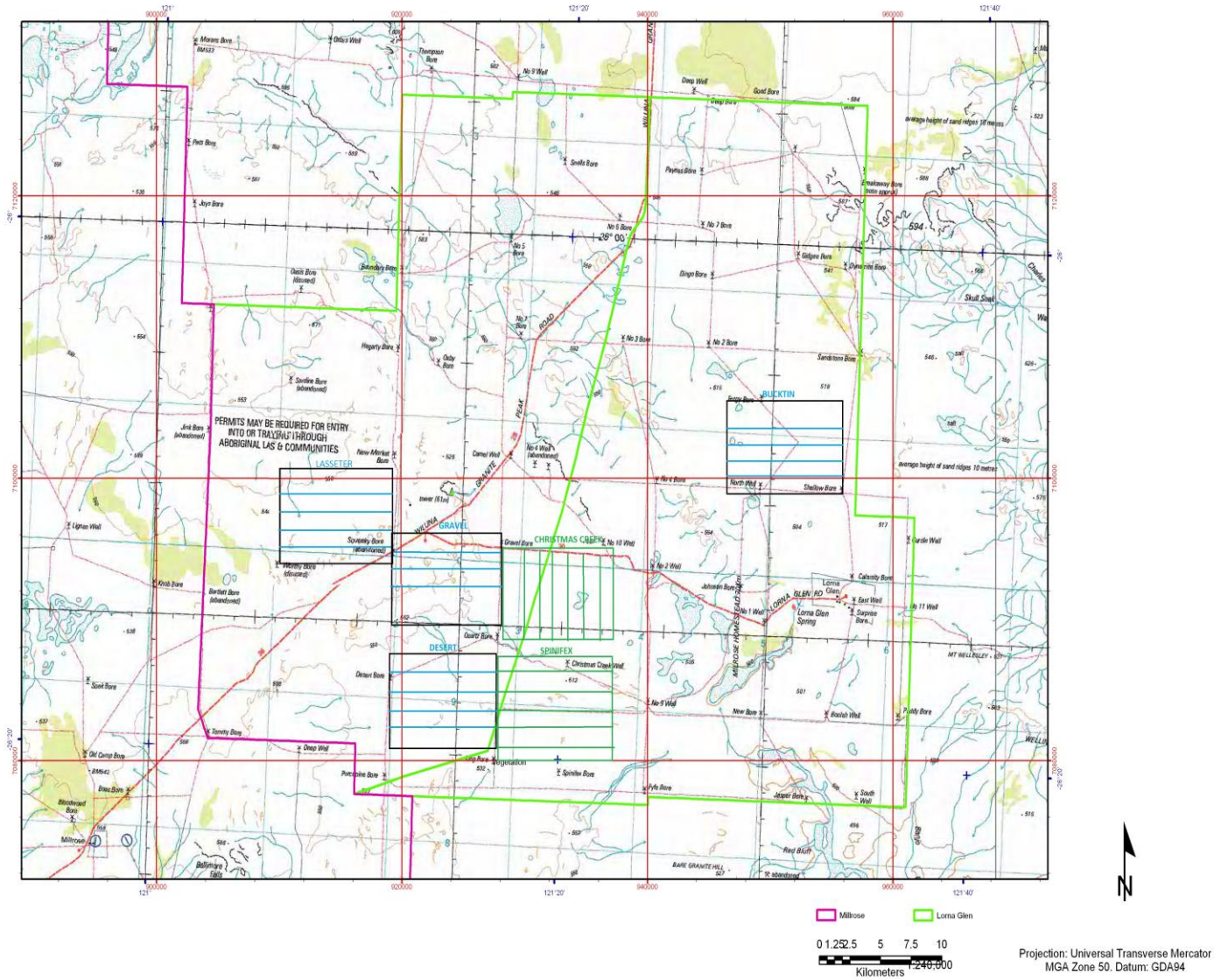


Figure 1: Bilby survey cells (paddocks) on Matuwa (Lorna Glen); lines approximate survey transects within the cells. Spinifex, Desert, Christmas Creek and Bucktin were surveyed using observers on horseback in 2012 and Lasseter, Desert, Gravel and Bucktin were surveyed in 2015. The Christmas Creek cell was re-surveyed in 2015 using quad bikes (Colleen Sims and Mark Blythman – see Figure 3a below). Bilby burrows were detected in all cells.

