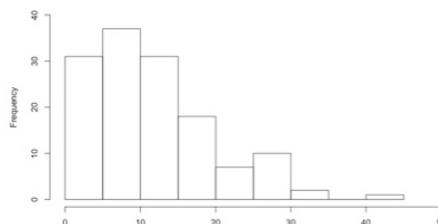




# Albany Ring Road Project Western Ringtail Possum Assessment





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Document Quality Checking History:

Version:	Rev 0	Peer review:	Victoria Ford
	Rev 0	Director review:	Garth Humphreys
	Rev 0	Format review:	Garth Humphreys

Approved for issue: Roy Teale

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# Albany Ring Road WRP Assessment

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# 1.0 Summary

The Albany Ring Road project is a proposed staged development to support freight growth in the City of Albany, by creating an alternative route for heavy vehicles accessing Albany Port and remove the necessity for these vehicles to travel through built up urban areas of the City. Stage 1 is complete and Stage 2 and Stage 3, the focus of this study, will connect Albany Highway, South Western Highway, Lower Denmark Road and Hanrahan Road allowing access to the port.

This report presents the results of sampling for the Western Ringtail Possum within the Albany Ring Road Project Area (the "Project Area" hereafter) as well as local and regional contextual sampling. Central to the overall assessment of the significance of the Western Ringtail Possum habitat encompassed by the Project Area is the provision of local and regional context. To provide local context, distance sampling was undertaken in the Down Road Nature Reserve located approximately 4 km north-west of the Project Area. The contextual assessment is extended further by comparison with abundance estimates derived for Bakers Junction Nature Reserve, Mt Melville, Mt Clarence and Mt Adelaide. Finally, the assessment extrapolates the density estimates to the extent of the Albany Regional Vegetation Survey to provide an 'Around Albany' sub-population estimate. Assumptions are presented that provide caveats relevant to this extrapolation of density estimates.

Two sampling methods were used within the Project Area: (i) strip sampling was employed in areas where the habitat comprised individual isolated trees or narrow strips of vegetation, and (ii) distance sampling was used over larger remnants (the Old Tip site and CSBP site). At the Down Road Nature Reserve context site, distance sampling was applied to the entire site.

Within the Project Area 16.2 km of strip transects yielded 13 observations of Western Ringtail Possums and, when the expected number of individuals based on distance sampling in the Old Tip site and CSBP site are included, the abundance estimate for the Project Area increased to between 20 and 37 individuals. For the area of habitat sampled (92.2 ha) this represents a density estimate ranging between 0.22 – 0.40 individuals per hectare.

The sampled area of Down Road Nature Reserve (363 ha) was estimated to support  $452 \pm 85$  (95% CI 312 – 656) individuals for a density estimate of  $1.246 \pm 0.234$  individuals per hectare.

At a regional scale, further distance sampling effort has been applied to three other remnant habitat sites, at Bakers Junction Nature Reserve, Mt Melville, Mt Clarence and Mt Adelaide where a combined estimate of 1,480 (95% CI 894 – 2,465) Western Ringtail Possums in an area of 4,400 ha was calculated.

If an average density estimate of 0.8 individuals per hectare (derived from the two largest areas surveyed: Down Road Nature Reserve and Bakers Junction Nature Reserve) is extrapolated to the mapped extent of the vegetation units surveyed within the Albany Regional Vegetation Survey boundary (a combined area of 21,633 ha), an estimate of 17,306 Western Ringtail Possums is obtained. Not all of this habitat would necessarily be utilised by Western Ringtail Possums, due either to land clearing that has occurred since 2010 (when the mapping was completed), recent fires or degradation from a variety of pressures. Nor is it necessarily accurate to apply a uniform density across the region encompassed by the mapping. However, the approach does indicate that the population estimate for the 'Around Albany' sub-population is considerably larger than the 500 reported in the IUCN assessment, perhaps by an order of magnitude.

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## 2.0 Introduction

### 2.1 Project Background

The Albany Ring Road project is a proposed staged development to support freight growth in the City of Albany, by creating an alternative route for heavy vehicles accessing Albany Port and remove the necessity for these vehicles to travel through built up urban areas of the City. Stage 1 is complete and Stage 2 and Stage 3, the focus of this document, will connect Albany Highway, South Western Highway, Lower Denmark Road and Hanrahan Road allowing access to the port (Figure 2.1).

A biological assessment of Stages 2 and 3 was undertaken in late 2017 (Rathbone and Gilfillan 2018) and determined that the Western Ringtail Possum *Pseudocheirus occidentalis*, which is listed as Critically Endangered at both State and Commonwealth levels, utilised a large proportion of the study area. Rathbone and Gilfillan (2018) categorised habitat as either Core, Supporting, Linkages or Likely Linkages. They subsequently identified areas of Core habitat in the southern section of their survey area, coincident with reserves and some remnants on private property. Supporting habitat included large areas in the east of their survey area predominantly within land owned by CSBP. Important habitat linkages were identified along the rail reserve, between Elleker Road and the railway line and along Link Road, south of Lancaster Road and on George Street. Much of the remaining habitat was identified as Likely Linkages.

### 2.2 Current IUCN Conservation Ranking of the Western Ringtail Possum: Rationale and Threats

The most recent assessment of the conservation status of the Western Ringtail Possum took place in 2014 and was published in 2017 (Burbidge and Zichy-Woinarski 2017). This re-assessment determined that the conservation ranking should be Critically Endangered under the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species. The key elements of the justification for the ranking were:

- An area of occupancy of <500 km<sup>2</sup> (area of occurrence 40,000 km<sup>2</sup>).
- Small severely fragmented populations.
- A continuing decline (threats being a drying climate, urban development, inappropriate fire regime, predation by foxes and cats).
- The upper Warren sub-population, which was identified as the largest prior to 2002, underwent a severe decline (>95%) between 1998 and 2009 (from >10,000 individuals to near extirpation).
- Remaining fragmented populations in coastal habitats also rapidly declining (equating to an overall population decline of >80% in the past 10 years).
- Predicted further decline of >80% within the next 10 years.

The following 2015 abundance estimates are quoted within the IUCN Red List for the five recognised subpopulations of Western Ringtail Possum with Dr B. Jones cited as the source:

- Southern Swan: 2,000
- Cape to Cape: 500
- Other Forest Rivers: 300
- Upper Warren: 100
- Around Albany: 500

These subpopulation estimates yield a 2015 total of about 3,400 adult Western Ringtail Possums (Burbidge and Zichy-Woinarski 2017). At the time of assessment they were considered to occur "...patchily in coastal areas from near Bunbury to the Leeuwin-Naturaliste National Park and near Albany (B. Jones pers. comm)." The authors go on to say that "Most of these fragmented habitat remnants are on private land" (Burbidge and Zichy-Woinarski 2017).

## 2.3 Study Purpose

This study details the results of targeted sampling for the Western Ringtail Possum within the Project Area as well as at a context site, the Down Road Nature Reserve (Figure 2.1). These results are also placed in further regional scale context by comparison with density estimates for Bakers Junction Nature Reserve, Mt Melville, Mt Clarence and Mt Adelaide which have been reported on separately (Figure 2.2). Finally, results of this local and regional work are placed in the wider "Around Albany" context.

## 2.4 Scale of Consideration

Four scales of geographic context are applied in this study (Project Area, Down Road Nature Reserve, Regional Scale and 'Around Albany sub-population') as defined in Table 2.1 and shown in Figure 2.1 and Figure 2.2.

To define the 'Around Albany' Western Ringtail Possum subpopulation identified (but undefined) in the IUCN conservation ranking published in 2017 (Burbidge and Zichy-Woinarski 2017), we have considered it to be equivalent to the extent of the Albany Regional Vegetation Survey (Sandiford and Barrett 2010). This is considered an appropriate definition for the 'Around Albany' sub-population as Sandiford and Barrett (2010) provides a detailed (67 native vegetation units mapped) thematic layer within which potential Western Ringtail Possum habitat can be identified, and for which density estimates can be extrapolated from the aforementioned distance sampling programs.

**Table 2.1: Description of project tiers used to provide context for the Albany Ring Road Western Ringtail Possum Assessment.**

Tiers	Description
Project Area	Various polygons along the length of the proposed Albany Ring Road route encompassing an area of 92.2 hectares (ha) (Figure 2.1).
Down Road Nature Reserve	The area adjacent to the Project Area within which a local context was ascertained. Specifically, the context is provided by a distance sampling program undertaken in the Down Road Nature Reserve that surveyed 21.8 kilometres (km) of line transects over seven nights. The reserve encompasses approximately 777.3 ha of which approximately 363 ha encompasses vegetation units sampled by the survey. Approximately one third of the reserve was burnt one month prior to the survey and this area has been estimated and excluded from all calculations.
Regional Scale	Extends context to include results of distance sampling programs in Bakers Junction Nature Reserve, Mt Melville, Mt Clarence and Mt Adelaide (Biota 2018a).
'Around Albany' sub-population	The IUCN species account for the Western Ringtail Possum (Burbidge and Zichy-Woinarski 2017) identifies 'Around Albany' as one of five sub-populations for the species. The geographic extent of this sub-population is not described any further by the IUCN account. This study recommends that for the purpose of this assessment, an area coincident with the boundary of the Albany Regional Vegetation Survey (ARVS) (Sandiford and Barrett 2010) be used to circumscribe the range of the 'Around Albany' subpopulation. The ARVS provides a description and extent of vegetation types encompassing 124,415 ha, bounding the Albany town site by 30 km to the east and west and 20 km to the north.

