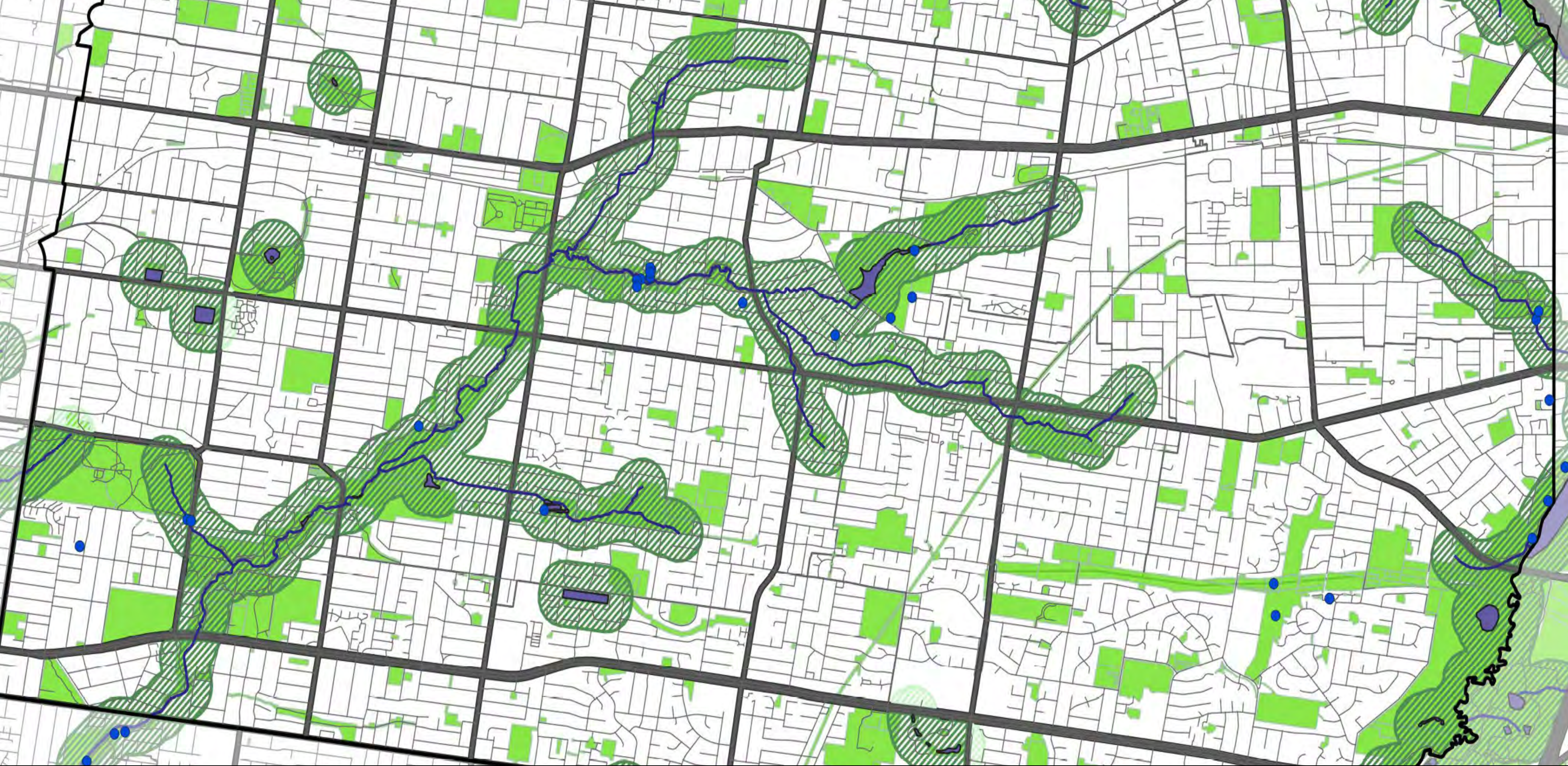

Wildlife habitat connectivity across the City of Whitehorse

Amy K. Hahs, Estibaliz Palma and Luis Mata

Cover photo by Luis Mata **'Blue-banded bee at Bushy Creek Reserve, Box Hill North'**

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Wildlife habitat connectivity across the City of Whitehorse

Report prepared for Whitehorse City Council

August 2021

by

Amy K. Hahs
Estibaliz Palma
Luis Mata

School of Ecosystem and Forest Sciences, The University of Melbourne

Acknowledgements

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Contents

1 Background

Whitehorse City Council is currently working to develop their next round of policy documents related to biodiversity and greenspace in their municipality. They invited researchers at The University of Melbourne to assist them with compiling baseline information related to a preliminary analysis of existing biodiversity, and wildlife habitat connectivity that can be used to inform future actions. This report presents the outcomes from those analyses.

1.1. What is the composition and distribution of species recorded in the municipality?

Biodiversity baseline from Atlas of Living Australia records and other datasets

We downloaded plant, fungi, and animal records from the Atlas of Living Australia for an area covering the City of Whitehorse and a 1 km buffer in the five adjacent LGAs (Boroondara, Knox, Maroondah, Manningham, and Monash). We also included in the dataset additional records provided by Whitehorse City Council.

We removed records with no species level taxonomic information and standardised species names following the Atlas of Living Australia taxonomy. We used this dataset to produce a summary table with:

1. Information related to the species, such as the main taxonomic group – including amphibians, arachnids, birds, fungi, insects, mammals, other invertebrates, plants, and reptiles – and subgroup (e.g. main insect orders such as Diptera (Flies) and Lepidoptera (Moths and Butterflies)). The origin (native or introduced) and EPBC/FFG status for all species was also included, which were based on the definitions of origin documented in the Victorian Biodiversity Atlas and the Federal Department of Environment websites.

2. Information related to the number of records and their distribution in time (year of earliest record, most recent record, and earliest record post 1990)

Table 1.1 Summary of total species richness

	Only in Whitehorse			**Only in buffer**			**Both in Whitehorse and buffer**			**Total**
Main group	Introduced	Native	Total	Introduced	Native	Total	Introduced	Native	Total	
Arachnids		73	73		7	7		26	26	106
Birds	3	32	35	3	26	29	12	190	202	266
Frogs	1	2	3		2	2		10	10	15
Fungi		113	113		49	49	3	65	68	230
Insects		711	711		22	22	2	100	102	835
Mammals	2	5	7		2	2	6	18	24	33
Other invertebrates		16	16		9	9	2	10	12	37
Plants	282	286	568	48	87	135	218	321	539	1242
Reptiles		6	6		3	3		11	11	20
Totals	**288**	**1244**	**1532**	**51**	**207**	**258**	**243**	**751**	**994**	**2784**

Table 1.2 Summary of species richness for Arachnids

	Only in Whitehorse			**Only in buffer**			**Both in Whitehorse and buffer**			**Total**
Main group	Introduced	Native	Total	Introduced	Native	Total	Introduced	Native	Total	
Harvestmen					1	1				1
Mites		1	1		2	2				3
Pseudoscorpions		2	2							2
Scorpions		1	1							1
Spiders		69	69		4	4		26	26	99
Totals		**73**	**73**		**7**	**7**		**26**	**26**	**106**

Table 1.3 Summary of species richness for Birds

	Only in Whitehorse			Only in buffer			Both in Whitehorse and buffer			Total
Main group	Introduced	Native	Total	Introduced	Native	Total	Introduced	Native	Total	
Birds of prey		4	4		3	3		16	16	23
Bushbirds		5	5	1	1	2	2	20	22	29
Parrots	1		1	1	2	3		20	20	24
Seabirds		3	3		9	9		11	11	23
Songbirds	1	15	16	1	7	8	9	89	98	122
Waterbirds	1	5	6		4	4	1	34	35	45
Totals	**3**	**32**	**35**	**3**	**26**	**29**	**12**	**190**	**202**	**266**

Table 1.4 Summary of species richness for Frogs

	Only in Whitehorse			Only in buffer			Both in Whitehorse and buffer			Total
Main group	Introduced	Native	Total	Introduced	Native	Total	Introduced	Native	Total	
Ground frogs	1		1					3	3	4
Tree frogs		2	2					5	5	7
Water frogs					2	2		2	2	4
Totals	**1**	**2**	**3**		**2**	**2**		**10**	**10**	**15**

Table 1.5 Summary of species richness for Fungi

	Only in Whitehorse			Only in buffer			Both in Whitehorse and buffer			Total
Main group	Introduced	Native	Total	Introduced	Native	Total	Introduced	Native	Total	
Club fungi		101	101		37	37	3	62	65	203
Sac fungi		12	12		12	12		3	3	27
Totals		**113**	**113**		**49**	**49**	**3**	**65**	**68**	**230**

Table 1.6 Summary of species richness for Insects

	Only in Whitehorse			Only in buffer			Both in Whitehorse and buffer			Total
Main group	Introduced	Native	Total	Introduced	Native	Total	Introduced	Native	Total	
Alderflies		1	1							1
Ants		16	16					3	3	19
Bark lice		1	1							1
Bees		25	25				1	1	2	27
Beetles		119	119		7	7		15	15	141
Butterflies		19	19				1	10	11	30
Caddisflies		3	3							3
Cicadas		4	4		1	1		2	2	7
Cockroaches		4	4					2	2	6
Dragonflies and Damselflies		3	3		1	1		13	13	17
Earwigs								1	1	1
Flies		33	33		3	3		7	7	43
Grasshoppers and Crickets		5	5		3	3		2	2	10
Heteropteran bugs		23	23		1	1		2	2	26
Jumping plant lice		1	1							1
Lacewings		19	19					1	1	20
Leafhoppers and Treehoppers		5	5							5
Mantises					1	1		2	2	3
Moths		372	372		5	5		33	33	410
Parasitoid wasps		18	18							18
Planthoppers		4	4					1	1	5
Sawflies		13	13							13
Scale insects		2	2					1	1	3
Stick insects		1	1							1
Stinging wasps		17	17					4	4	21
Thrips		3	3							3
Totals		**711**	**711**		**22**	**22**	**2**	**100**	**102**	**835**

Table 1.7 Summary of species richness for Mammals

	Only in Whitehorse			Only in buffer			Both in Whitehorse and buffer			Total
Main group	Introduced	Native	Total	Introduced	Native	Total	Introduced	Native	Total	
Bats		1	1		2	2		7	7	10
Carnivore mammals	1		1				2		2	3
Hares and Rabbits							1		1	1
Hoofed mammals	1		1							1
Marsupials		4	4					8	8	12
Mice and Rats							3	1	4	4
Platypus and Echidnas								2	2	2
Totals	**2**	**5**	**7**		**2**	**2**	**6**	**18**	**24**	**33**

Table 1.8 Summary of species richness for Other invertebrates

	Only in Whitehorse			Only in buffer			Both in Whitehorse and buffer			Total
Main group	Introduced	Native	Total	Introduced	Native	Total	Introduced	Native	Total	
Centipedes		1	1							1
Crustaceans		2	2		3	3		3	3	8
Flatworms		7	7					1	1	8
Millepedes		1	1				1	1	2	3
Mollusks		4	4		6	6	1	5	6	16
Springtails		1	1							1
Totals		**16**	**16**		**9**	**9**	**2**	**10**	**12**	**37**

Table 1.9 Summary of species richness for Plants

	Only in Whitehorse			Only in buffer			Both in Whitehorse and buffer			Total
Main group	Introduced	Native	Total	Introduced	Native	Total	Introduced	Native	Total	
Clubmosses		1	1					1	1	2
Conifers	6		6				1		1	7
Eudicots	207	139	346	24	42	66	150	184	334	746
Ferns	1	15	16	1	2	3		4	4	23
Liverworts		8	8		1	1		2	2	11
Magnoliids	1	1	2					2	2	4
Monocots	64	92	156	22	40	62	66	116	182	400
Mosses	2	30	32	1	2	3	1	12	13	48
Water lilies	1		1							1
Totals	**282**	**286**	**568**	**48**	**87**	**135**	**218**	**321**	**539**	**1242**

Table 1.10 Summary of species richness for Reptiles

	Only in Whitehorse			Only in buffer			Both in Whitehorse and buffer			Total
Main group	Introduced	Native	Total	Introduced	Native	Total	Introduced	Native	Total	
Geckos								1	1	1
Skinks		3	3		2	2		6	6	11
Snakes		1	1		1	1		3	3	5
Turtles		2	2					1	1	3
Totals		**6**	**6**		**3**	**3**		**11**	**11**	**20**