Plate 1: Observers set out on a transect in Bucktin paddock in search of signs of bilbies.

Fresh burrows were those that had signs of being used very recently, most likely in the last 2-4 days. Old, or not recently used burrows were those that were structurally sound with no weathering or other signs of deterioration or decay, but had the appearance of not having been used recently, within the last 2-4 days, and certainly since the last significant rain (22 days prior to the commencement of the survey; note – 1.3 mm of rain fell on 14th and 15th July - during the survey). All tracks and other signs of activity of interest were marked and stored on a GPS and hand written notes were made about the observation. While bilby burrows were generally obvious, on occasions, it was difficult to determine the animal responsible for diggings or other soil disturbance especially if they were 'old'. Occasionally it was difficult to discriminate between old echidna and bilby digs and between old bilby and varanid digs.

Results & Discussion

The total distance travelled on horseback was ~443.6 horse km and the total area visually checked was ~1,242 ha. Total moving time per observer was 24.4 h, or about 6.1 h per survey cell including travel time. The average time to complete a survey cell, including stops, was 6.58 h and average moving speed was 5.6 km/h. While the survey transects are mapped as straight lines in Figure 1 above, the actual track taken by observers was not always a straight line, as explained above and demonstrated in Figures 2 & 3. A summary of observations of bilby activity made for all survey cells is contained in Table 1.

Table 1: Summary of bilby activity recorded in each survey paddock (cell) by observers on horseback.

Bilby activity	Gravel Cell (GR) *2 survey lines (144 ha) in ~6,000 ha bilby habitat		Lasseter Cell (LA) 4 survey lines (288 ha) in ~7000 ha bilby habitat		Desert Cell (DE) 4 survey lines surveyed (288 ha) in ~9,000 ha of bilby habitat		Bucktin Cell (BU) 4 survey lines (288 ha) in ~8,000 ha of bilby habitat		TOTAL ACTIVITY
	Actual	Per ha	Actual	Per ha	Actual	Per ha	Actual	Per ha	
Bilby burrows fresh	6	0.0416	10	0.0347	8	0.0277	6	0.0208	30
Bilby burrows old	5	0.0347	2	0.0069	2	0.0069	11	0.0381	20
Bilby digs fresh	19	0.1319	18	0.0625	24	0.0833	20	0.0694	81
Bilby digs old	13	0.0902	2	0.0069	11	0.0381	39	0.1354	65
TOTAL ACTIVITY	43	0.2986	32	0.1111	45	0.1562	76	0.2638	196

**Note: Three lines were surveyed in Gravel, but the third line was mostly through the Sherwood (stony) land system so was excluded from analysis.*

Plates 2 & 3: Bilby burrow (L) and dig, Gravel cell. Patches of intense, fresh digging activity were found in recently burnt areas of Gravel cell.