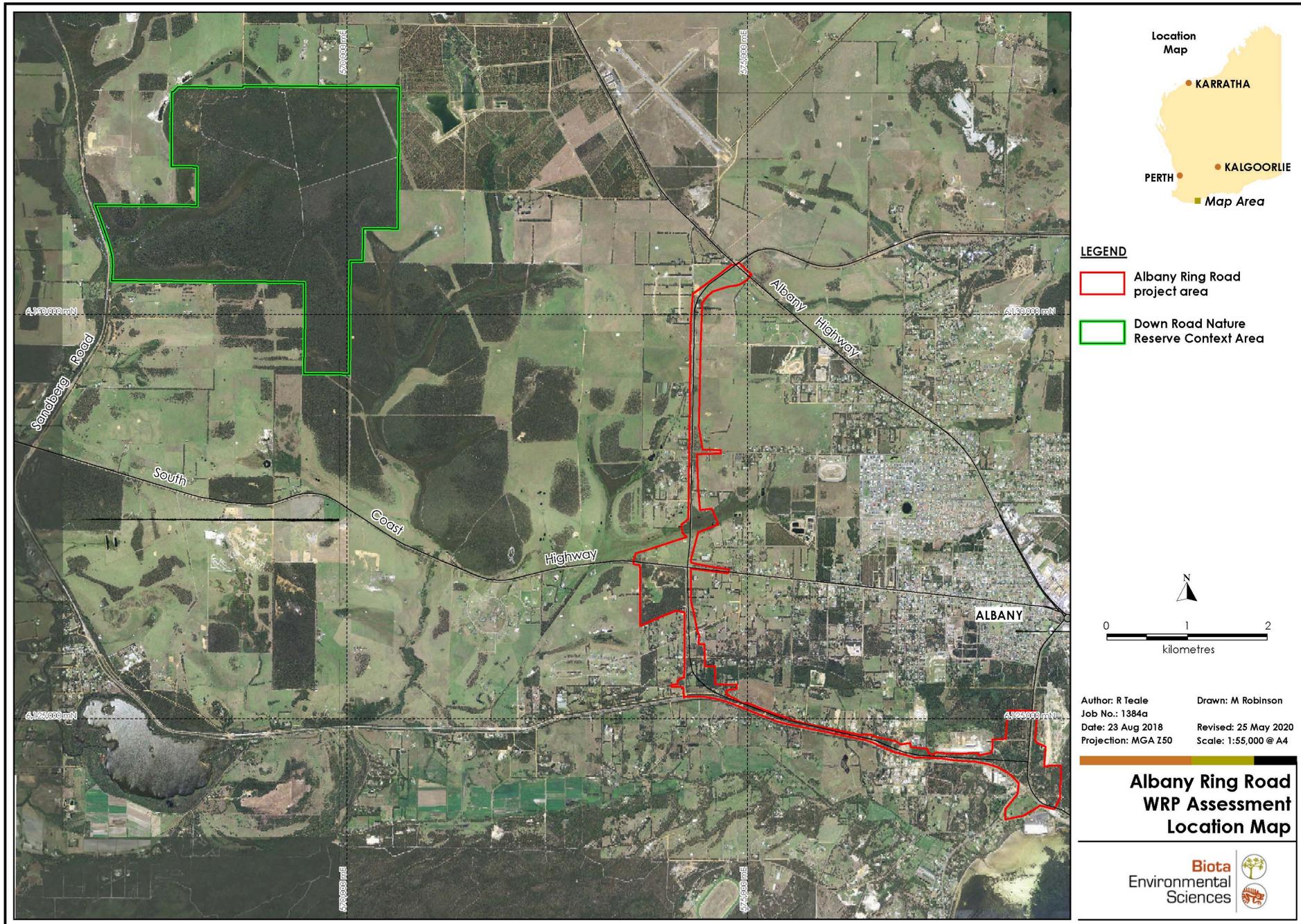


Figure 2.1 The Albany Ring Road Project Area and Down Road Nature Reserve Study Area.

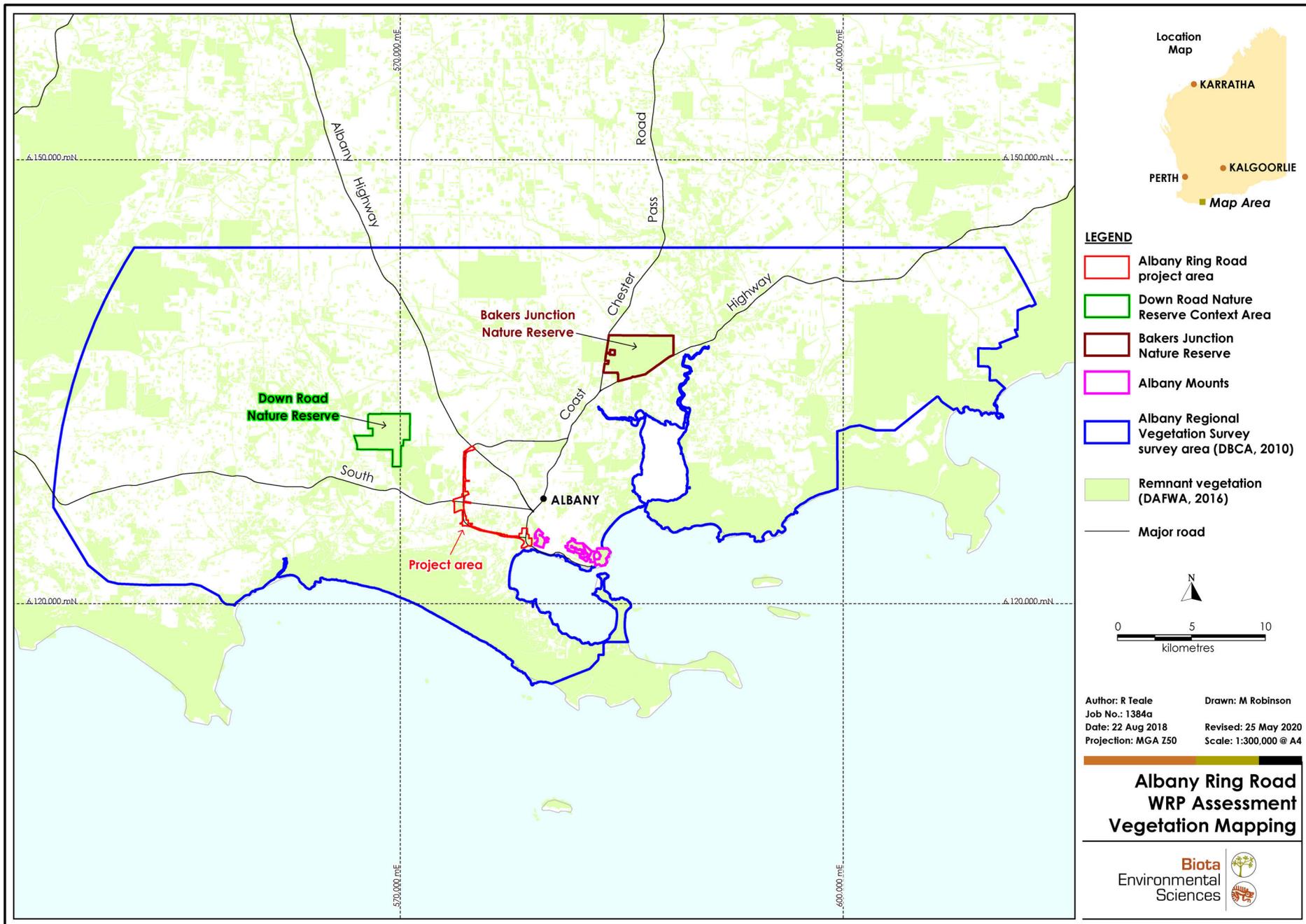


Figure 2.2: Locations of the Project Area, Down Road Nature Reserve and additional contextual sites (Bakers Junction Nature Reserve, Mt Clarence, Mt Adelaide and Mt Melville).

## 3.0 Methods

### 3.1 Survey Timing, Personnel and Permits

The survey was undertaken over 11 nights between 5 July and 21 July 2018 by Roy Teale, Stewart Ford, Victoria Ford and Zoe Hamilton all of Biota Environmental Sciences under a Department of Biodiversity, Conservation and Attractions (DBCAs) Regulation 17 Licence to take fauna for scientific purposes (08-002410-1).

### 3.2 Survey Design

#### 3.2.1 Project Area: Strip Transects and Line Transect Distance Sampling

Areas of scattered trees and shrubs and narrow vegetation remnants within the Project Area were surveyed using strip transects (Figure 3.1 - Figure 3.4). Each transect was at most 20 m in width and varied in length between 35 m and 1,376 m. The total length of strip transects in the Project Area was 16.2 km. The 20 m width was selected to yield greater than 90% probability of detection as derived from modelled detection functions fitted to perpendicular distances of Western Ringtail Possum sightings data from other studies (see Section 4.1).

Each 20 m wide strip transect was systematically searched for Western Ringtail Possums by a zoologist using a high-powered head torch. Survey work commenced at approximately 30 min after sunset and ended by 12:30 am. In some areas where the Road Reserve comprised scattered single trees, spotlighting was conducted from a vehicle. In all cases, the location of an observed possum was recorded using a handheld GPS while standing directly below the possum.

When complete detectability is less certain (i.e. probability of detection is less than 1.0, such as when surveying over large areas) other approaches must be adopted that allow the probability of detection and the effective survey area to be estimated. Distance sampling is one such method and is a robust and well documented approach to estimating density. Line transect distance sampling was undertaken at two locations within the Project Area; the George Street Old Tip site and the CSBP Fertiliser site. The Old Tip site encompassed approximately 35 ha and was sampled by ten line transects spaced at 75 m intervals yielding a total effort (combined transect length) of 3.9 km. The CSBP site encompassed approximately 17 ha and was traversed by nine line transects spaced at 75 m intervals with a combined effort of 2.3 km. Distance sampling of these sites followed the methodology in Section 3.3.2.

#### 3.2.2 Down Road Nature Reserve: Line Transect Distance Sampling

To provide local context for the assessment of the habitat within the Project Area, a distance sampling approach (Buckland et al. 2001) was used to estimate the density and abundance of Western Ringtail Possums within the Down Road Nature Reserve (Study Area). Down Road Nature Reserve is a large habitat remnant (777.3 ha) that lies approximately 4 km to the west of the Project Area (see Figure 2.1) and was considered likely to support Western Ringtail Possums.

A total of 50 km of transect was initially proposed for survey (Biota 2018b) however, a fire burnt approximately one third of the Reserve one month prior to the survey and these burnt sections were excluded. The Study Area sampling program was subsequently designed around 17 north-south and 47 east-west oriented parallel line-transects spaced 75 m apart and spanning the entire extent of unburnt sections of the Nature Reserve (Figure 3.5). However, transects generally took longer to complete than initially anticipated, especially those transects within the *Hakea* spp. Shrubland / Woodland Complex vegetation unit (of the ARVS by Sandiford and Barrett (2010)), and the majority of the transects within this vegetation unit were not sampled. Of the initial 50 km of planned transects (Biota 2018b), 21.8 km were actually sampled during this study.

Sandiford and Barrett (2010) define 11 vegetation units within the Down Road Nature Reserve, of which three (considered to represent primary habitat for Western Ringtail Possum) were surveyed as part of the distance sampling program (Table 3.1).

**Table 3.1: Vegetation units (after Sandiford and Barrett 2010) surveyed as part of the Western Ringtail Possum distance sampling program in the Down Road Nature Reserve.**

Vegetation unit / wetland feature	Area in Reserve (prior to the May 2018 fires)
Jarrah/Marri/Sheoak Laterite Forest (Unit 12)	302.3 ha
Jarrah/Sheoak/ <i>Eucalyptus staeri</i> Sandy Woodland (Unit 13)	65.4 ha
<i>Hakea</i> spp. Shrubland / Woodland Complex (Unit 31)	258.1 ha

Two zoologists (Roy Teale and Stewart Ford) undertook the survey within the Down Road Nature Reserve. Each transect was walked by one observer using a high-powered head torch (Led Lenser XEO 19R model) to detect animals. The location of each observation was recorded using a Hemisphere R330 Differential GPS, typically providing accuracy to within 1.5 m. The following data were recorded for each observation:

- species (Western Ringtail Possum or Common Brushtail Possum);
- observer;
- animal location using GPS standing directly underneath;
- time;
- number of individuals;
- cue: Seen (eyeshine), seen (no eyeshine), heard or silhouette; and
- tree type.