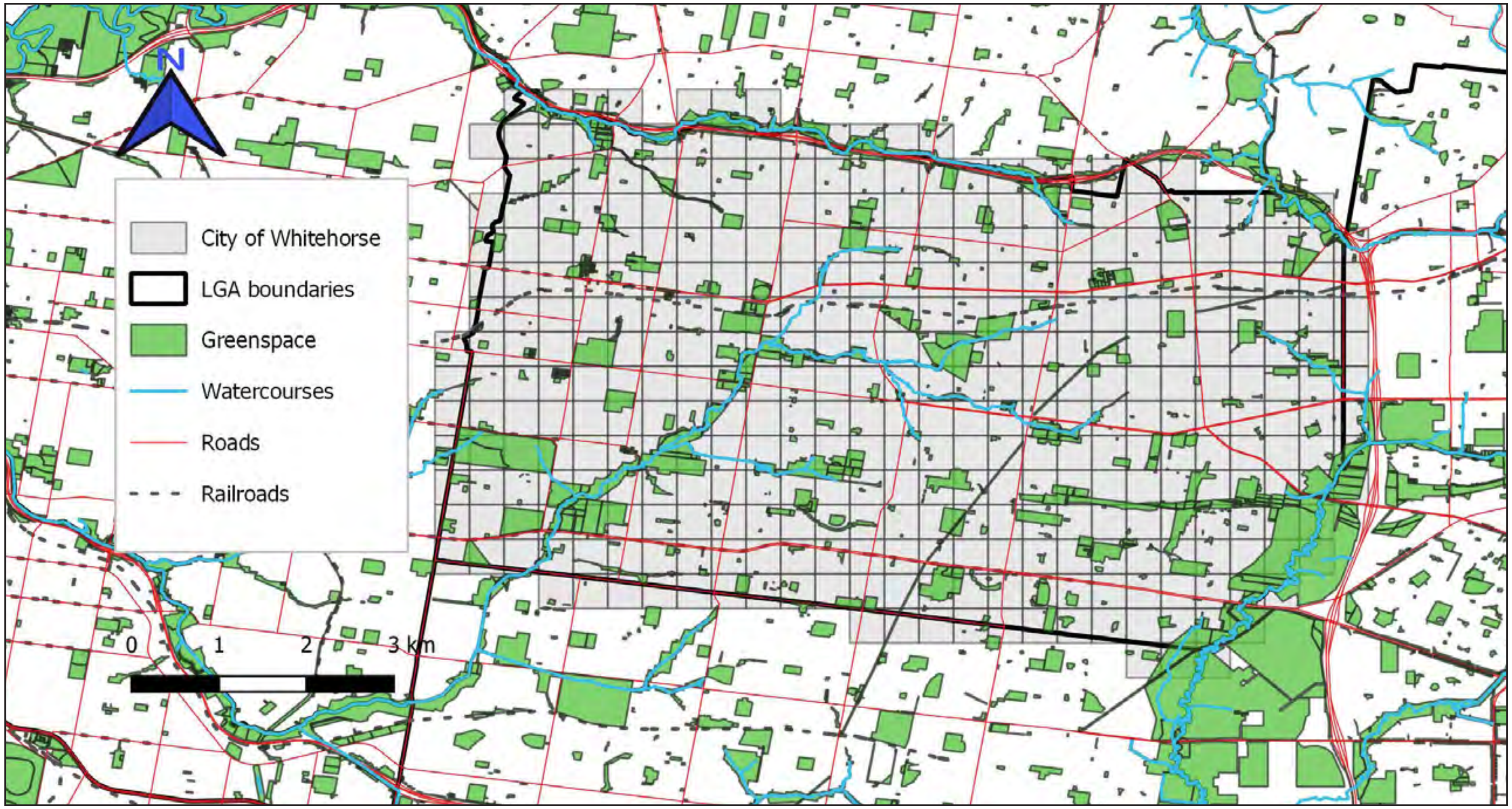


Figure 1.1 Legend map of the City of Whitehorse for grid-based biodiversity summaries. Each cell is 500x500 m.

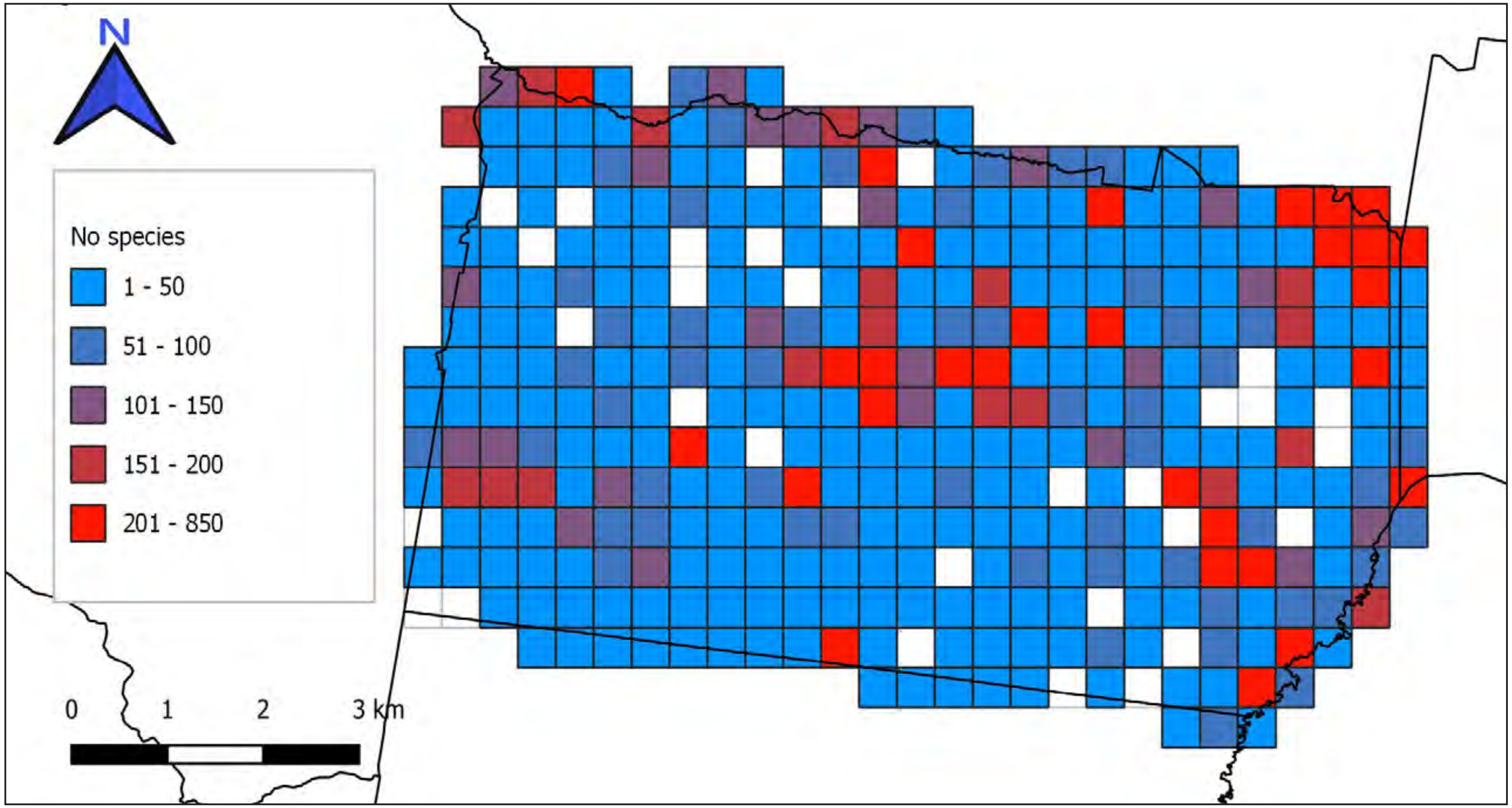


Figure 1.2 Total species richness by cell. The City of Whitehorse has been divided in 500mx500m cells. Empty cells represent areas where no species have been recorded.

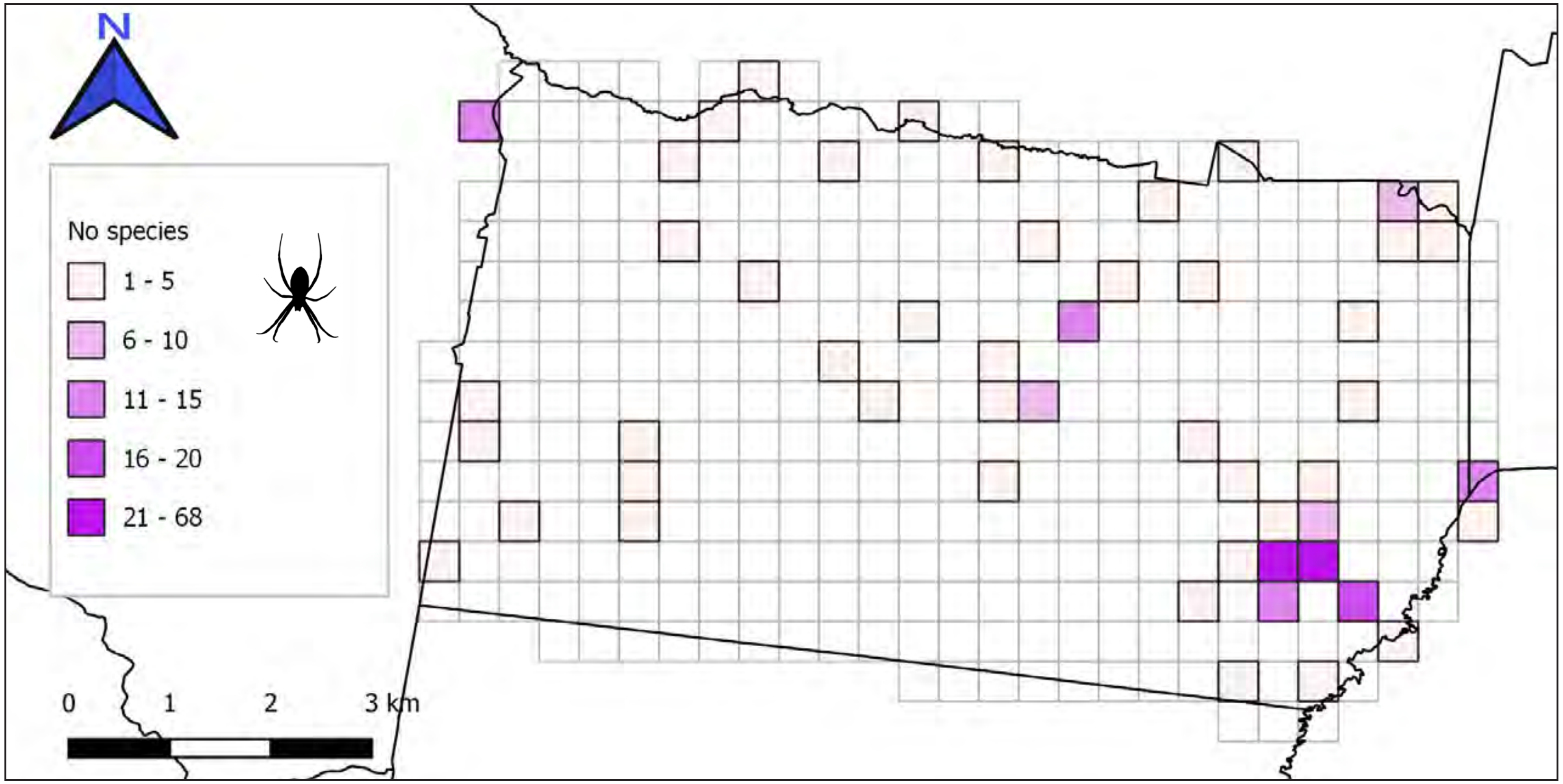


Figure 1.3 Species richness of arachnids by cell. The City of Whitehorse has been divided in 500mx500m cells. Empty cells represent areas where no arachnid species have been recorded.

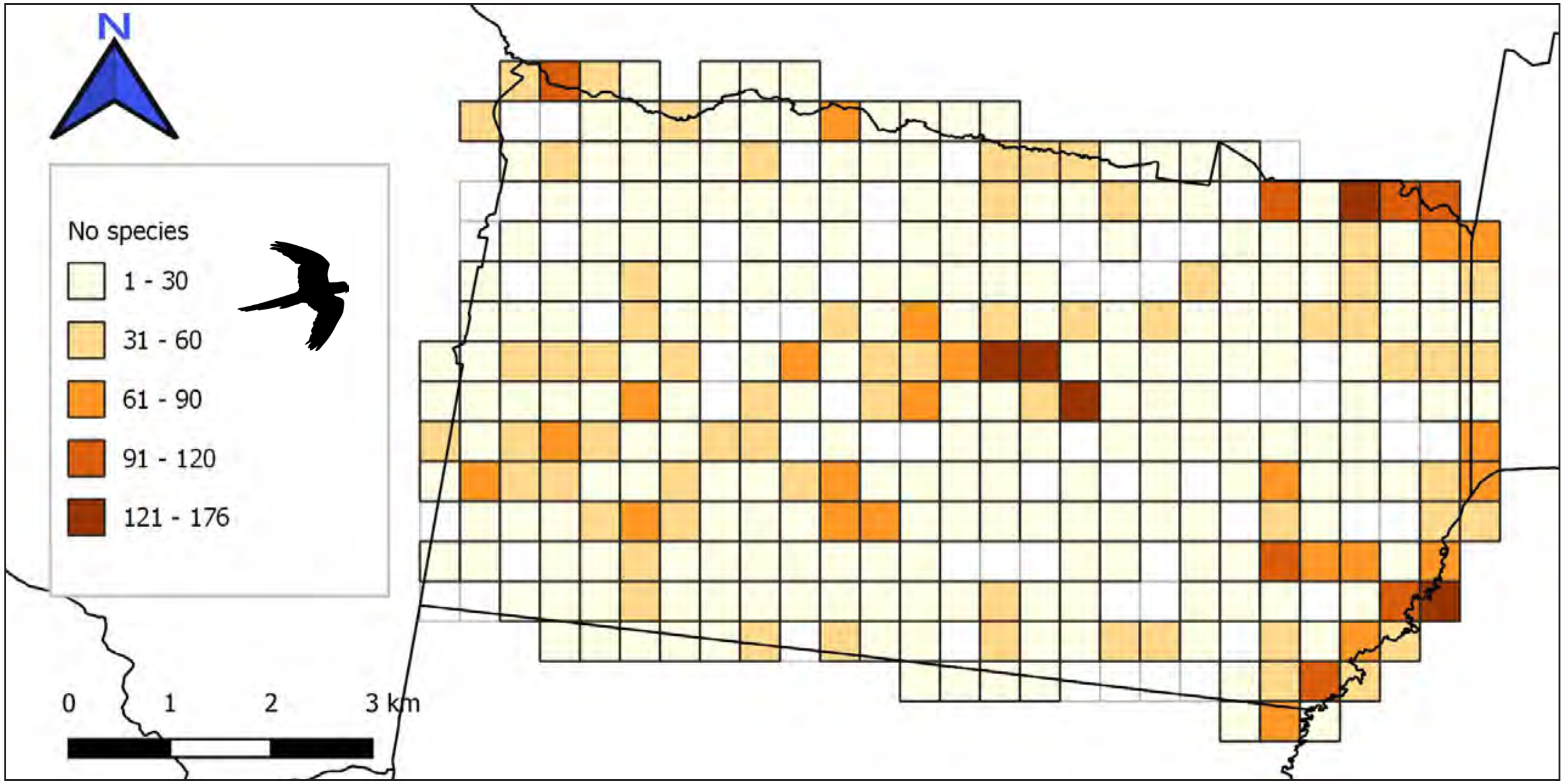


Figure 1.4 Species richness of birds by cell. The City of Whitehorse has been divided in 500mx500m cells. Empty cells represent areas where no bird species have been recorded.