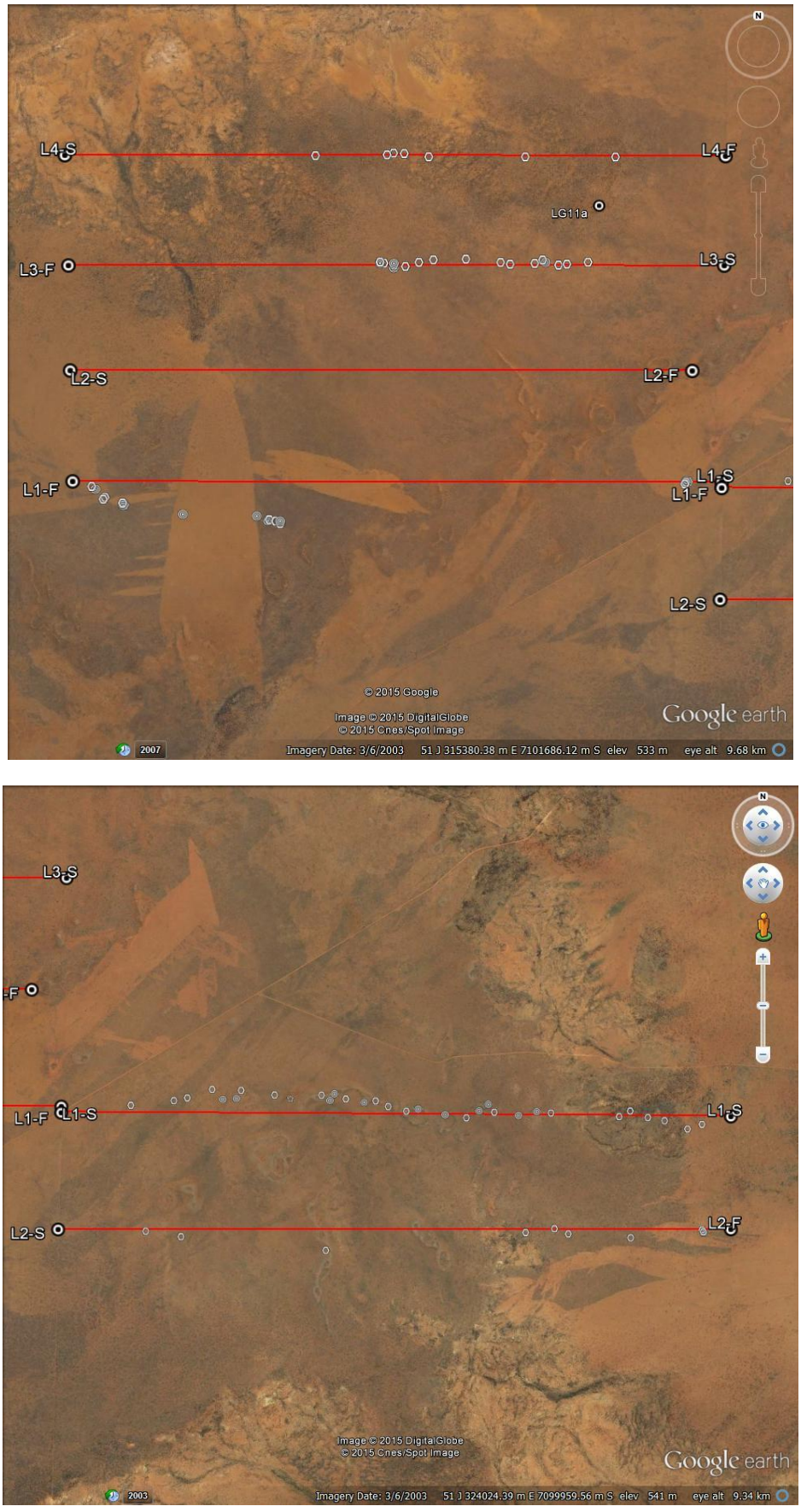
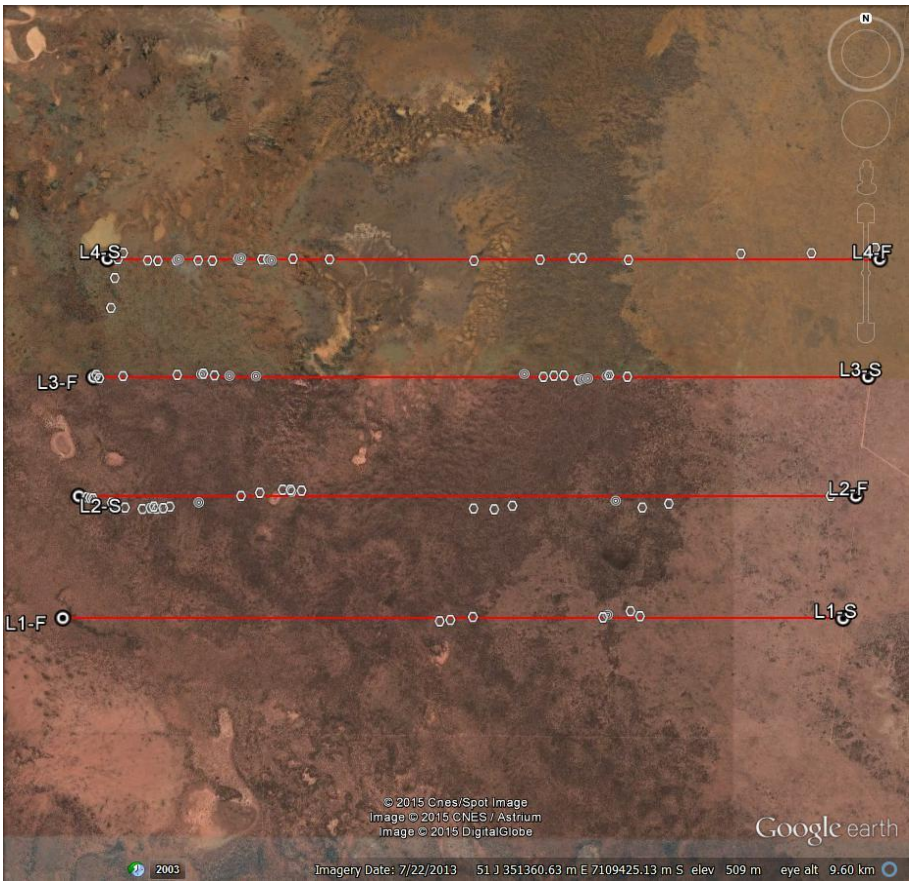