Walking pace along transects was generally equivalent to approximately 0.5 km per hour.

### 3.2.2.1 Data Analysis

There were sufficient observations of Western Ringtail Possums ( $n=80$ ) yielded by the Down Road Nature Reserve distance sampling program to independently model a detection function (required to derive animal density estimates using distance sampling approaches; Buckland et al. (2001)). However, the number of observations yielded by the distance sampling program within the Old Tip and CSBP sites ( $n = 7$  after truncation) was fewer than the number generally recognised as being suitable for modelling a detection function ( $n=60$  to  $80$ ) (Buckland et al. 2001). Hence, observations from these two small remnants (CSBP site and the old George Street Tip site) were pooled with observations from Down Road Nature Reserve and Bakers Junction Nature Reserve to yield a global detection function with derived parameter estimates which were then stratified by Reserve and remnant.

Perpendicular distances to each observation from the transect were calculated using MapInfo Professional Geographical Information System (GIS) v12.5 from the GPS location taken at the point of observation. Perpendicular distance data were analysed using the 'mrds' (Laake et al. 2013) and 'Distance' (Miller 2013) packages in R statistical software (R Core Team 2013). Probability Detection Functions were modelled based on the histogram of perpendicular distance measurements to individuals and pairs (clusters). Perpendicular distance data were plotted as histograms with customised cut-points and examined to determine whether evasive movement of animals was occurring prior to detection. Stepped lower initial intervals that increase away from the centreline can indicate movement away from the observer, while initially high then decreasing intervals indicate relatively little movement away from the observers (Buckland et al. 2001). Both can lead to bias in density estimation.

Histograms were right truncated as necessary to achieve better model fit, optimally at the distance at which detection probability was 0.15 as recommended by Buckland et al. (2001), but other truncation distances were tested as part of the model selection phase. Akaike's Informative Criterion (AIC) is a quantitative method of model selection and was used to select between potential models (Buckland et al. 2001). In addition to AIC, candidate models were also compared using visual inspection of their fit to histograms of the perpendicular distance, goodness of fit quantile-quantile (Q-Q) plots, Kolmogorov-Smirnov (K-S) and Cramér-von Mises

(CvM) test statistics (Buckland et al. 2004). The half-normal and hazard rate keys were used for modelling the Probability Detection Function, with or without adjustment terms (Buckland et al. 2001).

The selected model was used to estimate the following parameters:

1. the encounter rate ( $n/L$ ), where  $n$  was the number of observed clusters and  $L$  was the total length of the transect;
2. the average probability of detection ( $p$ );
3. a density estimate ( $D$ ); and
4. an estimate of the number of animals in the specified area ( $N$ ).

Variation in the Probability Detection Function caused by observers (factor covariate: observer) and study area (factor covariate: study area) were modelled. The effect of time elapsed since survey commencement (minutes past 18:30) was also examined to see if observer fatigue played a role in affecting detection rates. Only the results from the preferred model are discussed here.

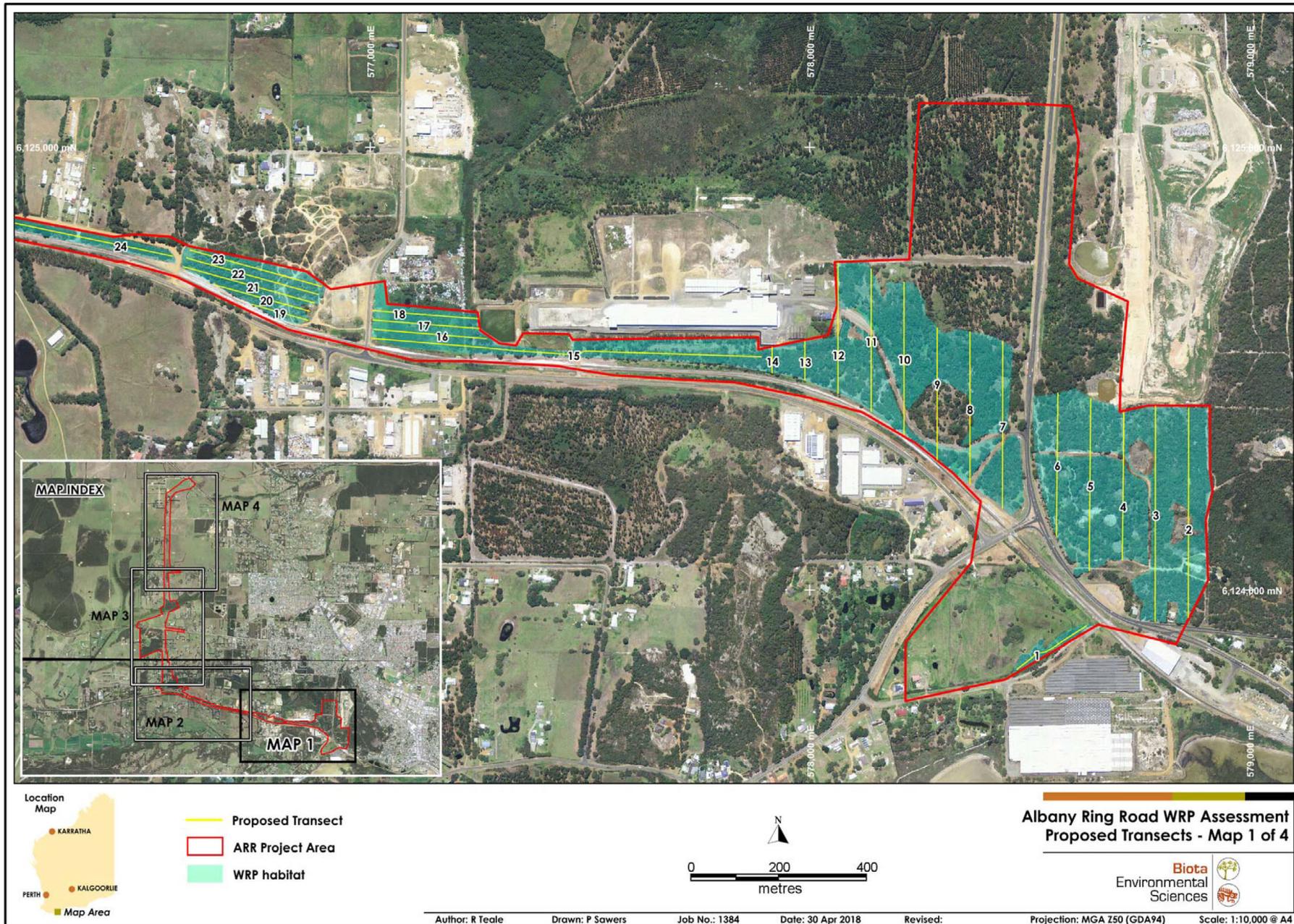


Figure 3.1: Distance sampling transects (Transects 2 – 14) within the CSBP site and strip transects (Transects 15 to 24) within the Albany Ring Road Project Area.

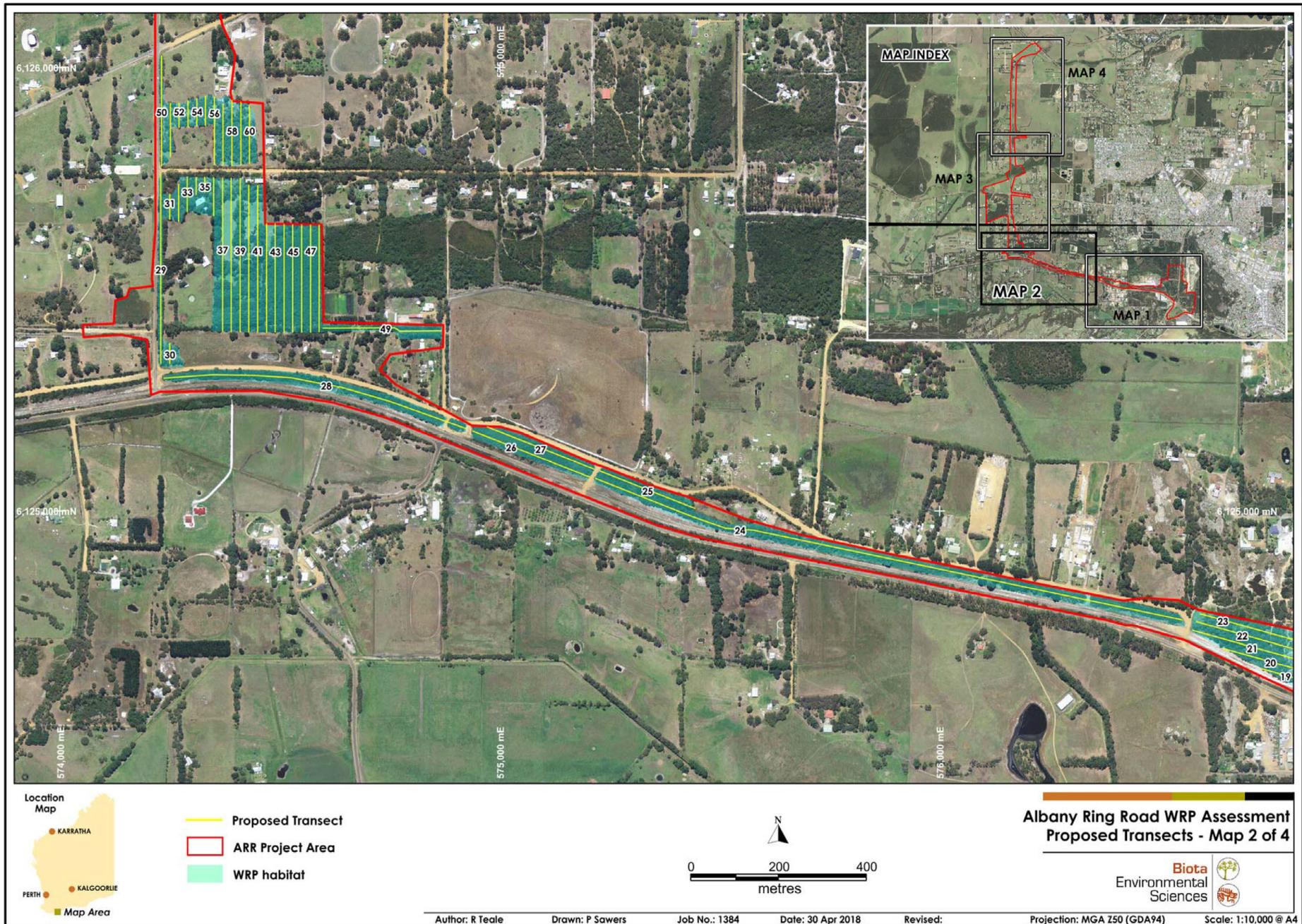


Figure 3.2: Strip transects (Transects 19 to 60) within the Albany Ring Road Project Area (continued).