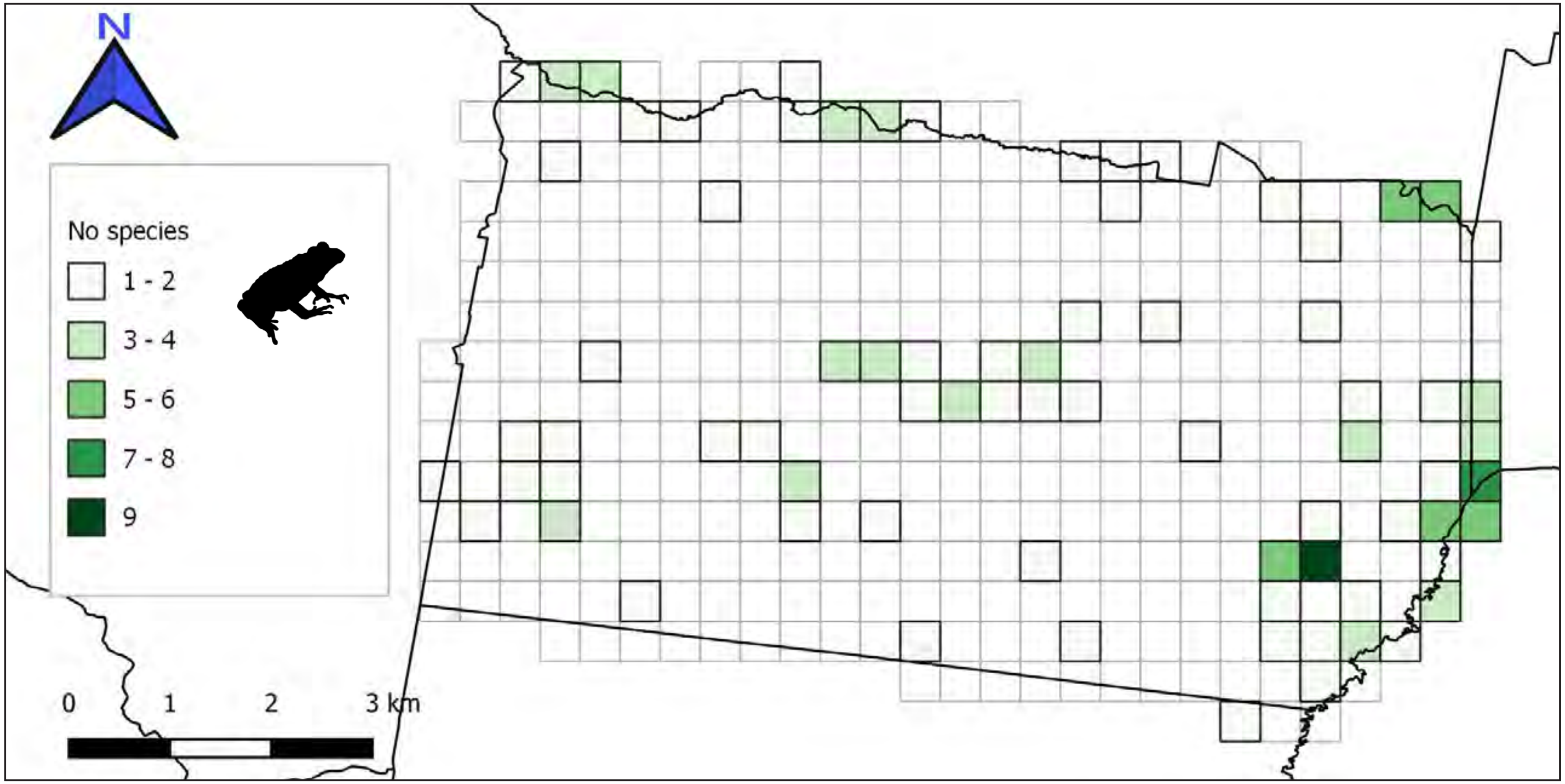


Figure 1.5 Species richness of amphibians by cell. The City of Whitehorse has been divided in 500mx500m cells. Empty cells represent areas where no amphibian species have been recorded.

Figure 1.6 Species richness of fungi by cell. The City of Whitehorse has been divided in 500mx500m cells. Empty cells represent areas where no fungi species have been recorded.

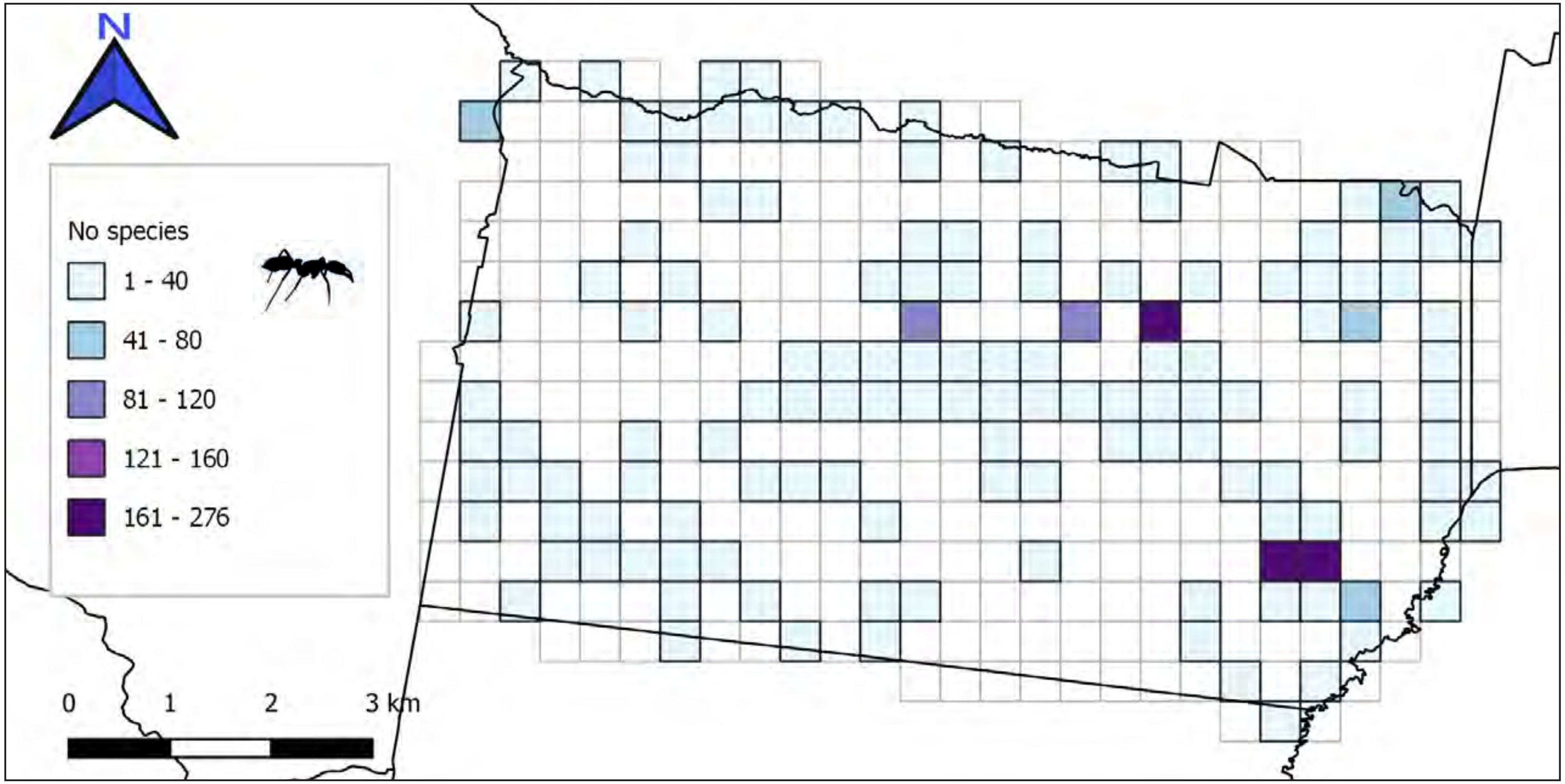


Figure 1.7 Species richness of insects by cell. The City of Whitehorse has been divided in 500mx500m cells. Empty cells represent areas where no insect species have been recorded.

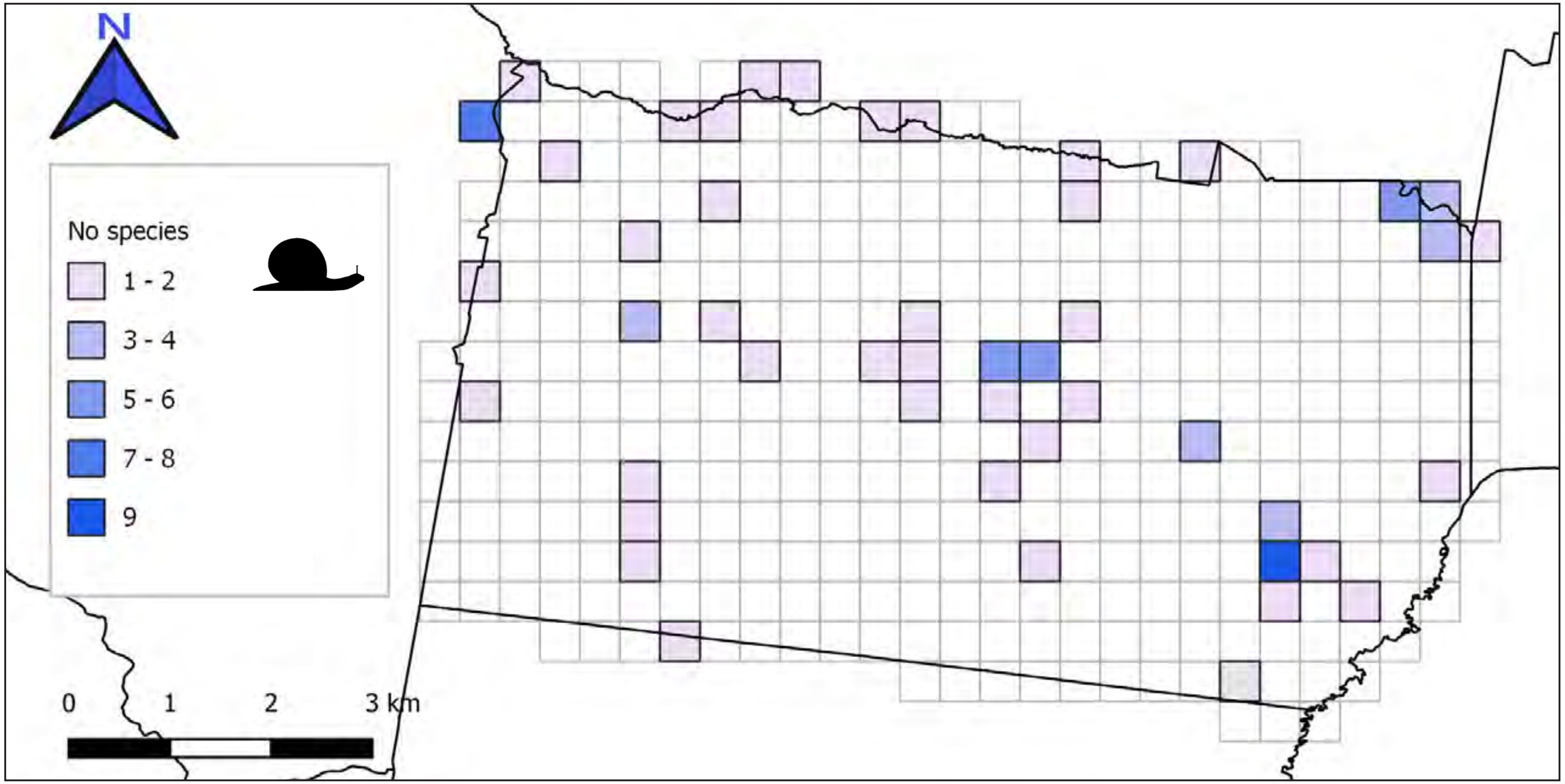


Figure 1.8 Species richness of other invertebrates by cell. The City of Whitehorse has been divided in 500mx500m cells. Empty cells represent areas where no other invertebrate species have been recorded.