Figure 2: Bilby activity recorded along survey transects in Lasseter (top) and Gravel cells (hexagon=digs, concentric=burrows). Gravel was burnt by wildfire in November 2014.



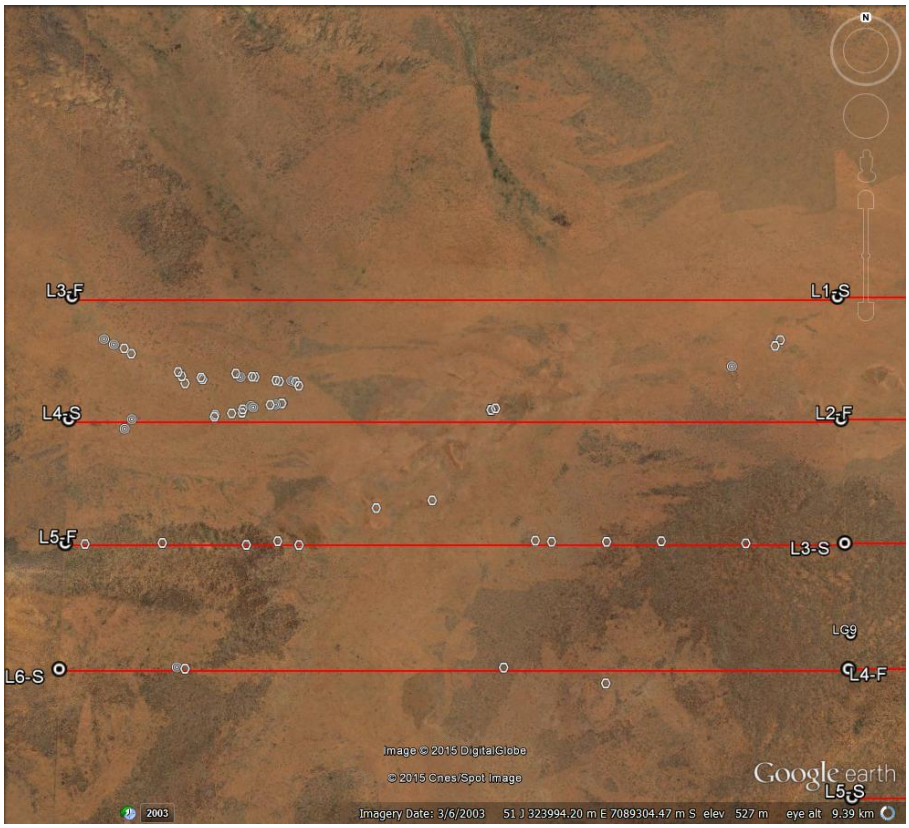


Figure 3: Bilby activity recorded along survey transects in Bucktin (top) and Desert cells (hexagon=digs, concentric=burrows). Note navigation issues on Lines 3&4!