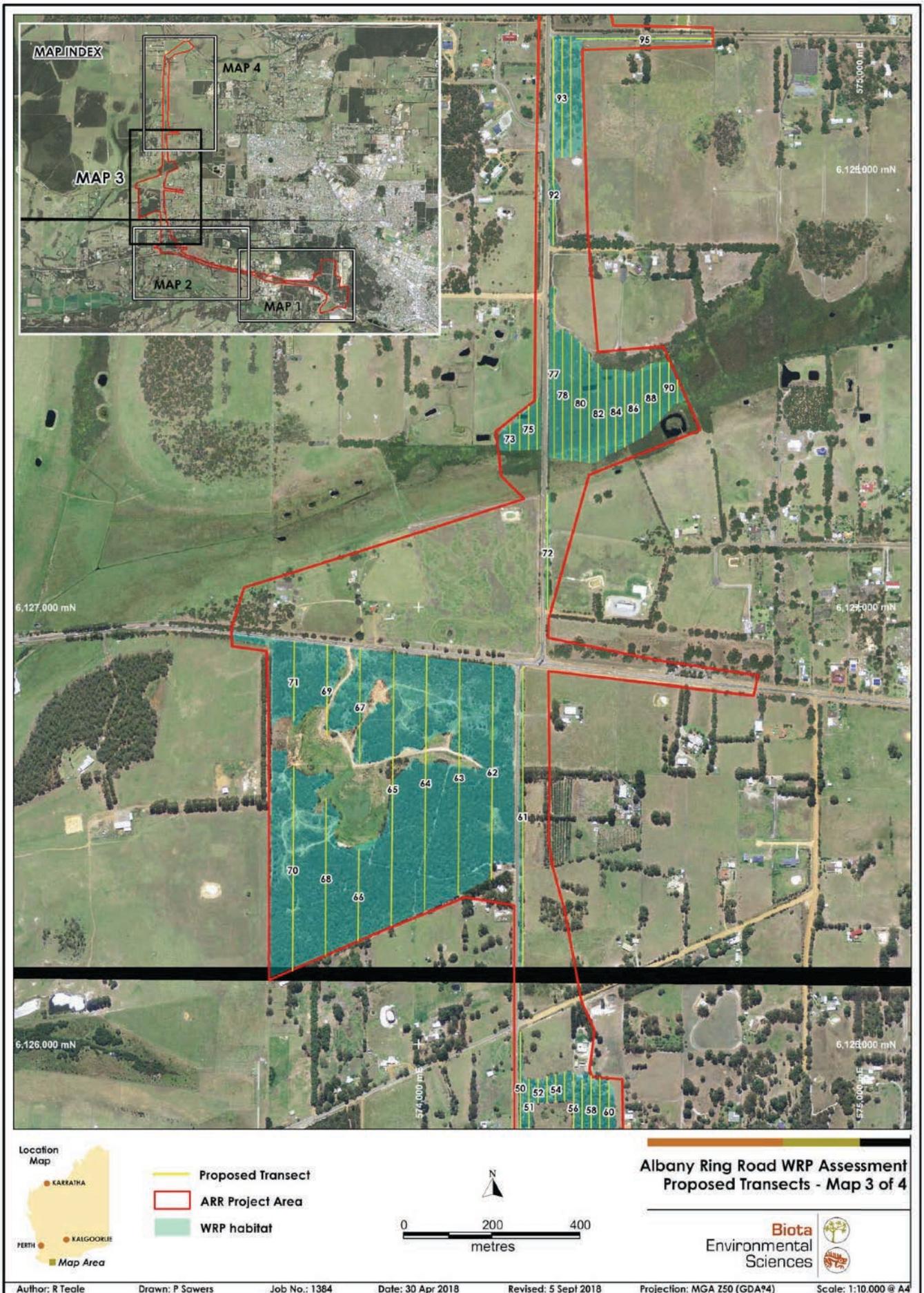


Figure 3.3: Distance sampling transects (Transects 52 – 61) within the Old Tip site and strip transects (Transects 50 to 95) within the Albany Ring Road Project Area (continued).

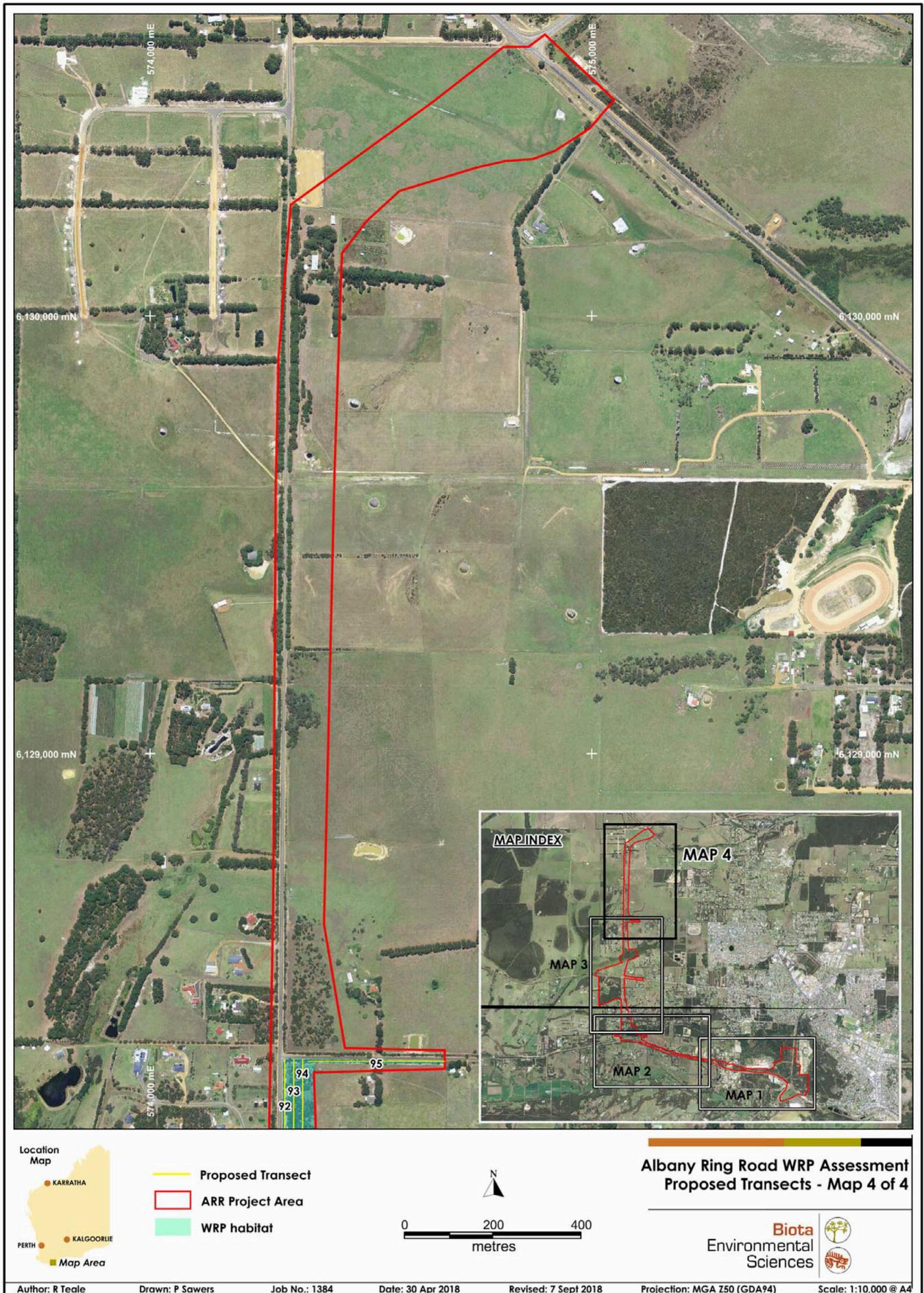


Figure 3.4: Strip transects (Transects 92 to 95) within the Albany Ring Road Project Area (continued).

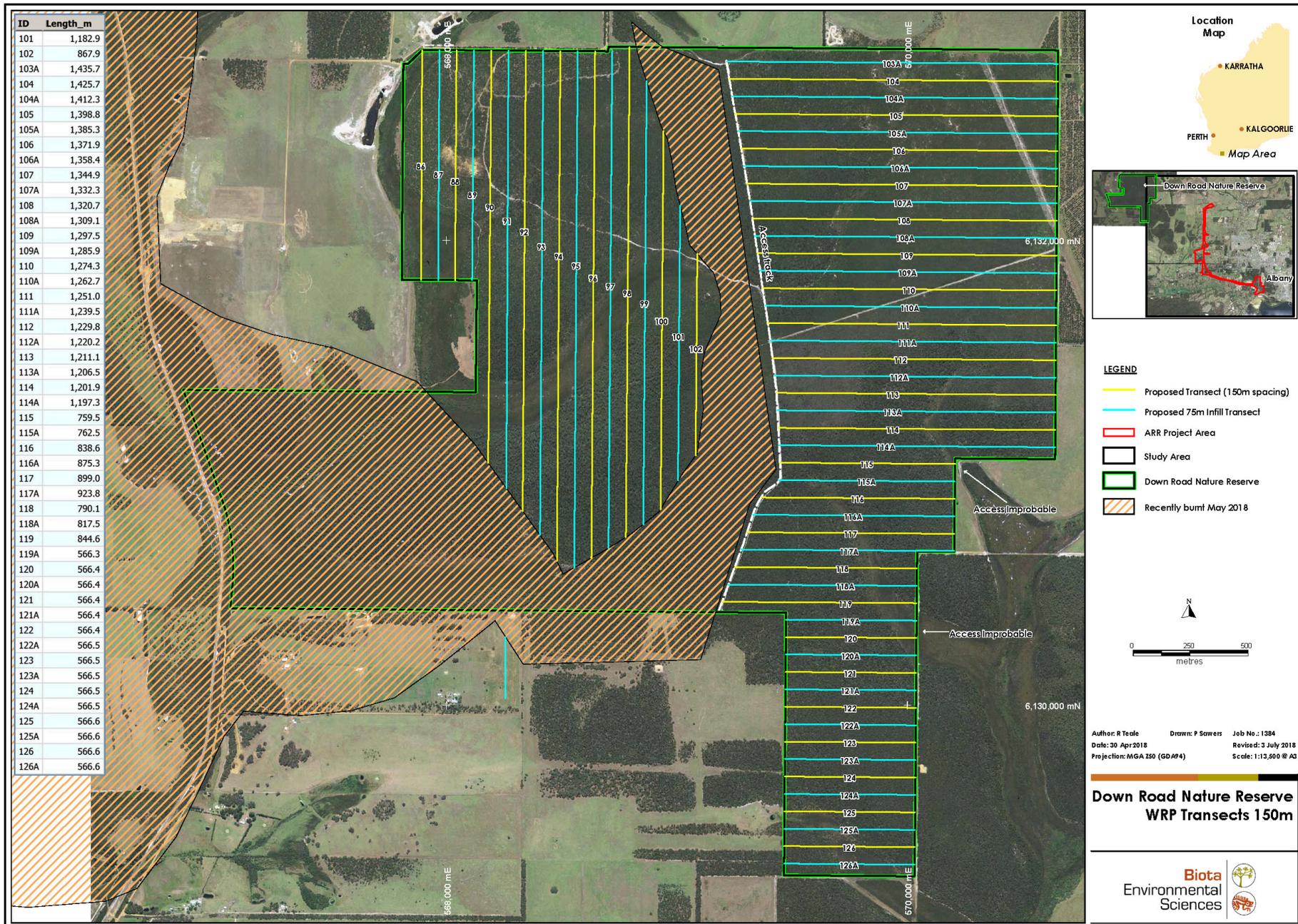


Figure 3.5: Proposed transects layout for the Western Ringtail Possum distance sampling program in the Down Road Nature Reserve study area.