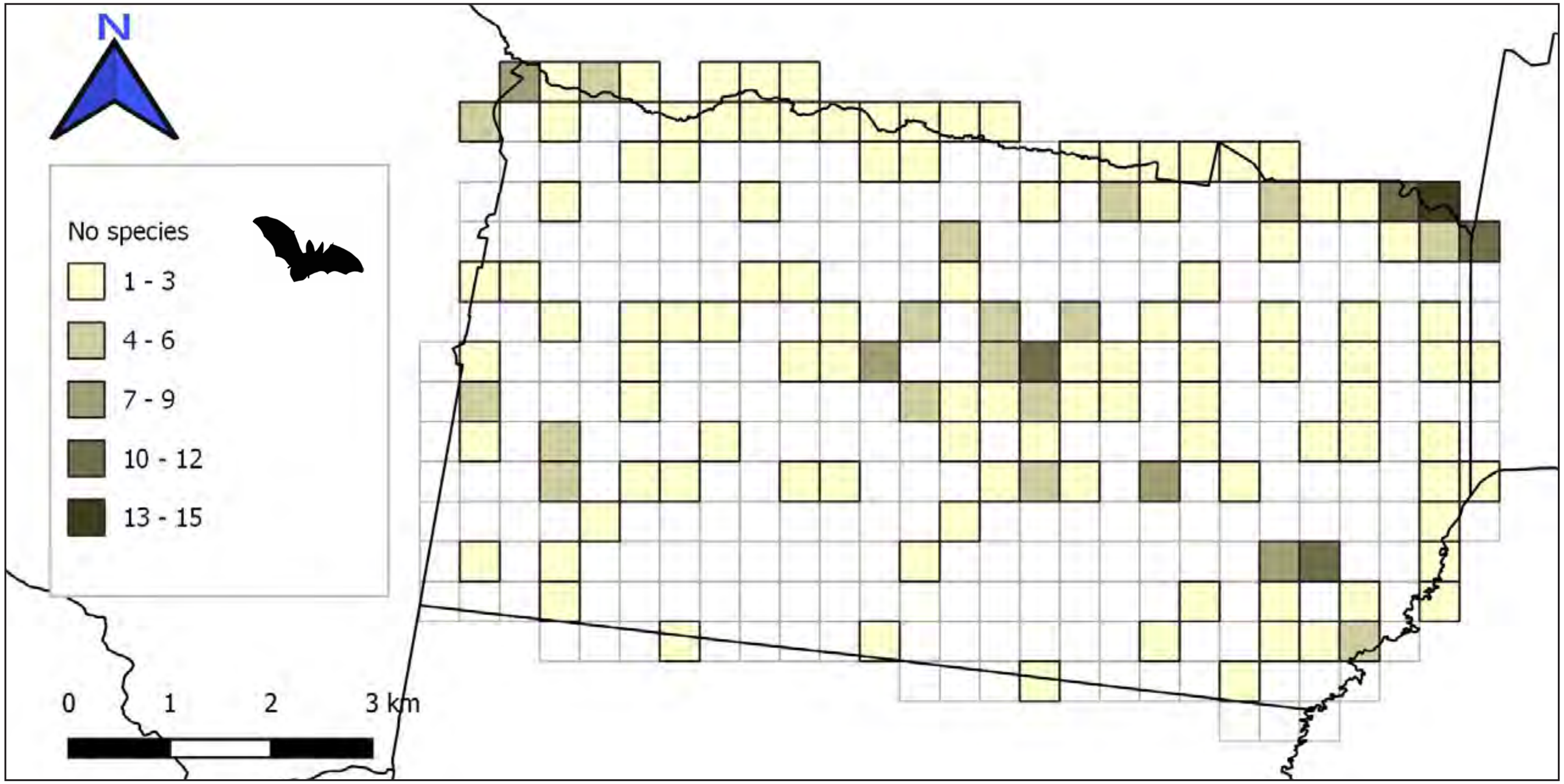


Figure 1.9 Species richness of mammals by cell. The City of Whitehorse has been divided in 500mx500m cells. Empty cells represent areas where no mammal species have been recorded.

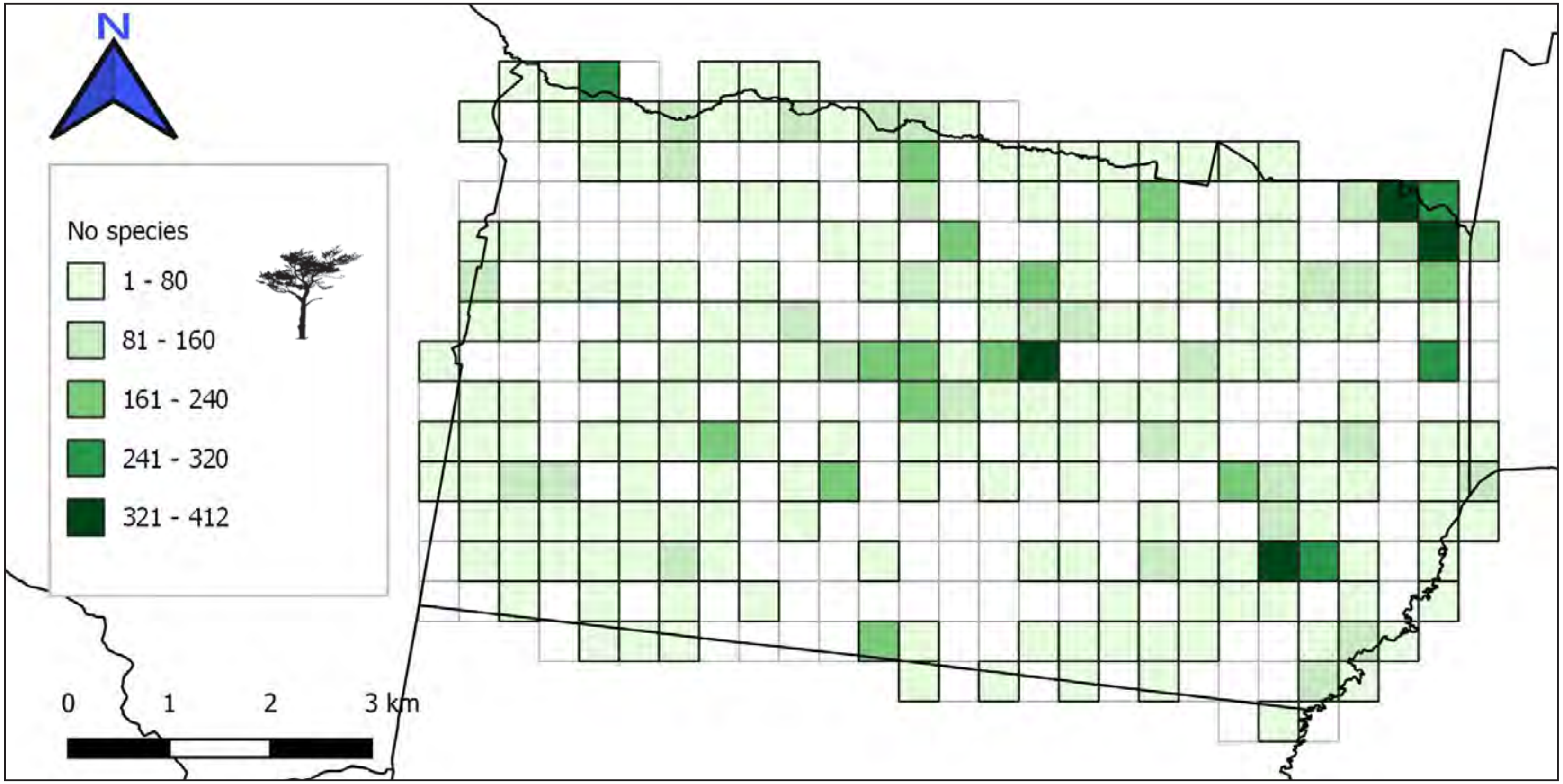


Figure 1.10 Species richness of plants by cell. The City of Whitehorse has been divided in 500mx500m cells. Empty cells represent areas where no plant species have been recorded.

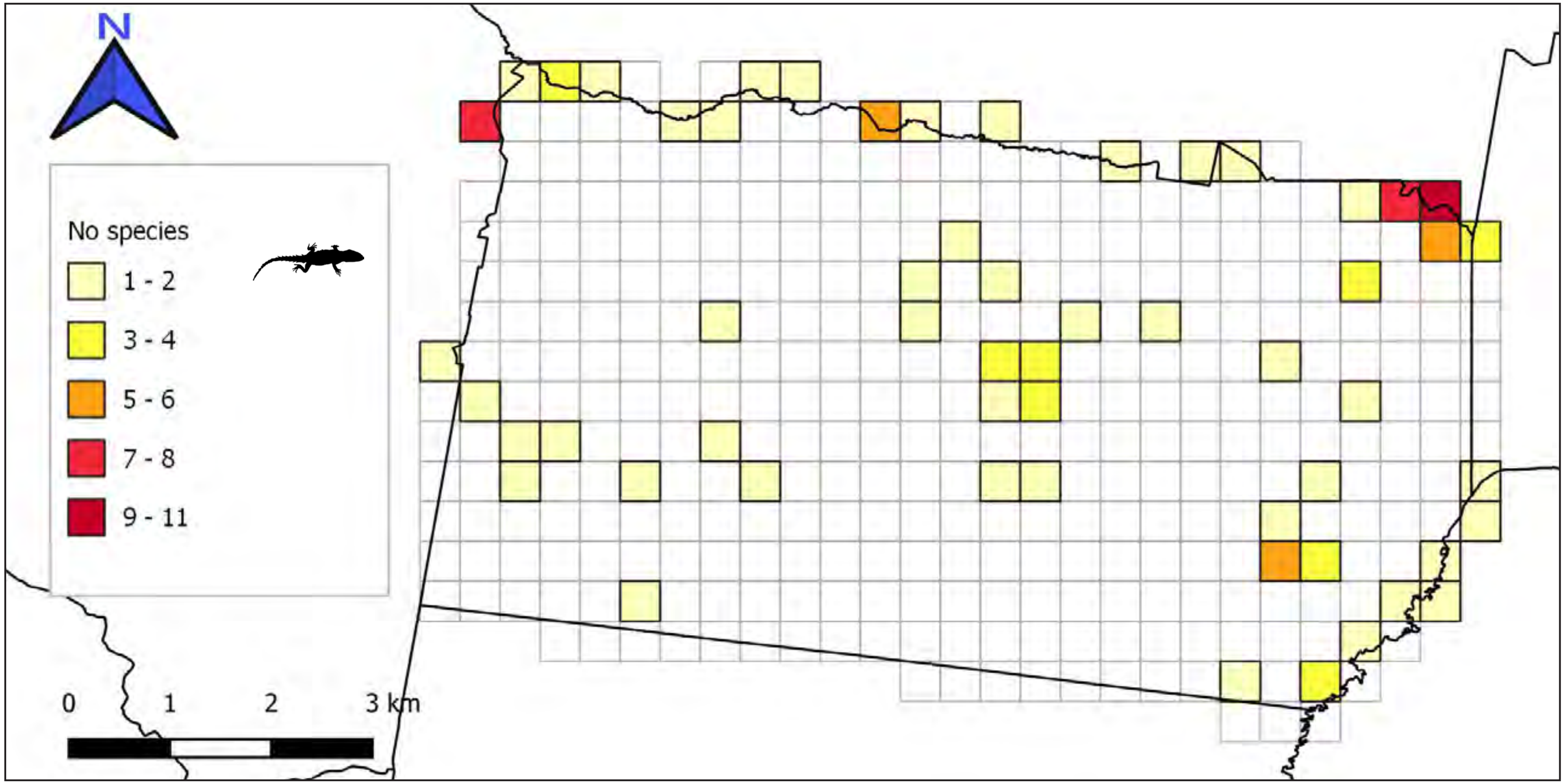


Figure 1.11 Species richness of reptiles by cell. The City of Whitehorse has been divided in 500mx500m cells. Empty cells represent areas where no reptile species have been recorded.

and space (proportion of records in Whitehorse versus the surrounding 1 km buffer).

The tables summarise over 157,000 records collected between 1770 and 2020 in the City of Whitehorse and a 1km outside buffer within its adjacent LGAs. Approximately 13,000 of these records came from datasets provided by the City of Whitehorse. In total, the records represent 2,784 species.

These tables were provided to Whitehorse City Council as Excel spreedsheets. Summaries of the number of species found exclusively in the City of Whitehorse, exclusively in the buffer area, and in both areas are given in Table 1.1-1.10.

Distribution of biodiversity based on Atlas of Living Australia records and other datasets

We mapped the distribution of records and the species richness for the main taxonomic groups using a 500 m x 500 m grid across the City of Whitehorse (Figures 1.1 - 1.11). Cells with a deeper shade indicate a higher number of species present.

With the exception of birds and plants, there are large areas of the municipality where there are no data in terms of species records. These areas could be used as focal locations for more detailed biodiversity surveys by taxa experts, or through community science crowdsourced biological surveys (e.g. Biodiversity Blitz or City Nature Challenge).