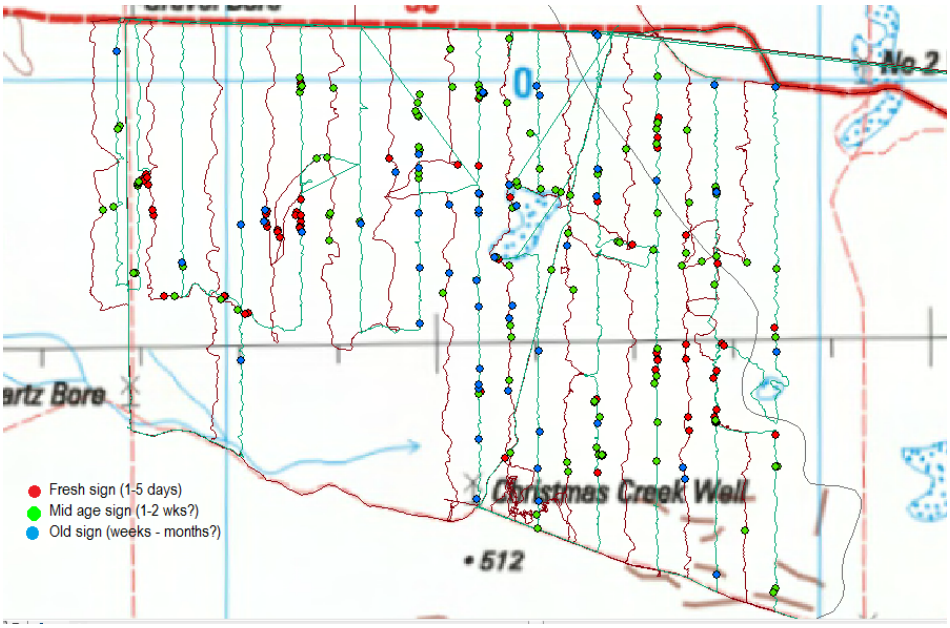


Figure 3a: Bilby activity data from a quad bike survey in Christmas Creek cell carried out in 2015 (courtesy Colleen Sims).

Of a total of 50 bilby burrows detected from the horseback survey, 60% were classified as 'fresh' and 40% were classified as 'old' (Table 1). In 2012, a total of 74 bilby burrows were detected; 38% were classified as fresh and 62% as old, a reverse of the 2015 survey ratio. Overall, the number of detected burrows was down by ~32% in 2015 compared with 2012, but this was in part due to the reduced sample area/survey effort in 2015. In 2012, a total of ~545 horse km was surveyed and observers visually inspected ~1,576 ha of ground. In 2015, ~443 horse km was surveyed equating to a total area visually inspected of ~1,242 ha. Therefore, ~21% of the reduction in the number of bilby burrows detected in 2015 was due to reduced sample effort, resulting in a net estimated reduction in bilby burrow detections (old and fresh) from 2012 to 2015 of ~11%, which, given the technique, is considered not significant.

Overall, the density of burrows per unit area was similar for the two survey periods. Assuming the transects were representative of the broader landscape within the survey cells, in 2015 there was a bilby burrow (old or fresh) approximately every 25 ha, compared with a burrow every ~21 ha in 2012. This equates to ~1,200 burrows (old and fresh) in ~30,000 ha of suitable habitat (Bullimore, Lorna, Sodary land systems – sandy loam substrate), in the cells surveyed. Of these, about 60% (~720) are estimated to have been recently used, equating to a fresh burrow every ~42 ha.

Two cells that were surveyed in 2012, Christmas Creek and Spinifex, were not surveyed from horseback in 2015 because a) it is known that bilbies occur in these cells and b) the Christmas Creek cell was surveyed by quad bike in 2015 (Colleen Sims). An objective of the horseback survey was to determine the extent of dispersal of the bilbies from the release sites and as we only had time to survey 4 cells, we decided to re-survey two cells and survey two new cells for bilby presence. A comparison of the three cells assessed in 2012 and in 2015 (Desert, Bucktin and Christmas Creek) revealed that the total number of burrows (fresh and old) recorded in the Desert and Bucktin cells was similar for both survey periods, however the proportion of fresh verses old burrows changed. In Desert cell in 2012, 70% of burrows observed were fresh and this increased to 80% in 2015 (not a significant difference). In Bucktin, 72% of burrows were fresh in 2012, but only 35% were fresh in 2015 (Figure 4), suggesting a decline in the population in this cell over the sample period.