## 4.0 Results

### 4.1 Project Area

The area of mapped Western Ringtail Possum habitat within the Project Area comprises approximately 92.2 ha (as per Rathbone and Gilfillan 2018), consisting of 30.89 ha of core Habitat, 31.95 ha of supporting habitat, 9.32 ha of linkage habitat and 20.04 ha of linkage likely habitat. Within this area, a total of 20 sightings of Western Ringtail Possums were recorded from 20 locations and records came from the entire length of the Project Area (Figure 4.5). The tally comprises 13 observations from the strip transects, four observations from the Old tip and three from the CSBP sites (within which distance sampling was conducted). Individuals were recorded from a variety of tree species including Sydney Wattle *Acacia longifolia*, Peppermint *Agonis flexuosa*, eucalypts, *Melaleuca* spp., and a Cypress Pine.

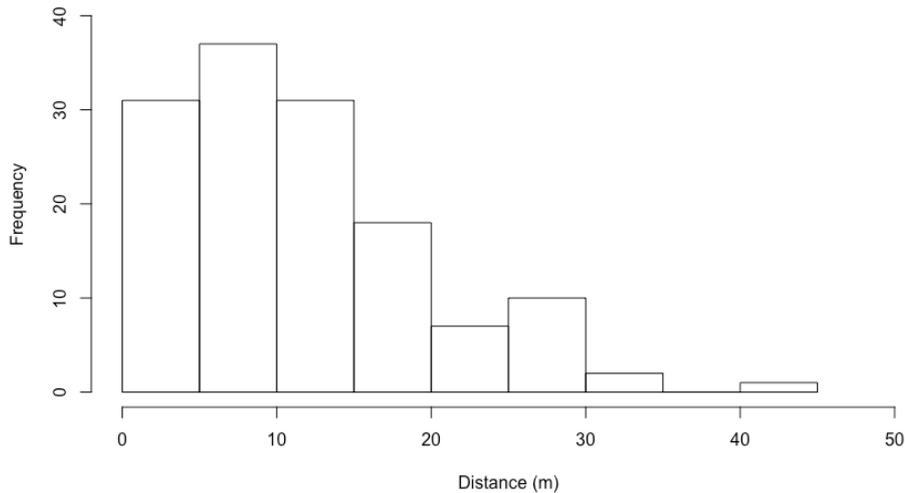
Within those areas sampled by strip transects, we are confident that most, if not all individuals present were recorded during the survey. This assertion is supported by the distance sampling program undertaken in the Down Road Nature Reserve (see Section 4.1.1) that yielded an average probability of detection of  $p=0.99$  from the detection function at a truncation distance of 10 m (i.e. consistent with the 20 m strip transects used). The more open habitat of the road reserve areas likely afforded greater visibility than was possible in the larger vegetation fragments resulting in a higher probability of detection.

Population estimates for the two larger remnants (Old Tip site and the CSBP site) were derived using a distance sampling approach rather than being directly observed as was the case for the strip transects. As noted earlier (Section 3.3.2), the number of observations yielded by the distance sampling surveys within the CSBP and Old Tip sites ( $n=7$ ) was too few to adequately model a stand-alone detection function and hence observations were combined across the Down Road and Bakers Junction Nature Reserves. The combined total of 63 transects across the four survey areas yielded 137 observations of Western Ringtail Possums prior to truncation, comprising 50 in Bakers Junction Reserve, 80 in the Down Road Nature Reserve, three in the CSBP site and four in the George Street Tip site.

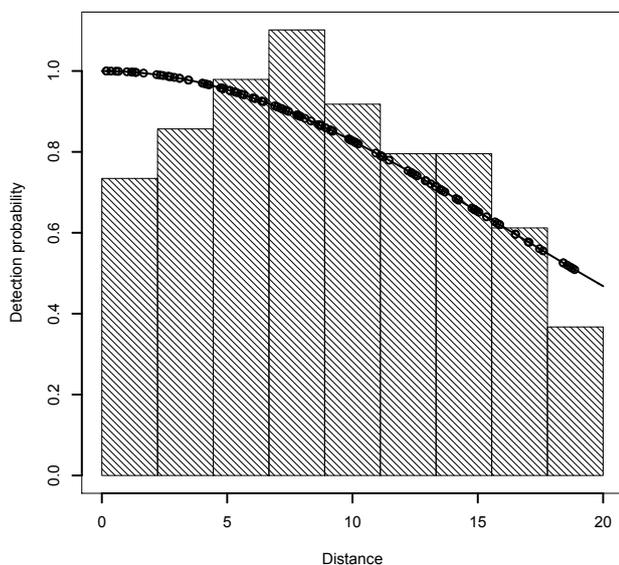
#### 4.1.1 Model Selection

The histogram of detection distances was indicative of Western Ringtail Possum movement away from the observer (Figure 4.1). An alternative explanation for the initial stepped increase in the number of observations is that insufficient attention was being spent observing along the transect, largely as a result of a requirement to navigate around trees and shrubs, removing the attention of the observer from along the transect. The consequence of the stepped increase is a negative bias in the estimate of Western Ringtail Possums (i.e. an underestimate). Methodological changes were developed to correct the observers' technique from the fifth night onwards and this markedly improved the histogram, supporting our suspicion that the cause of the spike was not animal movement away from the transect (and observer).

The best overall model fit was a hazard rate key with no adjustment terms and no covariate on the detection process (truncation = 20 m,  $n = 117$ , K-S  $p = 0.80$ , CvM  $p = 0.96$ ) (Figure 4.2). Key summary statistics are presented in Table 4.1.



**Figure 4.1:** Histogram of all Western Ringtail Possum observations from Down Road Nature Reserve, Bakers Junction Nature Reserve, the Old Tip site and the CSBP site (n=137) (n.b. observations include occasions where two individuals were seen together. The tally of individuals was 156).



**Figure 4.2:** Histogram of Western Ringtail Possum observations from Down Road Nature Reserve, Bakers Junction Nature Reserve, the Old Tip site and the CSBP site with hazard-rate Probability Detection Function and truncation at 20 m.

Density estimates derived from the observation data were post-stratified by Reserve / Remnant to provide parameter estimates for the two remnants (namely the Old Tip site and the CSBP site) and then used to obtain abundance estimates. Density estimates of  $0.36 \pm 0.087$  and  $0.14 \pm 0.101$  Western Ringtail Possums per hectare were derived for the CSBP and Old Tip sites respectively (Table 4.2). The density estimates translate to abundance estimates of  $6.1 \pm 2.5$  and  $5.0 \pm 3.6$  individuals for the CSBP and Old Tip sites respectively (Table 4.3).

**Table 4.1:** Key summary statistics from the Distance Sampling program for Western Ringtail Possum observations (equals clusters) in the CSBP and Old Tip sites (ER = Encounter Rate, n = number of observations, k = number of transects, cv = coefficient of variation).

	Region Area (ha)	Covered Area (ha)	Effort (km)	n	k	ER km <sup>-1</sup>	se.ER Rate km <sup>-1</sup>	cv.ER
CSBP site	17	9.3	2.3	3	9	1.29	0.53	0.41
Old Tip site	35	15.6	3.9	2	10	0.51	0.36	0.71

**Table 4.2:** Density estimates for Western Ringtail Possums (individuals) in the CSBP and Old Tip sites (cv = coefficient of variation, lcl = lower confidence limit, ucl = upper confidence limit).

	Estimate (per ha)	se (per ha)	cv	lcl (per ha)	ucl (per ha)
CSBP site	0.36	0.087	0.41	0.14	0.90
Old Tip site	0.14	0.101	0.71	0.03	0.61

**Table 4.3:** Abundance estimates for Western Ringtail Possums (individuals) in Bakers Junction Nature Reserve (cv = coefficient of variation, lcl = lower confidence limit, ucl = upper confidence limit).

	Estimate	se	cv	lcl	ucl
CSBP site	6.1	2.5	0.42	2.4	15.3
Old Tip site	5.0	3.6	0.71	1.2	21.3

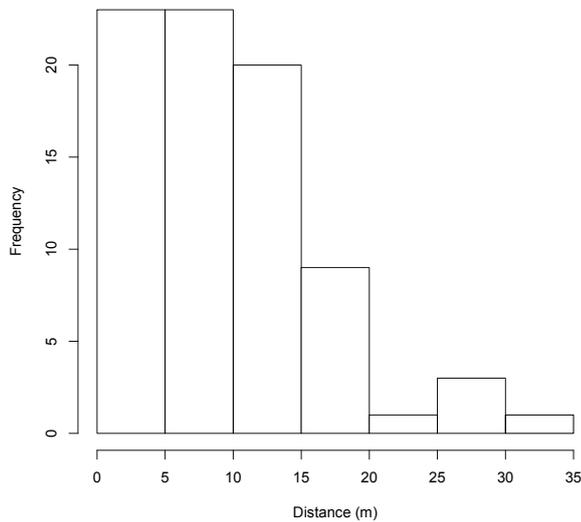
When the distance sampling abundance estimates (rather than the direct observations) from the Old Tip site and the CSBP site are added to the tally for the Project Area, then the number of expected individuals increases to 25 and ranges between 20 and 37 individuals, yielding a range of densities between 0.22 – 0.40 individuals per ha.

While the Project Area boundary may intersect the home ranges of more individual Western Ringtail Possums than the 20 to 37 estimated above (given that sections about larger contiguous habitat remnants), we believe it is reasonable to state that the Project Area encompasses habitat that could support the equivalent of 20 to 37 individuals. The local and regional significance of this habitat is in part understood by placing it into a local and regional context by direct comparison with habitat in other nearby remnants, in this case the Down Road Nature Reserve.