In the areas of the municipality where there are biodiversity records, the locations with the highest species richness for most taxa correspond with known natural areas within the municipality, such as Blackburn Lake Sanctuary, Bellbird Dell Reserve, and the Mullum Mullum Creek corridor and Yarran Dheran Reserve. While these locations are likely to support a higher diversity of species, it is possible that other areas within the municipality may support similar levels of diversity but have simply not been sampled with the same level of effort. The information obtained through additional surveys will help to fill out a more complete picture of biodiversity across the municipality.

2 Habitat connectivity

2.1 Where are the important habitat and connectivity opportunities for biodiversity?

In collaboration with the Whitehorse City Council project team, we identified a suite of 12 focal taxa to represent a (1) diverse array of taxonomic and functional groups of species within the municipality, and (2) range of different habitat requirements and movement capabilities. While habitat connectivity is also an important consideration for plants, for the purpose of this project the focus will be on mobile animal species.

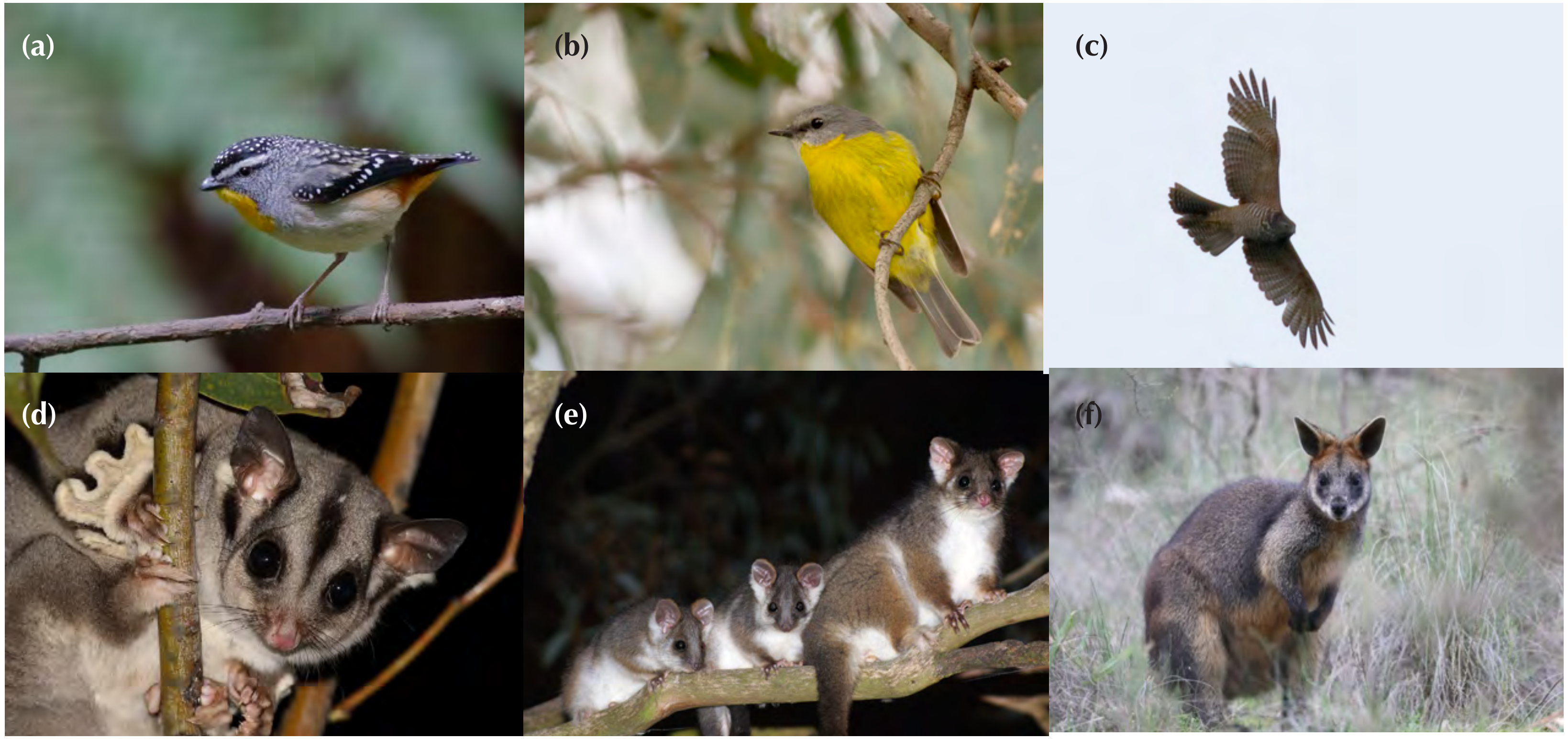
In a multistep process, the 12 focal taxa were conceptualised to represent a balanced selection in terms of:

- Habitat requirements (e.g. canopy, midstorey, understory, riparian/wetland)
- Dispersal distances
- Dispersal heights (ground vs aerial) or modes (flying vs walking)
- Taxonomic groups (e.g. amphibians, birds, insects, mammals, reptiles)

as well as:

- Number of records in the municipality
- Habitat requirements and dispersal information related to each species and the ability to represent this using existing spatial data sources
- Stories and meanings relevant to Whitehorse City Council initiatives and local interest.

The twelve focal taxa are presented in Table 2.1 and Figure 2.1. The selected taxa belong to many of the important species groups and habitat characteristics present in Whitehorse. Collectively they represent a diversity of (1) movements (ground and aerial);



(2) dispersal distances (0 m – 1500 m); (3) habitat needs (water, open areas, tree canopy, remnant vegetation, dark areas); and (4) the main animal groups present within Whitehorse, including one amphibian, three birds, two insects, four mammals (one bat and three marsupials), and two reptiles.

2.2 Habitat connectivity maps for individual focal groups

As the focal taxa were selected to deliberately represent a range of habitat requirements and dispersal characteristics, it is helpful to look at the individual connectivity maps to understand the different scales and opportunities for connectivity within Whitehorse. Here, we present the habitat

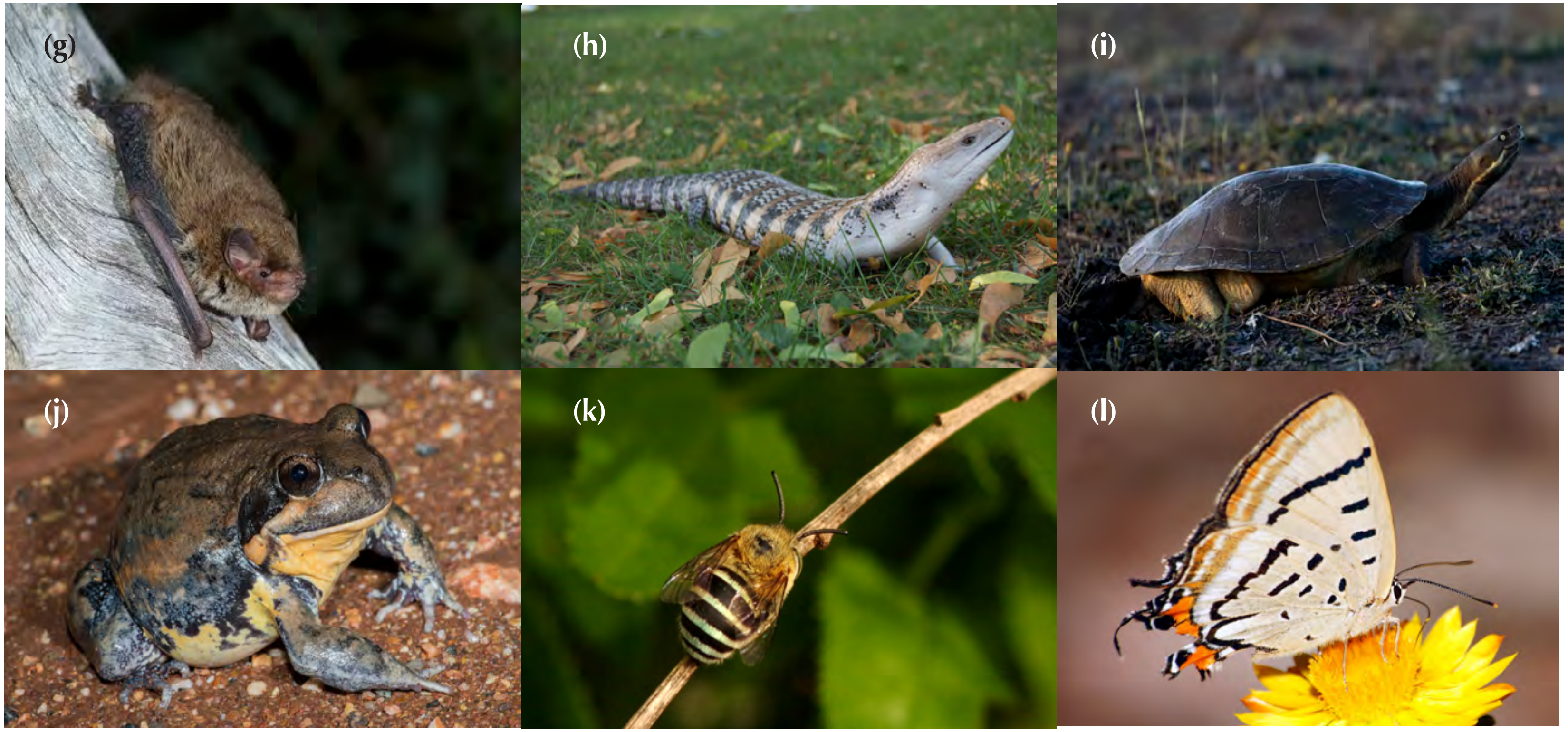


Figure 2.1 ***This and previous page*** Focal taxa of the study; (a) Spotted pardalote, (b) Eastern yellow robin, (c) Brown goshawk, (d) Sugar glider, (e) Common ringtail possum, (f) Swamp wallaby, (g) Little forest bat, (h) Common blue-tongued lizard, (i) Eastern long-necked turtle, (j) Pobblebonk, (k) Blue-banded bee and (l) Common imperial blue. Photos by Mark Sanders (g), David Cook (e, l), Ed Dunens (i), David Curtis (a, c), Patrick Kavanagh (b, d, f), David Nelson (j) and Luis Mata (k).

connectivity maps for each of the focal taxa. In the next section, this information will be synthesised to provide an overall understanding of wildlife habitat connectivity, and where there are opportunities to strengthen connectivity for multiple species through targeted actions.

2.2.1. Spotted pardalote | *Pardalotus punctatus*

The spotted pardalote is one of Australia's smallest birds. They build their nests in horizontal tunnels dug into the soil of creek banks, embankments,

Table 2.1 Characteristics of the twelve focal taxa

Focal taxa	Scientific name	Movement	Dispersal distance	Habitat connectivity representation
Spotted pardalote	*Pardalotus punctatus*	Aerial	Medium from tree canopy	Buffer of varying size around patches with *Eucalyptus* tree canopy; 150 m for patches <1 Ha, 500 m for patches 1-6 Ha, and 1300 m for patches >6 Ha
Eastern yellow robin	*Eopsaltria australis*	Aerial	Medium from shrub areas	Greenspace patch size >5 Ha. 75 m buffer around greenspaces, 189 m buffer around greenspaces with remnant vegetation
Brown goshawk	*Accipiter fasciatus*	Aerial	Large from riparian dense vegetation	234 m buffer around riparian dense vegetation
Sugar glider	*Petaurus breviceps*	Arboreal	Short from dense vegetation	30 m buffer around open space patches with remnant vegetation
Common ringtail possum	*Pseudocheirus peregrinus*	Arboreal	Medium from dense vegetation	400 m buffer around areas of dense vegetation
Swamp wallaby	*Wallabia bicolor*	Ground	Large around dense vegetation	300 m buffer around areas of dense vegetation to identify core habitat, and 1500 m buffer to identify islands of dense vegetation forming a corridor
Little forest bat	*Vespadelus vulturnus*	Aerial	Medium within darker nocturnal canopy areas	600 m buffer around open space patches with remnant vegetation, excluding areas with nocturnal light levels above 9 nW/cm2/sr (ideally <1 Lumen, but unable to represent this with available data)
Common blue-tongued lizard	*Tiliqua scincoides*	Ground	Large around open areas with shrubs and grass	1000 m buffer around greenspace with remnant vegetation
Eastern long-necked turtle	*Chelodina longicollis*	Ground	Medium around water	395 m buffer around waterbodies

Table 2.1 ***Cont.*** Characteristics of the twelve focal taxa

Focal taxa	Scientific name	Movement	Dispersal distance	Habitat connectivity representation
Pobblebonk	*Limnodynastes dumerilii*	Ground	Medium around water	200 m buffer around watercourses and waterbodies
Blue-banded bees	*Amegilla asserta* and *Amegilla chlorocyanea*	Aerial	Medium around areas with specific indigenous plant species	350m buffer around open space patches with records of known host plants (*Dianella* spp., *Pelargonium australe*, *Goodenia ovata*, *Isotoma axillaris*, *Crowea exalata*, *Bulbine bulbosa*, and *Wahlenbergia* spp.)
Common imperial blue	*Jalmenus evagoras*	Aerial	Limited around specific *Acacia* species	0 m buffer around open space patches with records of known host plants (*Acacia mearnsii*, *A. implexa*, and *A. melanoxylon*)

quarries, rabbit burrows, or potted plants in gardens. Spotted pardalotes forage in gum tree crowns, plucking psyllids and other invertebrates from leaves (Birdlife Australia 2021).