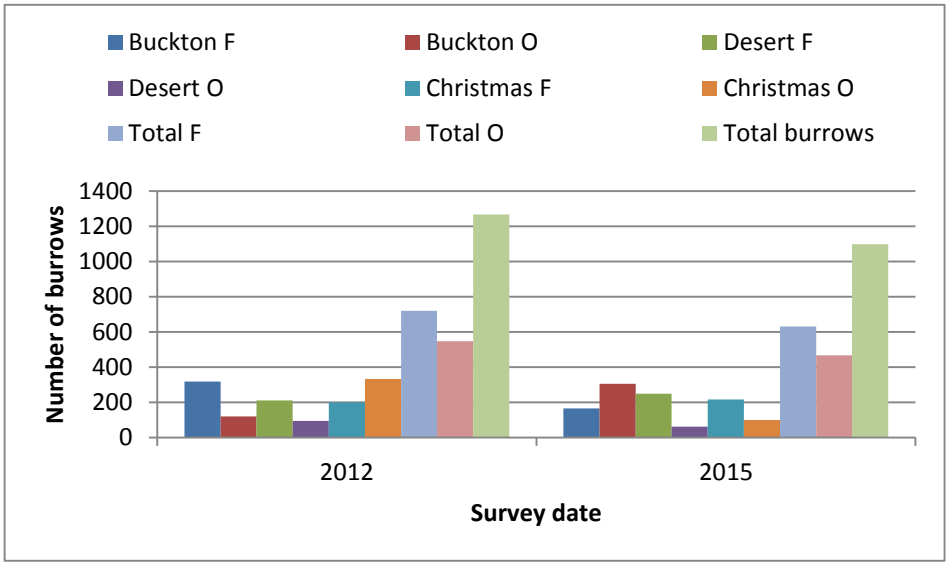


Figure 4: A comparison of the number of bilby burrows (fresh - F and old - O) based on horseback surveys in Bucktin, Desert and Christmas Creek cells in 2012, in Bucktin and Desert in 2015, and on a quad bike survey in the Christmas Creek cell in 2015 (courtesy Colleen Sims).

The number of fresh burrows recorded in the Christmas Creek cell was similar for both survey periods, but the total number of burrows had decreased by ~40% by 2015. In 2012, the proportion of fresh burrows in Christmas Creek cell was 37%, but this increased to 68% in 2015.

In Gravel cell, which was burnt by wildfire in November 2014, there is an indication from the survey data that the fire may have had a beneficial effect on the bilby population with the frequency of digging activity in this cell being higher than other cells (Table 1). This contrasts with the 2015 Christmas Creek quad bike survey which shows higher bilby burrow density in the longer unburnt vegetation (Table 2). A possible explanation is that bilbies prefer to burrow in the cover of spinifex/vegetation, but prefer to forage in recently burnt areas. It is known that seed from fire ephemeral plants such as *Yakirra australiense,* which occurs through much of central and northern Western Australia including on Matuwa, can form an important part of the diet of the bilby. *Yakirra* production is enhanced by late spring fires followed by good rainfall (Southgate and Carthew 2008). The virtual absence of foxes and reduced numbers of feral cats resulting from the on-going baiting program likely reduced predation pressure on bilbies once the vegetation cover was removed by fire. In the absence of predator control, it is likely that following fire, bilbies and other mammals are increasingly exposed to predation.

Plate 4: Seed of the fire ephemeral Yakirra australiensis can form an important part of bilby diet (photo courtesy Florabase, the Western Australian Herbarium)

Plate 5: Gravel cell was burnt by wildfire in November 2014. Bilby digging activity was highest in this cell.