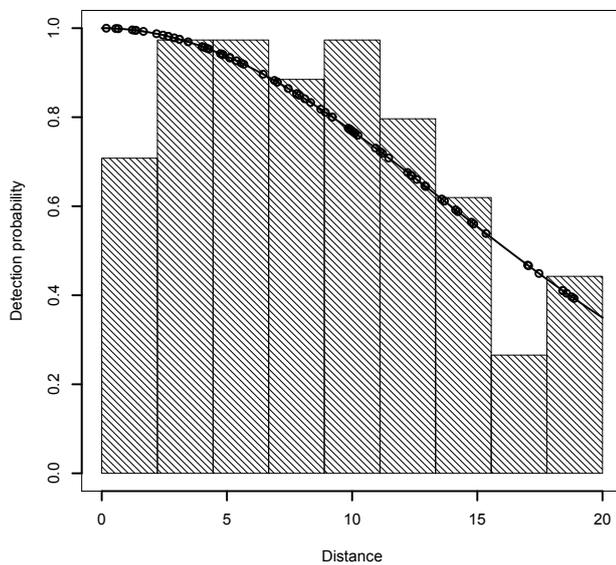
## 4.2 Local Context Area: Down Road Nature Reserve

The histogram of detection distances for the 80 observations (Figure 4.3) shows a clear “shoulder” out to 10 m indicating relatively even detectability to at least this distance from the transect. The best overall model fit for the observation data from the surveyed vegetation units of the Down Road Nature Reserve was a half-normal with no adjustment terms and no covariate on the detection process (truncation = 20 m, n = 75, K-S p = 0.99, CvM p = 0.98) (Figure 4.4). Key summary statistics derived from this model are presented in Table 4.4. An encounter rate of  $3.45 \pm 0.47$  Western Ringtail Possums per kilometre of transect was estimated from a truncation distance of 20 m.

The Jarrah/Marri/Sheoak Laterite Forest and Jarrah/Sheoak/*Eucalyptus staeri* Sandy Woodland vegetation units of the Down Road Nature Reserve yielded a density estimate of  $1.246 \pm 0.234$  individuals per hectare (Table 4.5), which translates to approximately  $452.3 \pm 85$  (95% CI 311.7 – 656.3) individuals for these vegetation units in the Reserve (Table 4.6).



**Figure 4.3:** Histogram of all Western Ringtail Possum observations from the Down Road Nature Reserve (n=80) (note: observations include occasions where two individuals were seen together. The tally of individuals was 86).



**Figure 4.4:** Histogram of Western Ringtail Possum observations from the Down Road Nature Reserve with half-normal Probability Detection Function and truncation at 20 m.

**Table 4.4:** Key summary statistics from the Distance Sampling program for Western Ringtail Possum observations (equals clusters) in Down Road Nature Reserve (ER = Encounter Rate, n = number of observations, k = number of transects, cv = coefficient of variation).

	Region Area (Ha)	Covered Area (Ha)	Effort (km)	n	k	ER km <sup>-1</sup>	se.ER Rate km <sup>-1</sup>	cv.ER
Down Road NR	363	87.1	21.8	75	29	3.45	0.47	0.136

**Table 4.5:** Density estimates for Western Ringtail Possums (individuals) in Down Road Nature Reserve (cv = coefficient of variation, lcl = lower confidence limit, ucl = upper confidence limit).

	Estimate (per ha)	se (per ha)	cv	lcl (per ha)	ucl (per ha)
Down Road NR	1.246	0.234	0.19	0.858	1.808

**Table 4.6:** Abundance estimates for Western Ringtail Possums (individuals) in Down Road Nature Reserve (cv = coefficient of variation, lcl = lower confidence limit, ucl = upper confidence limit).

	Estimate	se	cv	lcl	ucl
Down Road NR	452.3	85.0	0.18	311.7	656.3

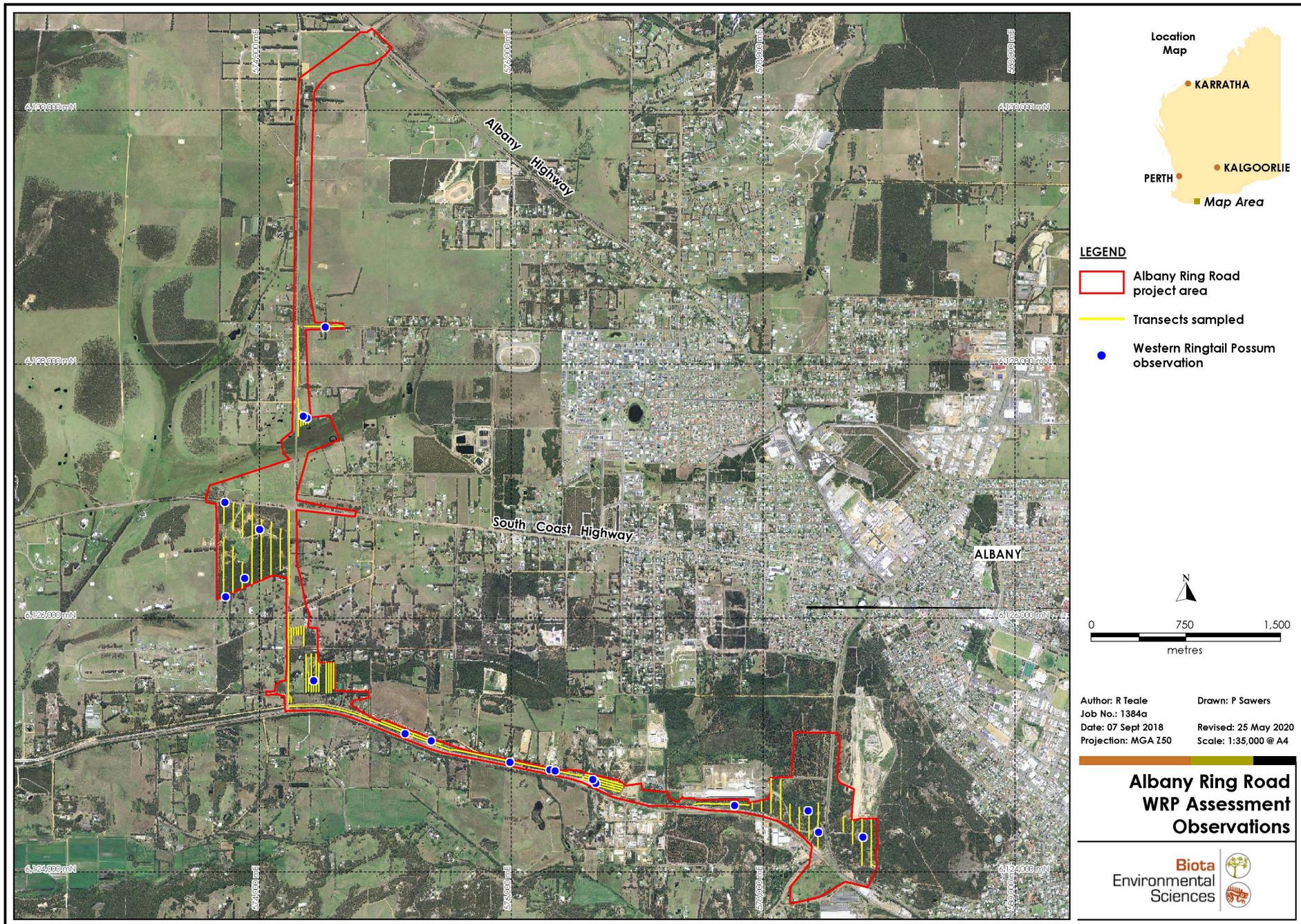


Figure 4.5: Observations of the Western Ringtail Possum within the Project Area from both Distance Sampling and Strip Sampling.

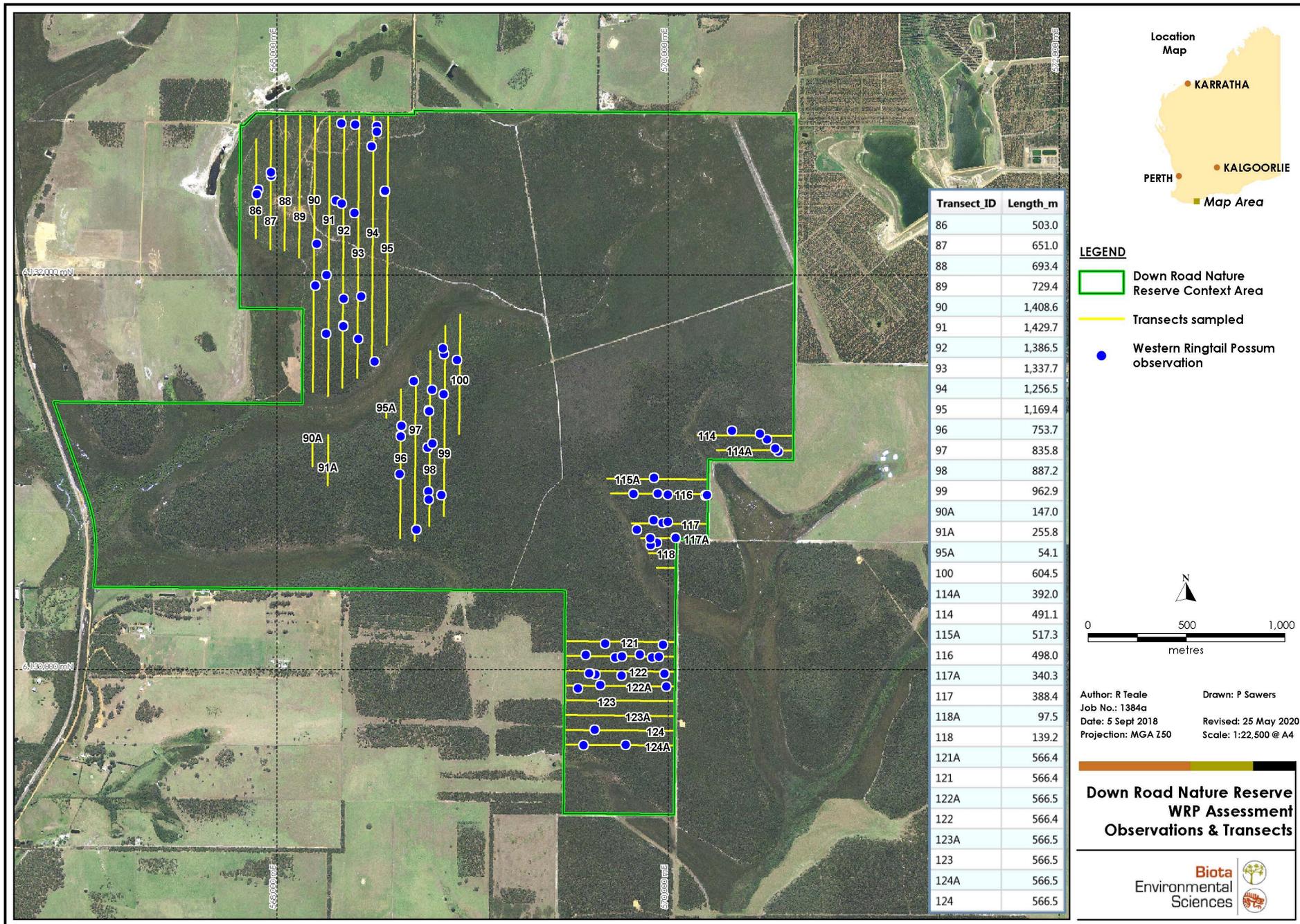


Figure 4.6: Locations from which Western Ringtail Possums were recorded within the Down Road Nature Reserve.