The map of habitat connectivity for the spotted pardalote is shown in Fig. 2.2a. Dark green areas represent open space that coincides with records of Eucalyptus, a genus on which spotted pardalote are know to forage. Spotted pardalote individuals have been found to fly between 150 m and 1.3 km from their nesting sites to find food (Doerr et al. 2004). Following this work, we defined the connectivity buffer for this species, presented in pale green in the map, as 150m around greenspace smaller than 1 ha, 500 m around those between 1 and 6 ha, and 1.3 km for greenspaces larger than 6 ha. The larger the area of the greenspace with Eucalyptus trees, the more likely it is that the pardalotes visit the site from further away. Watercourses are shown in the map in dark blue.

Habitat connectivity for the spotted pardalote within the City of Whitehorse could be promoted by increasing the presence of gum trees on open greenspaces (for foraging), particularly those around

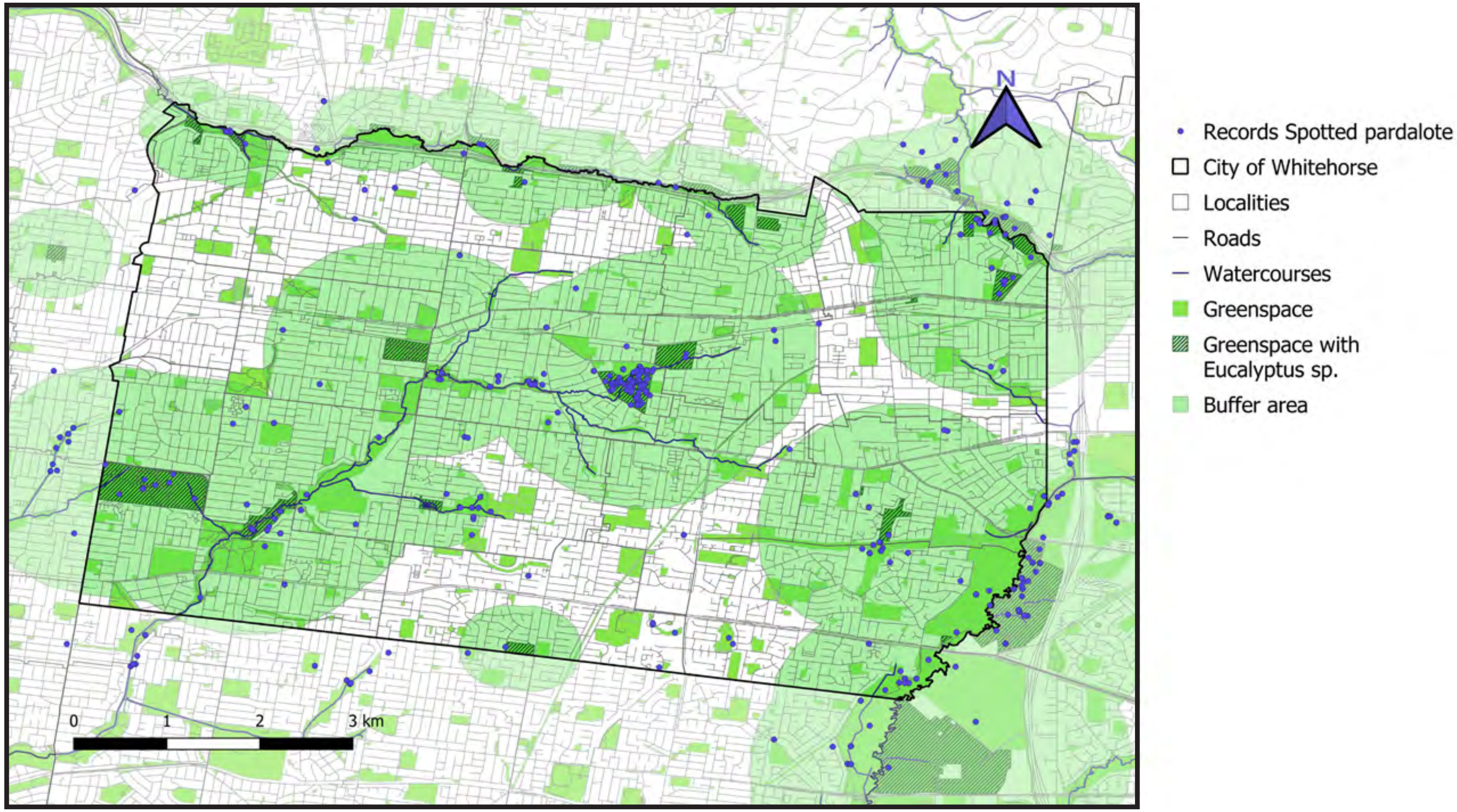


Figure 2.2a Map of habitat connectivity for the spotted pardalote *Pardalotus punctatus*.

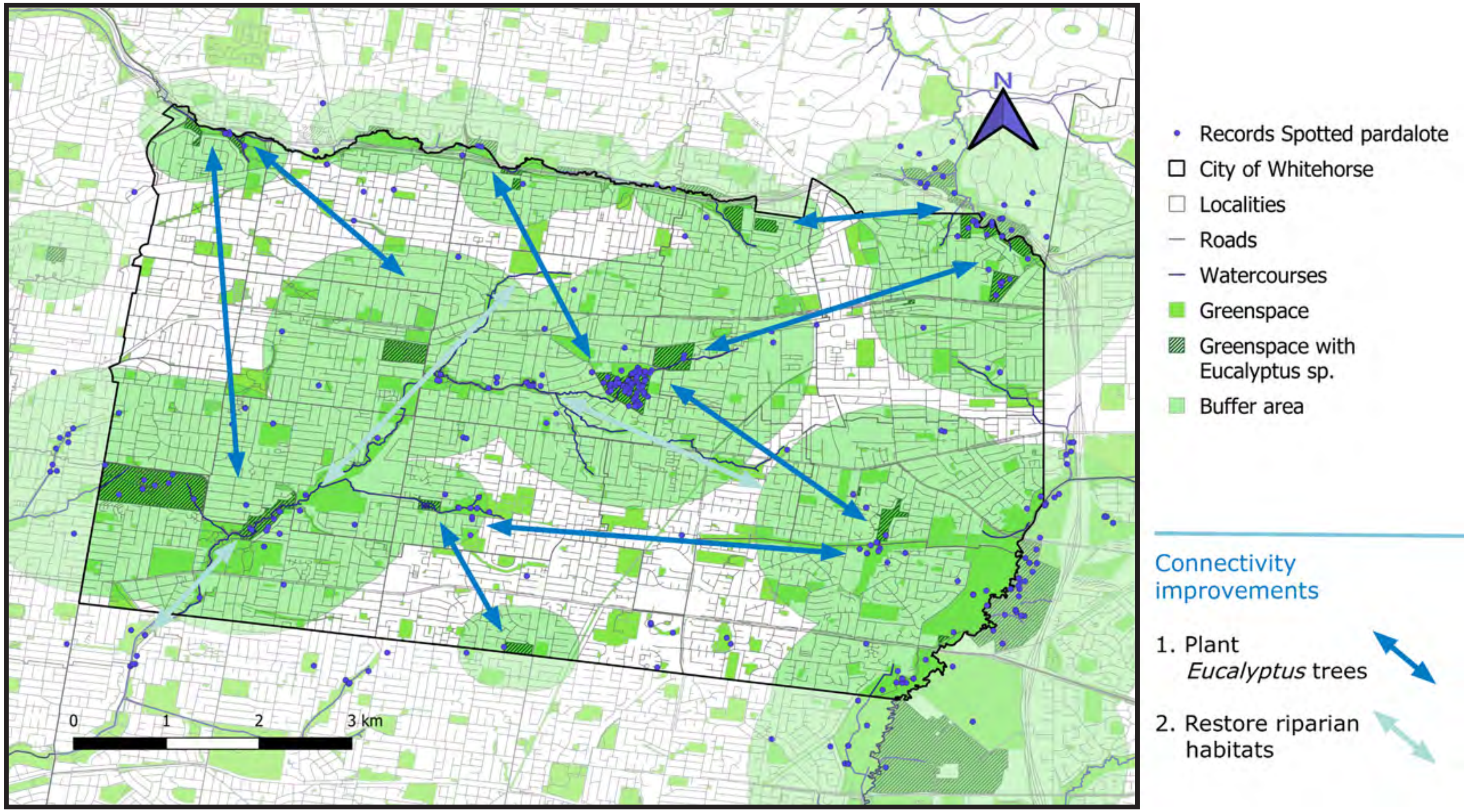


Figure 2.2b Suggested actions to improve habitat connectivity for the spotted pardalote *Pardalotus punctatus*.

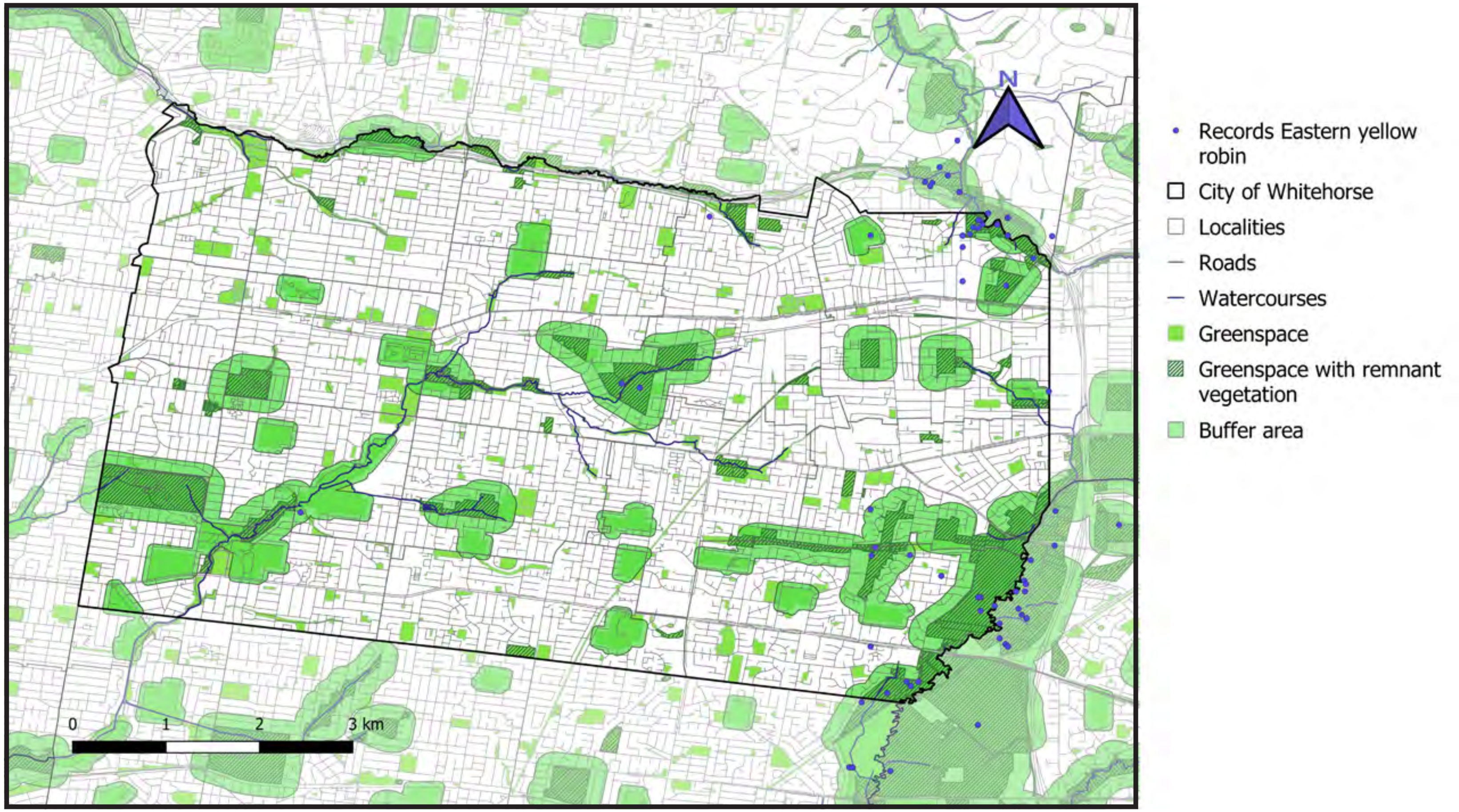


Figure 2.3a Map of habitat connectivity for the eastern yellow robin *Eopsaltria australis*.