Data provided by Colleen Sims following a quad bike survey in the Christmas Creek cell in 2015 is shown in Table 2 below. These data show that this cell still contains a high level of bilby activity and based on this, supports a relatively high bilby population. The density of burrows in the older vegetation (burnt 2002) is considerably higher than the recently burnt vegetation. Overall, the density of fresh burrows is about one burrow 37 ha^{-1}, and total burrow density is one burrow 25.5 ha^{-1}. These figures are very similar to those derived from the horseback survey in other cells, being one fresh burrow 42 ha^{-1} and a total burrow density of one burrow ~25 ha^{-1}.

Table 2: Survey data for Christmas Creek cell based on a quad bike survey in 2015 (data courtesy Colleen Sims). Burrow density is similar to that recorded by horseback surveys in other cells.

	Transect length (km)	Estimated average detection distance from line (m)	Estimated total area surveyed (ha)	No. fresh burrows	No. Mid age (1-2 wks) burrows	No. Old (>2weeks) burrows	Approx. fresh burrow density (ha^{-1})
Burnt spring 2014	55	50 m (100m wide)	550	9	2	7	61
Burnt summer 2002	114	5m (10m wide)	114	9	8	20	13
Total	169		664	18	10	27	37

An estimate of the bilby population in the cells surveyed is provided in Table 3 based on the assumptions below. These data are also graphed in Figure 5, which shows an estimate of the bilby population changes based on the 2012 and 2015 surveys. Three population estimates are made; the first is based only on the number of fresh burrows recorded, the second estimate is based on all burrows recorded and the third is based on the mean of these figures. In calculating this estimate, the following assumptions were made:

1. The density of bilby burrows derived from the sampled transects is the same as the density throughout the estimated habitable area of each cell (Table 3). That is, the survey sample is a reliable estimate of the broader habitable landscape in the cell.
2. On average, there are 5 burrows per bilby.

3. The density of bilbies in the Spinifex cell, which was surveyed in 2012 but not in 2015, has not significantly changed between surveys, as was the case for the nearby Desert cell.
4. There are no other bilby populations on Matuwa (although there is anecdotal evidence of bilbies beyond the survey cells).

Based on these assumptions, the current bilby population is probably between 234 (based on fresh burrows) and 390 (based on all burrows) (mean = 312) (Figure 5). This compares with a known (founder) population of 128 in 2009, and an estimated population of 128 -339 (mean=233) animals in 2012. This represents an increase of ~33% in 3 years and an overall increase of ~143% since bilbies were reintroduced in 2009 (based on the mean population estimate). As there may be other populations not surveyed, this could be an under-estimate of the total population on Matuwa.

*Table 3: Summary of area of suitable bilby habitat in each survey cell (paddock), the number of bilby burrows (fresh and old) and the estimated bilby population in the cells based on horseback surveys in 2012 and 2015 (ns=not sampled) and *based on 2015 quad bike survey (courtesy Colleen Sims).*

Cell	Suitable habitat (ha)	2012		2015		Bilby population (mean)	
		Fresh burrows	Total Burrows	Fresh Burrows	Total Burrows	2012	2015
Gravel	~6000	ns	ns	249	458	ns	50-91 (70)
Desert	~9000	100	375	249	311	20-75 (47)	50-62 (56)
Lasseter	~7000	ns	ns	242	291	ns	48-58 (53)
Bucktin	~8000	288	688	166	471	58-137 (98)	33-94 (63)
Spinifex	~9000	50	100	ns	ns	10-20 (15)	ns
Christmas Creek	~8000	200	533	*216	*316	40-107 (73)	*43-63 (53)