## 5.0 Discussion

The purpose of this study was to assess the importance of the identified Western Ringtail Possum habitat within the Albany Ring Road Project Area (as per Rathbone and Gilfillan 2018) by direct comparison with habitat in a local (the Down Road Nature Reserve) and wider contexts including the extent of the ARVS (Sandiford and Barrett 2010). Density was identified as the preferred metric for making such comparisons and was estimated using either strip transects or a distance sampling approach depending on the extent of habitat. Within the Albany Ring Road Project Area, Western Ringtail Possum habitat ranged from isolated individual habitat trees (both native and exotic), through remnant vegetation strips (between 10 and 80 m wide) surrounded by cleared land, to larger remnants; either isolated from or broadly contiguous with, much larger remnants. Narrow habitat corridors were not amenable to undertaking a distance sampling program and to obtain density estimates in such sections, the strip transect approach was adopted. Strip transects were considered a suitable method for estimating density given that the probability of detection was essentially 1.0 (see Section 3.1) and that in most instances the area of habitat was clearly demarcated. Distance sampling was used to estimate density within two larger remnants of the Project Area (Old Tip site and the CSBP site) as well as the Jarrah/Marri/Sheoak Laterite Forest and Jarrah/Sheoak/*Eucalyptus staeri* Sandy Woodland vegetation units of the Down Road Nature Reserve.

The strip transects within the Project Area yielded 13 observations of Western Ringtail Possums and, when the expected number of individuals based on the distance sampling exercises in the Old Tip site and CSBP site were included, the estimate for the Project Area increased to between 20 and 37 individuals. The 20 to 37 individuals and an area of habitat of 92.2 ha (encompassed by the Project Area boundary and as mapped by Rathbone and Gilfillan (2018) yielded a density estimate ranging between 0.22 – 0.40 individuals per ha.

At the local scale, the estimate of 20 – 37 individuals supported by the 92.2 ha of mapped habitat within the Project Area compares to an estimate of  $452.3 \pm 85$  individuals from the Jarrah/Marri/Sheoak Laterite Forest and Jarrah/Sheoak/*Eucalyptus staeri* Sandy Woodland vegetation units (encompassing 363 ha) of the Down Road Nature Reserve for a density estimate of  $1.246 \pm 0.234$  individuals per ha, more than three times that of the Project Area.

At a 'Around Albany' scale, an original estimate of approximately 500 individuals was ascribed to the 'Around Albany' sub-population as presented in the IUCN re-assessment of the conservation status of the Western Ringtail Possum (Burbidge and Zichy-Woinarski 2017). However, since the 2017 publication (initiated in 2014) (Burbidge and Zichy-Woinarski 2017), several programs (including this study) have been implemented in the Albany Region to more robustly estimate the density of Western Ringtail Possums using a distance sampling approach and these have provided additional data to re-evaluate the IUCN estimate.

The Down Road Nature Reserve study reported here was also run in conjunction with a distance sampling program within the Bakers Junction Nature Reserve (Biota 2018a). Neither reserve has previously been surveyed for Western Ringtail Possums and both were previously highlighted as regional gaps in determining the likely distribution of Western Ringtail Possums in the greater Albany region (Gilfillan 2008). The two programs involved walking a combined total of 51.7 km of transects across 13 nights, which yielded 130 individual Western Ringtail Possums (an encounter rate of  $2.51 \text{ km}^{-1}$ ) and yielded population estimates of  $306 \pm 75$  for Bakers Junction Nature Reserve and  $452 \pm 85$  for Down Road Nature Reserve (Table 5.1).

A third program (with Natural Resource Management funding) implemented by the Oyster Harbour Catchment Group (OHGC) and using volunteers to collect the observation data, conducted distance sampling at Mt Clarence, Mt Adelaide and Mount Melville. This program involved repeated monthly sampling of six groups of four transects yielding a total effort of 51.8 km and has been in operation since 2016. The observation data were provided to Main Roads Western Australia for the purpose of providing additional regional context. These data were also analysed as part of the current study, and density for the Mt Clarence and Mt Adelaide sites was estimated to be  $3.48 \pm 0.91$  individuals per ha yielding a population estimate of  $767 \pm 201$ ,

whilst the density estimate for the Mt Melville site was  $1.54 \pm 0.38$  individuals per ha, yielding a population estimate of  $156 \pm 39$  (Table 5.1).

**Table 5.1: Density and population estimates for four sites at which distance sampling has been undertaken in the Albany region.**

Reserve / Remnant Bushland (Area of Surveyed habitat)	Number of individuals recorded	Density (ha)	CV	Abundance Estimate (95% CI)
Bakers Junction Nature Reserve (843 ha)	54	$0.363 \pm 0.088$	24%	$306 \pm 75$ (185 – 507)
Down Road Nature Reserve (363 ha)†	80	$1.246 \pm 0.234$	17.9%	$452 \pm 85$ (311 – 656)
Mt Clarence / Mt Adelaide (2,211.7 ha)	Repeat Sampling	$3.478 \pm 0.908$	26.2%	$767 \pm 201$ (441 – 1335)
Mt Melville (1,012.9 ha)	Repeat Sampling	$1.54 \pm 0.381$	24.7%	$156 \pm 39$ (92 – 263)

† Excludes habitat burnt in June 2018 fires. The area is an approximate estimate only as the exact area burnt was not known at the time of reporting.

The distance sampling campaigns at Bakers Junction Nature Reserve, Down Road Nature Reserve, Mt Clarence / Mt Adelaide and Mt Melville yielded in excess of 135 distinct Western Ringtail Possums. These three studies yielded a combined population estimate of 1,681 individuals from a combined area of approximately 4,400 ha. The population estimate for these areas alone is therefore three times the estimate provided for the 'Around Albany' sub-population in the IUCN assessment.

By drawing on the population estimates obtained from recent studies employing a systematic distance sampling approach in the Albany Region (i.e. 1. Biota: Bakers Junction Nature Reserve and Down Road Nature Reserve and 2. OHGC: Mt Clarence, Mt Adelaide and Mount Melville), and placing them in the context of regional vegetation mapping (Sandiford and Barrett 2010) of the same habitat sampled in these studies, it is possible to calculate an approximate population size for these vegetation units in the broader Albany region.

The ARVS (Sandiford and Barrett 2010) provides a description and extent of vegetation types that encompasses 124,415 ha in an area bounded to the east and west of the Albany town site by 30 km and to the north by 20 km (shown in Figure 2.1).

The distance sampling program within the two Bakers Junction Nature Reserve and Down Road Nature Reserve primarily sampled two vegetation Units:

- i) Jarrah/Marri Sheoak laterite forest (Unit 12); and
- ii) Jarrah/Sheoak/*Eucalyptus staeri* Sandy Woodland (Unit 13).

Sandiford and Barrett (2010) mapped 13,144 ha of the Jarrah/Marri Sheoak laterite forest (Unit 12) within the ARVS boundary and noted that 1,273 ha was encompassed by IUCN I-IV reserves, a further 3,991 ha occurred on other Crown reserves and 7,879 ha was on non-reserve land. The mapped extent of Jarrah/Sheoak/*Eucalyptus staeri* Sandy Woodland (Unit 13) occurred on 5,148 ha including 1,334 ha on IUCN-IV reserves, 1,878 ha on other Crown Reserves and 1,936 ha on non-reserved land. The combined area of both vegetation units occurring on reserved land is 8,477 ha, with 9,815 ha on non-reserved land (at the time of mapping). The mean Western Ringtail Possum density across Bakers Junction Nature Reserve and Down Road Nature Reserve was estimated to be approximately 0.80 individuals per hectare. Using this density across the 8,477 ha of reserved land yields over 6,820 individuals and, if the entirety of the 2010 mapped extent is used, the estimate increases to over 14,600 individuals. Clearly not all of this habitat would currently be available either due to land clearing that has occurred since 2010, recent fires or degradation from a variety of pressures. Nor is it necessarily appropriate to apply a uniform density across the region encompassed by the mapping. However, there are a variety of other vegetation types considered likely to support Western Ringtail Possums occurring in the ARVS boundary but not surveyed as part of this study. Conservatively, these include *Hakea* spp. Shrubland/Woodland Complex (2,366 ha), *Banksia coccinea* Shrubland / *Eucalyptus staeri* / Sheoak Open Woodland (1,330 ha) and Peppermint Low Forest (1,232 ha). In addition, Western

Ringtail Possums have been documented to inhabit the urban environment within Albany utilising narrow road reserves and residential gardens (this study and Gilfillan 2008).

Further extrapolation can be obtained with a similar approach, including the additional vegetation units sampled during the studies at Mt Clarence / Mt Adelaide and Mt Melville, and applying the conservative density estimate of 0.8 individuals per hectare (lower than actually recorded during those studies). The vegetation units included in the surveys conducted at Mt Clarence / Mt Adelaide and Mt Melville were as follows:

- i) Coastal *Banksia illicifolia* / Peppermint Low Woodland (Unit 4);
- ii) Marri / Jarrah Forest / Peppermint Woodland (Unit 10); and
- iii) Marri / Jarrah Coastal Hills Forest (Unit 17).

When an average density estimate of 0.8 individuals per hectare (as derived from the two Nature Reserves) is extrapolated to the mapped extent of all five vegetation units surveyed by distance sampling within the ARVS boundary (a combined area of 21,633 ha; Table 5.2), an estimate of 17,306 Western Ringtail Possums is yielded. Again, not all of this habitat would necessarily be utilised by Western Ringtail Possums and nor is it necessarily accurate to apply a uniform density across the region encompassed by the mapping. However, the approach does indicate that the population estimate for the 'Around Albany' sub-population is considerably larger than the 500 reported in the IUCN assessment, perhaps by an order of magnitude.

**Table 5.2: Broader extent of the sampled vegetation units within the ARVS (Sandiford and Barret 2010) and the estimated abundance of Western Ringtail Possum given an average density of 0.5 ha<sup>-1</sup>.**

Vegetation Unit	ARVS Occurrence	Abundance Estimate at 0.8 ha <sup>-1</sup>
Coastal <i>Banksia illicifolia</i> / Peppermint Low Woodland (Unit 4)	506 ha (411 ha in Reserves)	405 (329 in Reserves)
Marri / Jarrah Forest / Peppermint Woodland (Unit 10)	1,597 ha (516 ha in Reserves)	1,278 (413 in Reserves)
Jarrah/Marri Sheoak laterite forest (Unit 12)	13,144 ha (5,264 ha in Reserves)	10,515 (4,211 in Reserves)
Jarrah/Sheoak/ <i>Eucalyptus staeri</i> Sandy Woodland (Unit 13)	5,148 ha (3,212 ha in Reserves)	4,118 (2,570 in Reserves)
Marri / Jarrah Coastal Hills Forest (Unit 17)	1,238 ha (990 ha in Reserves)	990 (792 in Reserves)
All units	21,633 ha (10,393)	17,306 (8,314 in Reserves)

Reserve equates to IUCN I-IV Reserves and Other Crown Reserves after Sandiford and Barrett (2010).