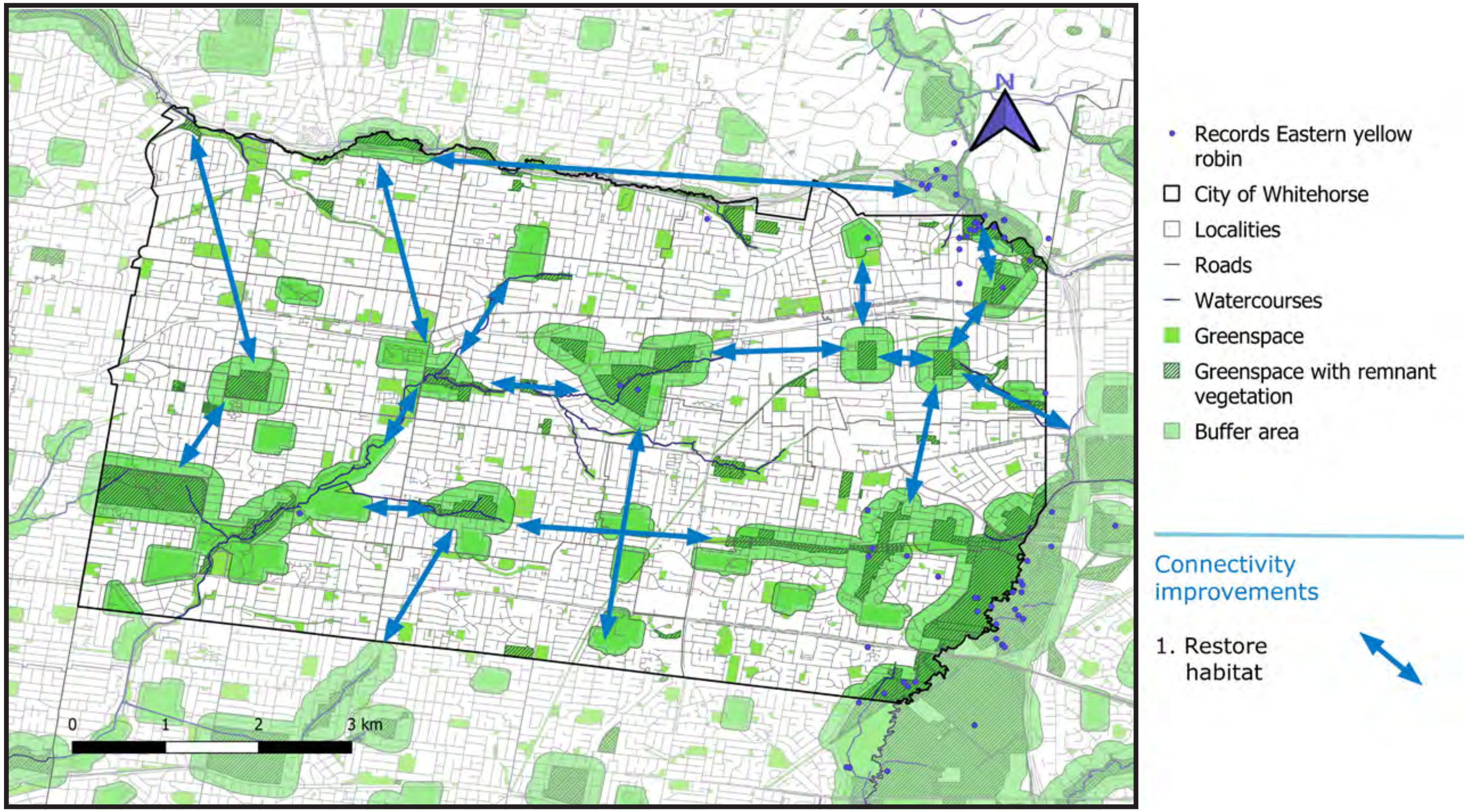


Figure 2.3b Suggested actions to improve habitat connectivity for the eastern yellow robin *Eopsaltria australis*.

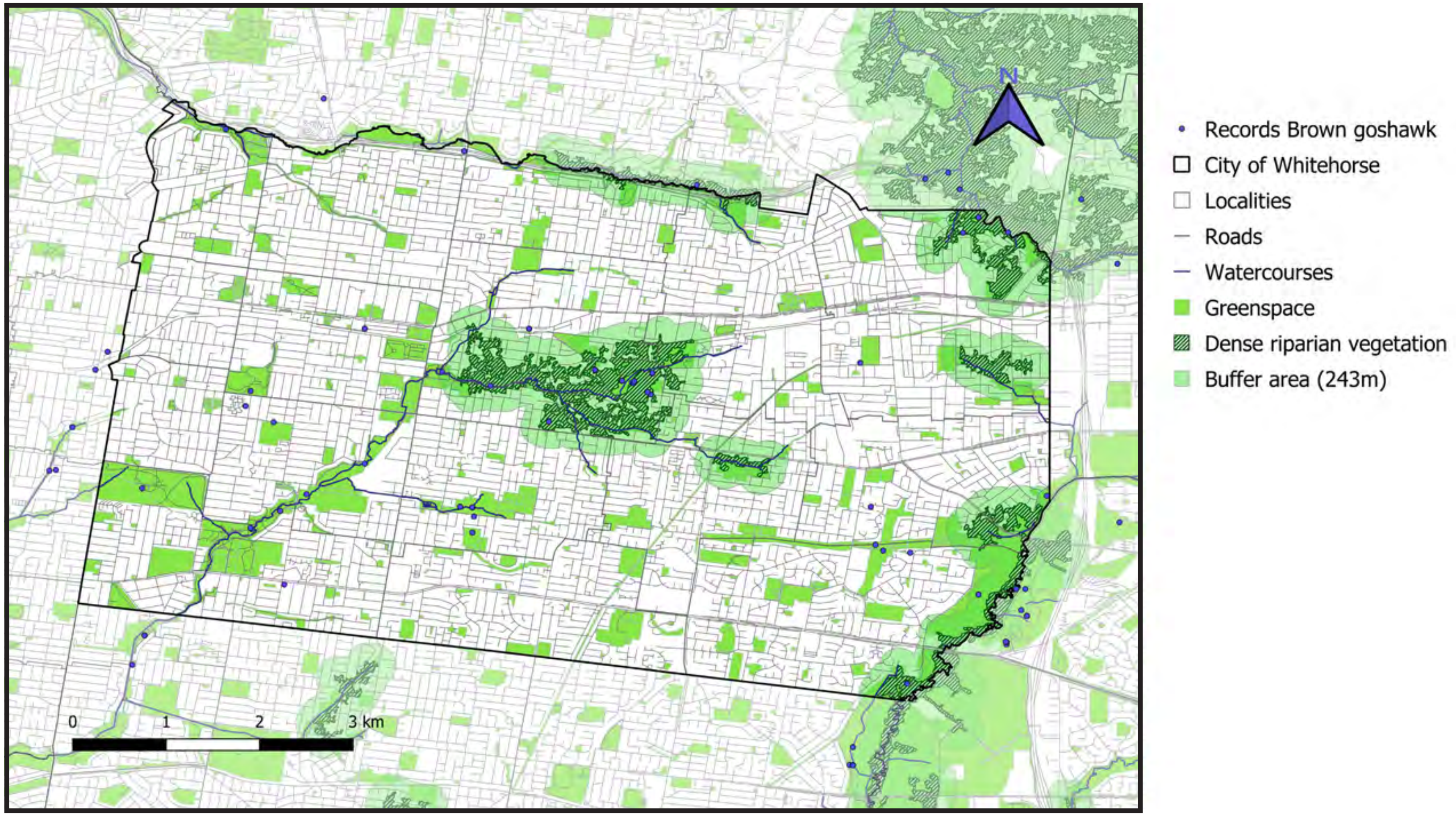


Figure 2.4a Map of habitat connectivity for the brown goshawk *Accipiter fasciatus*.

Figure 2.4b Suggested actions to improve habitat connectivity for the brown goshawk *Accipiter fasciatus*.

watercourses, and restoring riparian habitats (for nesting spots). Fig. 2.2b shows suggested locations for actions to improve habitat connectivity.

Although these connectivity maps have been developed for the spotted pardalote, they are representative of the connectivity limitations and opportunities that exist for other small birds living in the City of Whitehorse, especially those using native tree canopies for foraging.

2.2.2. Eastern yellow robin | *Eopsaltria australis*

Eastern yellow robins live in forests and woodlands, usually with a tall shrub layer and sparse ground cover, and are also common in urban greenspaces (Birdlife Australia 2021). They feed on insects, spiders, and other arthropods.

The map of habitat connectivity for the eastern yellow robin is shown in Fig. 2.3a. Greenspaces are highlighted in bright green and those with remnant vegetation in dark green. Habitat for this species is represented by greenspaces larger than 5 ha (Higgins and Peter 2002), surrounded by a buffer area of 75 m, if they have no remnant vegetation left, or 189 m, if they have remnant vegetation. These distances are based on Doerr et al. (2011). Fig. 2.6a assumes that greenspaces with remnant vegetation provide habitat of better quality and support longer dispersal distance for robins.

Actions that improve habitat connectivity for the eastern yellow robin rely on habitat restoration, particularly on increasing the shrub and ground cover layers of greenspaces with no remnant vegetation. Fig. 2.3b suggests locations in the City of Whitehorse for actions of habitat restoration.

The connectivity maps developed for the eastern yellow robin can be extrapolated to other small insectivorous birds living in the City of Whitehorse, especially those nesting in remnant or shrubby vegetation.

2.2.3. Brown goshawk | *Accipiter fasciatus*

Brown goshawks occur across most of Australia. They prey predominantly on medium-sized birds, but also feed on small mammals, reptiles, and insects (Birdlife Australia 2021). Brown goshawks are found in most timbered habitats, and nest close to aquatic habitats (Birdlife Australia 2021).

The map of habitat connectivity for the brown goshawk is shown in Fig. 2.4a. Areas with dense riparian vegetation are marked in dark green, with a buffer area of 243 m around them in pale green. This number is a conservative measure of the mean distance to the nearest neighbour between nests (Riddell 2015). Watercourses and areas of open space are also shown in blue and bright green. These elements may also provide smaller, suitable patches (e.g. isolated large trees) of habitat for nesting and feeding for the brown goshawk. The lack of open greenspaces with trees that can act as stepping stones between aquatic habitats may act as a habitat disruptor for the brown goshawk.

Habitat connectivity for the brown goshawk within the City of Whitehorse could be promoted by increasing the density of trees on open green spaces and improving the health of riparian vegetation along watercourses. Fig. 2.4b shows suggested locations for actions to improve habitat connectivity.

The habitat connectivity limitations highlighted in these maps may apply to other birds that utilize denser tree cover. The larger areas of connected open space may also favour other raptors such as the collared sparrowhawk *Accipiter cirrocephalus*.

2.2.4. Sugar glider | *Petaurus breviceps*

Sugar gliders live in forests and woodlands. They are most active at night, sleeping by day in nests made of leaves in tree hollows. Sugar gliders have a membrane extending from their fifth finger to their ankle, which enables them to glide up to 50 m between trees (Australian Museum 2021).

The map of habitat connectivity for the sugar glider is shown in Fig. 2.5a. Greenspaces with remnant vegetation are considered to be suitable habitat for this species, and are shown in dark green. A buffer area of 30 m around these greenspaces is presented in pale green and represents the dispersal ability of the species (Suckling 1984; Caryl et al. 2013).

Increased habitat connectivity for sugar gliders requires habitat restoration, with an emphasis on the conservation of old trees inside and outside greenspaces. In Fig. 2.5b, we suggest areas in the City of Whitehorse where habitat restoration may benefit connectivity for the species.

The habitat connectivity maps developed for the sugar glider can be used to understand connectivity limitations that apply to other arboreal marsupials, such as the narrow-toed feather-tailed glider *Acrobates pygmaeus*.

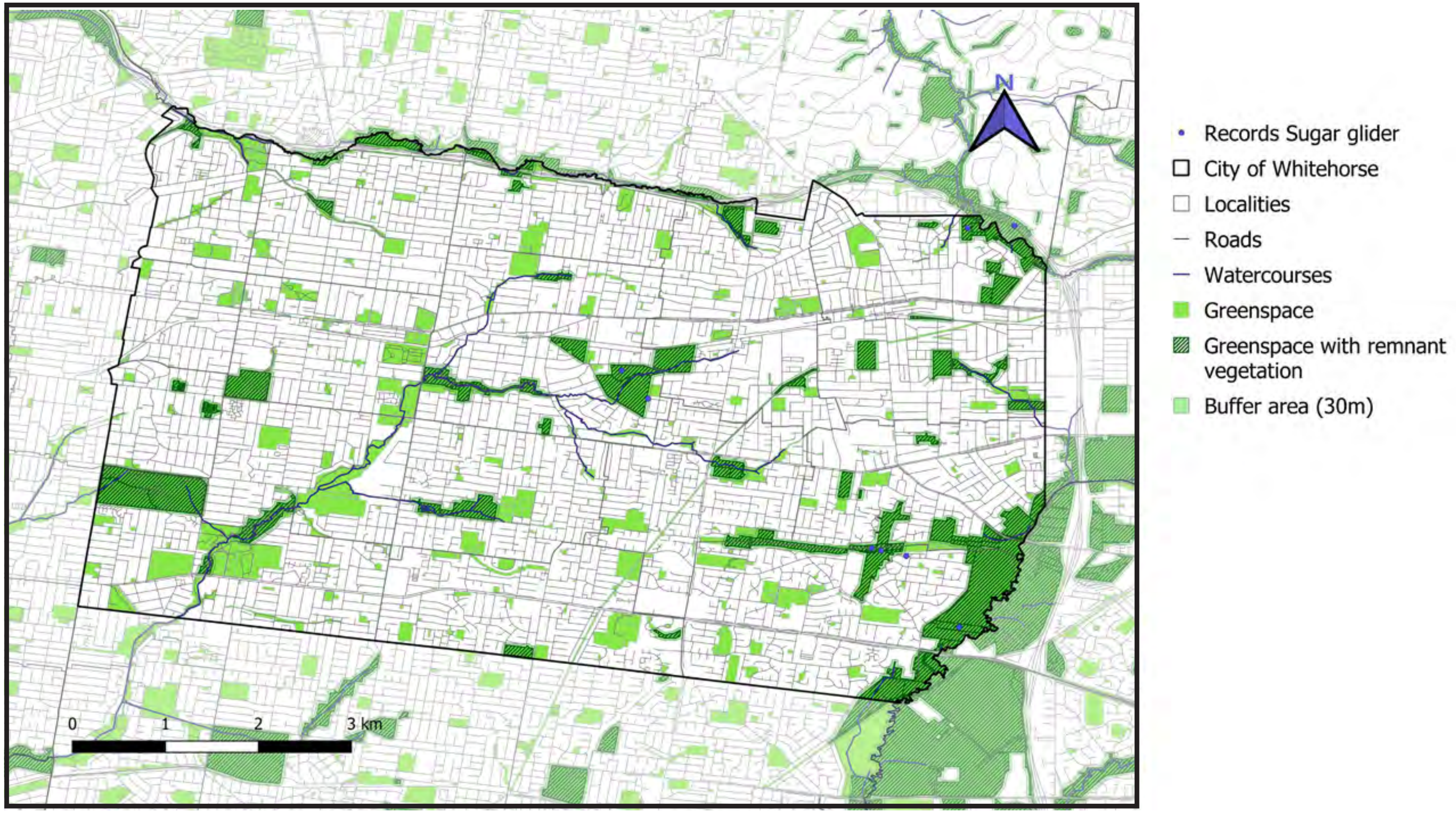


Figure 2.5a Map of habitat connectivity for the sugar glider *Petaurus breviceps*.