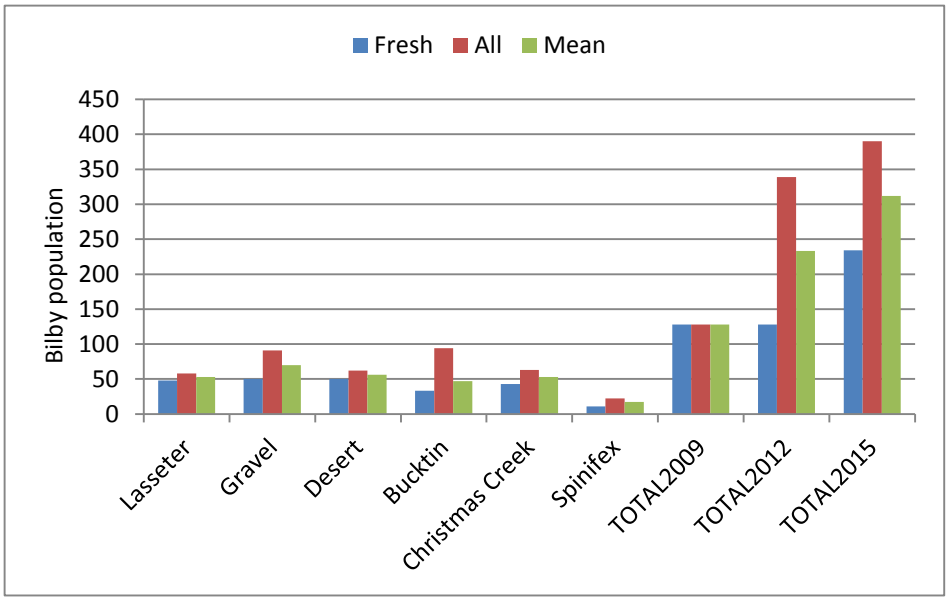


Figure 5: Estimated bilby population in survey cells on Matuwa based on a) recently used (fresh) burrows, b) all burrows and c) the mean of these figures. The total population on Matuwa is estimated to have increased by more than two-fold since 2009.

Pertuisel (2010) estimated the bilby population had fallen from 126 to 56 animals in 2010, a declining population due to predation by cats, native predators and lack of resources, or an inability of the founder population to find resources in a new environment. Fecundity was not an issue, with 75% of adult females breeding (Pertuisel 2010). Using PVA, Pertuisel also predicted that under most scenarios, and regardless of the size of the founder population, the bilby population at Lorna Glen would most likely be extinct within 20 years, assuming the same level of mortality rates experienced in the early stages post-reintroduction. One of her models suggests a population of just 40 animals by 5 years after reintroduction, but all models predict a declining population.

Based on best estimates from this survey, the bilby population on Lorna Glen is between 234 and 390 (most likely ~312) animals, considerably more than the predicted 40 by one of the models. Even if the actual population is at the lower end of the estimated range (234 animals), then rather than declining, the population is actually gradually increasing. Pertuisel's modelling clearly demonstrated the sensitivity of bilby population growth to adult mortality rate, so if the population is growing, then it suggests that the adult mortality rate has decreased since the early stages of the initial reintroductions. The primary causes of adult mortality in the early stages were predation and lack of resources. If the population estimates from this survey are realistic, then a decline in adult mortality rate suggests that subsequent generations of bilbies born on site, unlike the founders which were captive bred, have adapted to the new environment, are more predator aware and are more efficient at locating food resources.

While not recorded, we also observed numerous mulgara burrows, including in the recently burnt Gravel cell where burrows were relatively easy to see.

Acknowledgements: We thank Dave and Corrie for providing water for the horses, ensuring we had hot water for a shower after a long day in the saddle, and for willingly helping out in other ways. We also thank the Goldfields Region for supporting this novel approach of bringing working horses back to the rangelands for conservation purposes. The senior author (Neil Burrows) thanks the volunteers (my co-authors) and their horses who gave up a week of their time to participate in this important project. We also thank Colleen Sims and Mark Blythman for providing 2015 data from a quad bike survey of the Christmas Creek cell.

References

Burrows, N., Burrows, S. and Dunlop, J. (2012). Searching for signs of bilby activity in central Western Australia using observers on horseback. Journal of the Royal Society of Western Australia 95; 167-170

Burrows N. *et al* (2012). Monitoring bilby (*Macrotic lagotis*) and other animal activity at Lorna Glen using observers on horseback. DEC Report.

Pertuisel, l. (2010). Modelling the reintroduction of bilbies (Macrotis lagotis) in the ranglends of Western Australia. Hons Thesis.

Southgate, R. and Carthew, S. (2008). Post-fire ephemerals and spinifex-fuelled fires: a decision model for bilby habitat in the Tanami Desert, Australia. International Journal of Wildliand Fire 16: 741-754.

Photo Gallery