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# Appendix 1

## Raw Observation Data





**Appendix A1: Distance Sampling Raw Data (Project Area and Down Road Nature Reserve)**

Site	Abundance	Date	Time	Easting	Northing	Dominant Veg
ARR Strip sampling	1	20/7/18		574362	6127591	
ARR Strip sampling	1	20/7/18		574379	6127579	Jarrah/Marri
ARR Strip sampling	1	20/7/18		574347	6127595	Jarrah/Marri
ARR Strip sampling	1	16/7/18		574524	6128298	Cypress pine
ARR Strip sampling	1	16/7/18		577776	6124531	Jarrah/Marri
ARR Strip sampling	1	16/7/18		576673	6124705	Melaleuca
ARR Strip sampling	1	16/7/18		576650	6124735	Melaleuca
ARR Strip sampling	1	16/7/18		575989	6124871	Sydney Wattle
ARR Strip sampling	1	16/7/18		575366	6125041	Melaleuca
ARR Strip sampling	1	16/7/18		576309	6124811	Melaleuca
ARR Strip sampling	1	16/7/18		576350	6124802	Melaleuca
ARR Strip sampling	1	12/7/18		575158	6125098	Melaleuca
ARR Strip sampling	1	12/7/18		574432	6125514	
CSBP_ARR Distance sampling	1	16/7/18	21:41	578359	6124488	Melaleuca
CSBP_ARR Distance sampling	1	16/7/18	21:23	578443	6124319	Jarrah/Marri
CSBP_ARR Distance sampling	1	14/7/18	19:01	578795	6124282	
Tip_ARR Distance sampling	1	13/7/18	21:17	573733	6126174	
Tip_ARR Distance sampling	1	13/7/18	23:54	574001	6126704	Jarrah/Marri
Tip_ARR Distance sampling	1	13/7/18	22:35	573726	6126916	Allocasuarina
Tip_ARR Distance sampling	1	13/7/18	21:32	573883	6126322	Allocasuarina

**Appendix A2: Down Road Nature Reserve Distance Sampling**

Distance	Size	Person	Date	Time	Easting	Northing	Zone	Dominant_Veg
14.223	1	Stewart Ford	10/7/18	7:54	568205	6132162	50	Allocasuarina
14.766	1	Stewart Ford	15/7/18	10:46	568553	6132426	50	Allocasuarina
12.576	1	Stewart Ford	15/7/18	10:51	568555	6132431	50	Allocasuarina
17.046	1	Roy Teale	15/7/18	11:44	568512	6132759	50	Allocasuarina
18.412	1	Roy Teale	15/7/18	11:59	568513	6132730	50	Allocasuarina
8.749	1	Roy Teale	15/7/18	11:52	568485	6132656	50	Allocasuarina
2.667	1	Roy Teale	20/7/18	6:40	570565	6131108	50	Allocasuarina
12.902	1	Roy Teale	20/7/18	6:43	570550	6131124	50	Allocasuarina
20.571	1	Roy Teale	20/7/18	8:53	569928	6130761	50	Jarrah/Marri
7.789	1	Roy Teale	20/7/18	9	569974	6130748	50	Allocasuarina
12.34	1	Roy Teale	20/7/18	9:05	570001	6130752	50	Jarrah/Marri
7.007	1	Roy Teale	20/7/18	7:58	570041	6130672	50	Jarrah/Marri
18.566	1	Roy Teale	18/7/18	9:23	569763	6129973	50	Jarrah/Marri
13.684	1	Roy Teale	18/7/18	9:36	569629	6129979	50	Jarrah/Marri
7.789	1	Roy Teale	18/7/18	9:40	569602	6129985	50	Allocasuarina
7.889	1	Roy Teale	18/7/18	9:41	569597	6129985	50	Allocasuarina
12.939	1	Roy Teale	10/7/18	7:26	567906	6132436	50	Jarrah/Marri
5.564	1	Roy Teale	10/7/18	7:35	567899	6132413	50	Jarrah/Marri
4.831	1	Roy Teale	10/7/18	8:42	567973	6132508	50	Jarrah/Marri
2.189	1	Roy Teale	10/7/18	8:48	567971	6132524	50	Hakea
14.132	1	Roy Teale	15/7/18	6:53	568331	6132773	50	Jarrah/Marri
34.082	1	Roy Teale	15/7/18	7:38	568302	6132381	50	Allocasuarina
9.21	1	Roy Teale	15/7/18	7:49	568333	6132365	50	Jarrah/Marri
4.008	1	Roy Teale	15/7/18	8:32	568343	6131884	50	Jarrah/Marri

Distance	Size	Person	Date	Time	Easting	Northing	Zone	Dominant_Veg
2.642	1	Roy Teale	15/7/18	8:50	568340	6131748	50	Jarrah/Marri
4.099	1	Roy Teale	15/7/18	8:53	568342	6131744	50	Allocasuarina
14.856	1	Roy Teale	15/7/18	9:29	568501	6131564	50	Allocasuarina
5.383	1	Roy Teale	17/7/18	8:31	568778	6131316	50	Jarrah/Marri
3.095	1	Roy Teale	17/7/18	8:32	568780	6131312	50	Jarrah/Marri
13.58	1	Roy Teale	17/7/18	8:52	568796	6131151	50	Jarrah/Marri
9.202	1	Roy Teale	17/7/18	8:56	568773	6131129	50	Jarrah/Marri
4.823	2	Roy Teale	17/7/18	9:22	568775	6130906	50	Jarrah/Marri
1.366	1	Roy Teale	17/7/18	9:29	568779	6130865	50	Allocasuarina
10.93	1	Roy Teale	18/7/18	0:26	568795	6131422	50	Jarrah/Marri
12.395	1	Roy Teale	17/7/18	10:17	568843	6130889	50	Allocasuarina
5.103	1	Roy Teale	17/7/18	11:13	568854	6131398	50	Jarrah/Marri
4.831	1	Roy Teale	17/7/18	11:36	568856	6131603	50	Jarrah/Marri
9.934	1	Roy Teale	17/7/18	11:41	568851	6131632	50	Jarrah/Marri
12.214	1	Stewart Ford	17/7/18	11:00	568923	6131573	50	Jarrah/Marri
17.012	1	Stewart Ford	20/7/18	6:44	570508	6131169	50	Allocasuarina
11.458	1	Stewart Ford	20/7/18	6:51	570471	6131198	50	Melaleuca
25.232	1	Stewart Ford	20/7/18	7:01	570328	6131213	50	Allocasuarina
10.235	1	Stewart Ford	20/7/18	7:51	569929	6130976	50	Jarrah/Marri
3.108	1	Stewart Ford	20/7/18	8:26	569825	6130894	50	Allocasuarina
5.674	1	Stewart Ford	20/7/18	8:43	569949	6130896	50	Jarrah/Marri
0.662	1	Stewart Ford	20/7/18	8:47	569999	6130891	50	Allocasuarina
9.894	1	Stewart Ford	18/7/18	7:35	569580	6130078	50	Jarrah/Marri
1.223	2	Stewart Ford	18/7/18	7:48	569731	6130066	50	Jarrah/Marri
3.448	1	Stewart Ford	18/7/18	8:40	569993	6129919	50	Jarrah/Marri
8.341	1	Stewart Ford	18/7/18	9:13	569655	6129926	50	Allocasuarina
10.005	2	Stewart Ford	18/7/18	9:20	569542	6129909	50	Allocasuarina
8.107	1	Stewart Ford	10/7/18	8:16	568197	6131951	50	Allocasuarina
11.12	1	Stewart Ford	10/7/18	9:29	568254	6131705	50	Jarrah/Marri
18.412	1	Stewart Ford	15/7/18	7:28	568401	6132767	50	Jarrah/Marri
18.774	1	Stewart Ford	15/7/18	8:07	568398	6132319	50	Allocasuarina
18.865	2	Stewart Ford	15/7/18	8:37	568433	6131895	50	Jarrah/Marri
4.28	1	Stewart Ford	15/7/18	9:05	568417	6131679	50	Allocasuarina
4.741	1	Stewart Ford	17/7/18	7:38	568639	6131238	50	Jarrah/Marri
0.181	1	Stewart Ford	17/7/18	7:44	568634	6131187	50	Allocasuarina
4.198	1	Stewart Ford	17/7/18	8:13	568628	6130994	50	Allocasuarina
9.844	1	Stewart Ford	17/7/18	9:01	568714	6130712	50	Allocasuarina
8.93	1	Stewart Ford	17/7/18	10:06	568701	6131466	50	Jarrah/Marri
28.239	1	Roy Teale	20/7/18	8:36	569843	6130713	50	Jarrah/Marri
17.463	1	Roy Teale	20/7/18	8:09	569946	6130648	50	Jarrah/Marri
29.904	2	Roy Teale	20/7/18	8:15	569912	6130636	50	Allocasuarina
5.113	1	Roy Teale	20/7/18	8:19	569910	6130671	50	Allocasuarina
6.897	1	Roy Teale	18/7/18	7:44	569679	6130136	50	Jarrah/Marri
10.125	1	Roy Teale	18/7/18	8:14	569975	6130130	50	Allocasuarina
7.448	1	Roy Teale	18/7/18	8:39	569983	6129983	50	Allocasuarina
7.007	1	Roy Teale	18/7/18	11:31	569626	6129700	50	Allocasuarina
1.664	1	Stewart Ford	20/7/18	8:58	570193	6130887	50	Allocasuarina

<b>Distance</b>	<b>Size</b>	<b>Person</b>	<b>Date</b>	<b>Time</b>	<b>Easting</b>	<b>Northing</b>	<b>Zone</b>	<b>Dominant_Veg</b>
1.333	1	Stewart Ford	20/7/18	8:59	570200	6130887	50	Jarra/Marri
5.113	1	Stewart Ford	18/7/18	7:55	569766	6130072	50	Allocasuarina
15.348	1	Stewart Ford	18/7/18	8:02	569858	6130081	50	Allocasuarina
0.561	2	Stewart Ford	18/7/18	8:08	569920	6130066	50	Allocasuarina
2.897	1	Stewart Ford	18/7/18	8:13	569955	6130068	50	Allocasuarina
6.446	1	Stewart Ford	18/7/18	11:09	569784	6129623	50	Allocasuarina
2.446	1	Stewart Ford	18/7/18	11:28	569568	6129621	50	Jarra/Marri
11.21	1	Stewart Ford	10/7/18	9:57	568255	6132003	50	Jarra/Marri
10.1	1	Roy Teale	15/7/18	-	-	-	50	-
21	1	Zoe Hamilton	13/7/18	9:17	-	-	50	-
25.1	1	Zoe Hamilton	13/7/18	11:54	-	-	50	Jarra/Marri
2.33	1	Zoe Hamilton	13/7/18	10:35	-	-	50	Allocasuarina
7.34	1	Zoe Hamilton	13/7/18	9:32	-	-	50	Allocasuarina