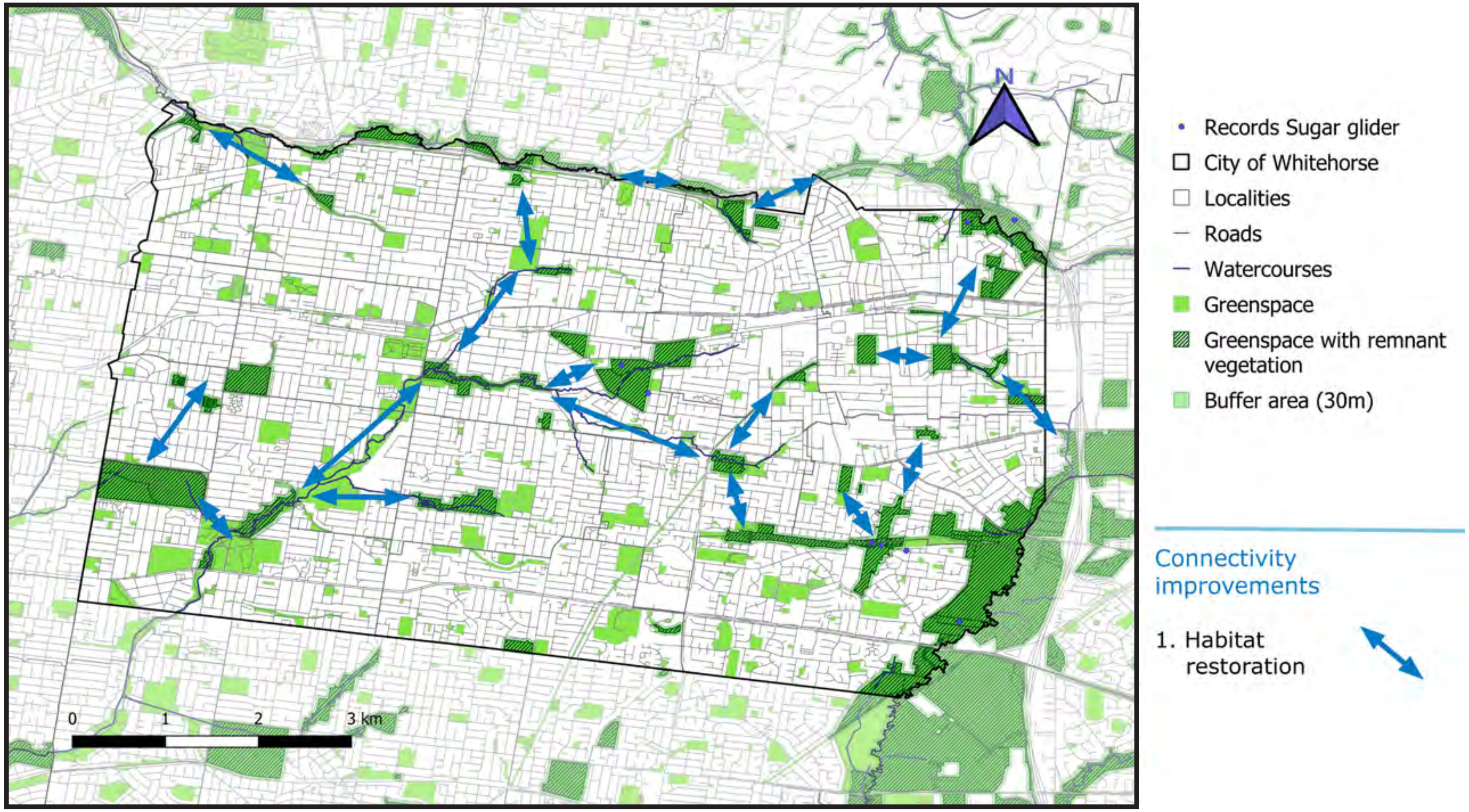


Figure 2.5b Suggested actions to improve habitat connectivity for the sugar glider *Petaurus breviceps*.

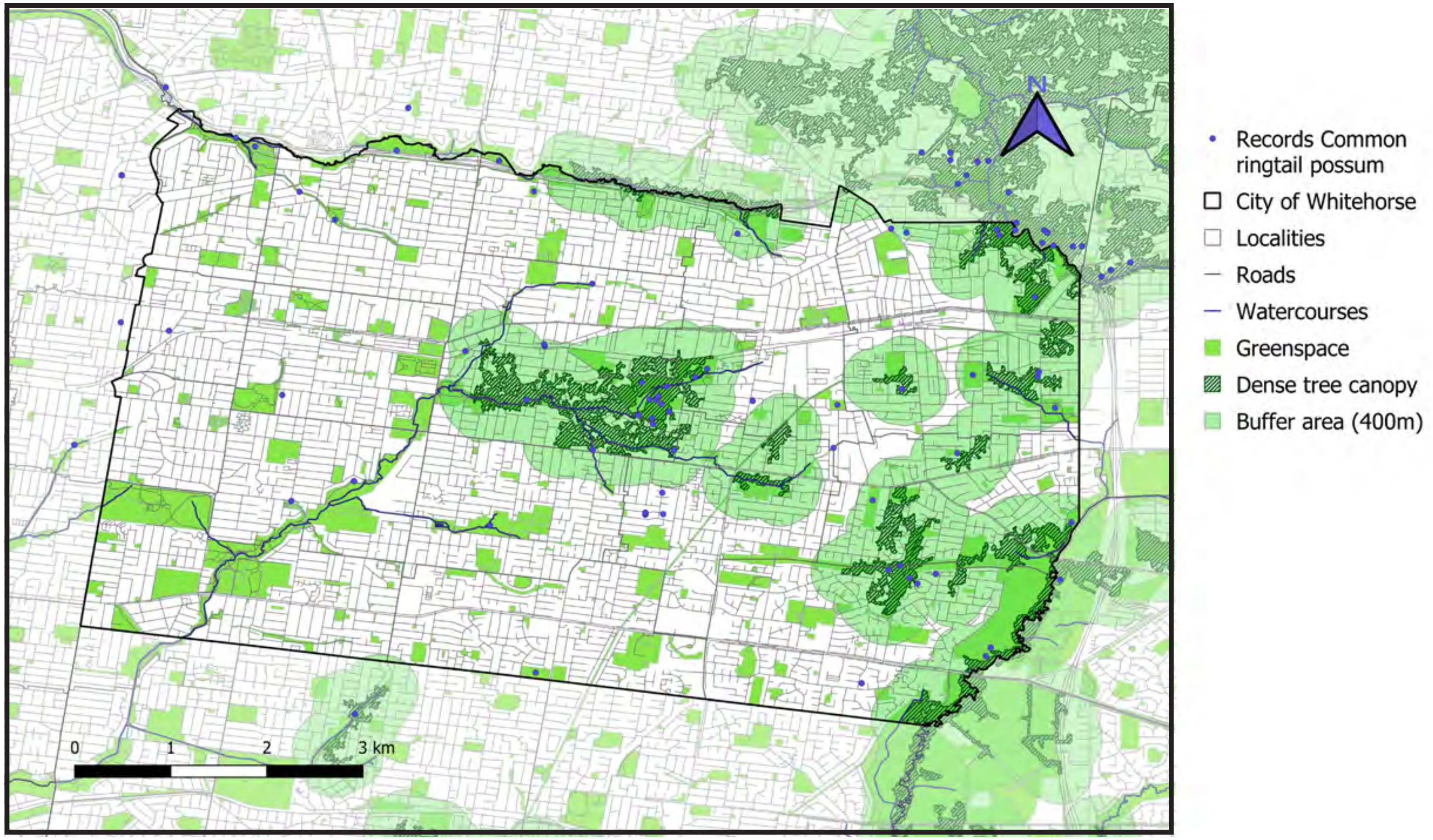


Figure 2.6a Map of habitat connectivity for the common ringtail possum *Pseudocheirus peregrinus*.

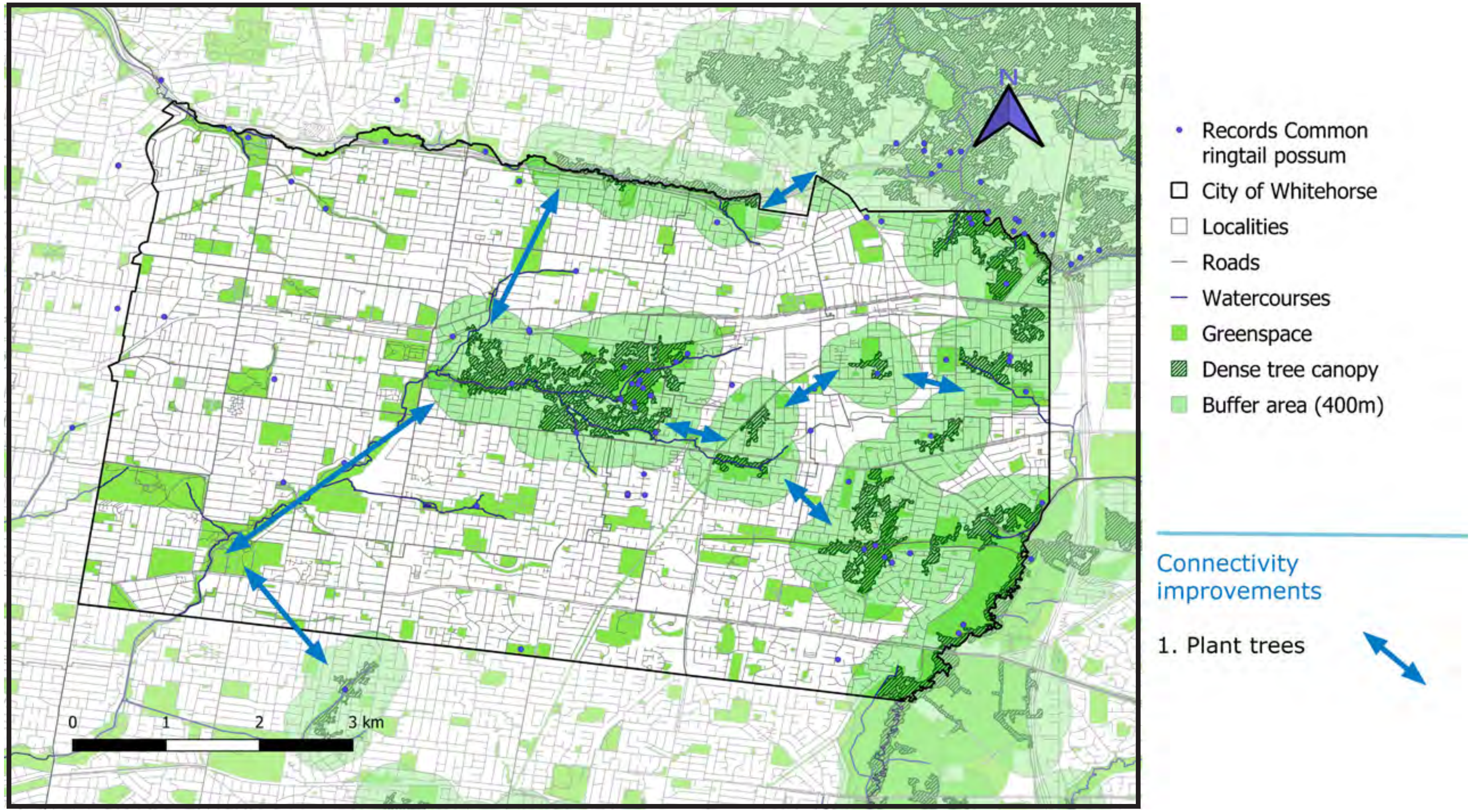


Figure 2.6b Suggested actions to improve habitat connectivity for the common ringtail possum *Pseudocheirus peregrinus*.

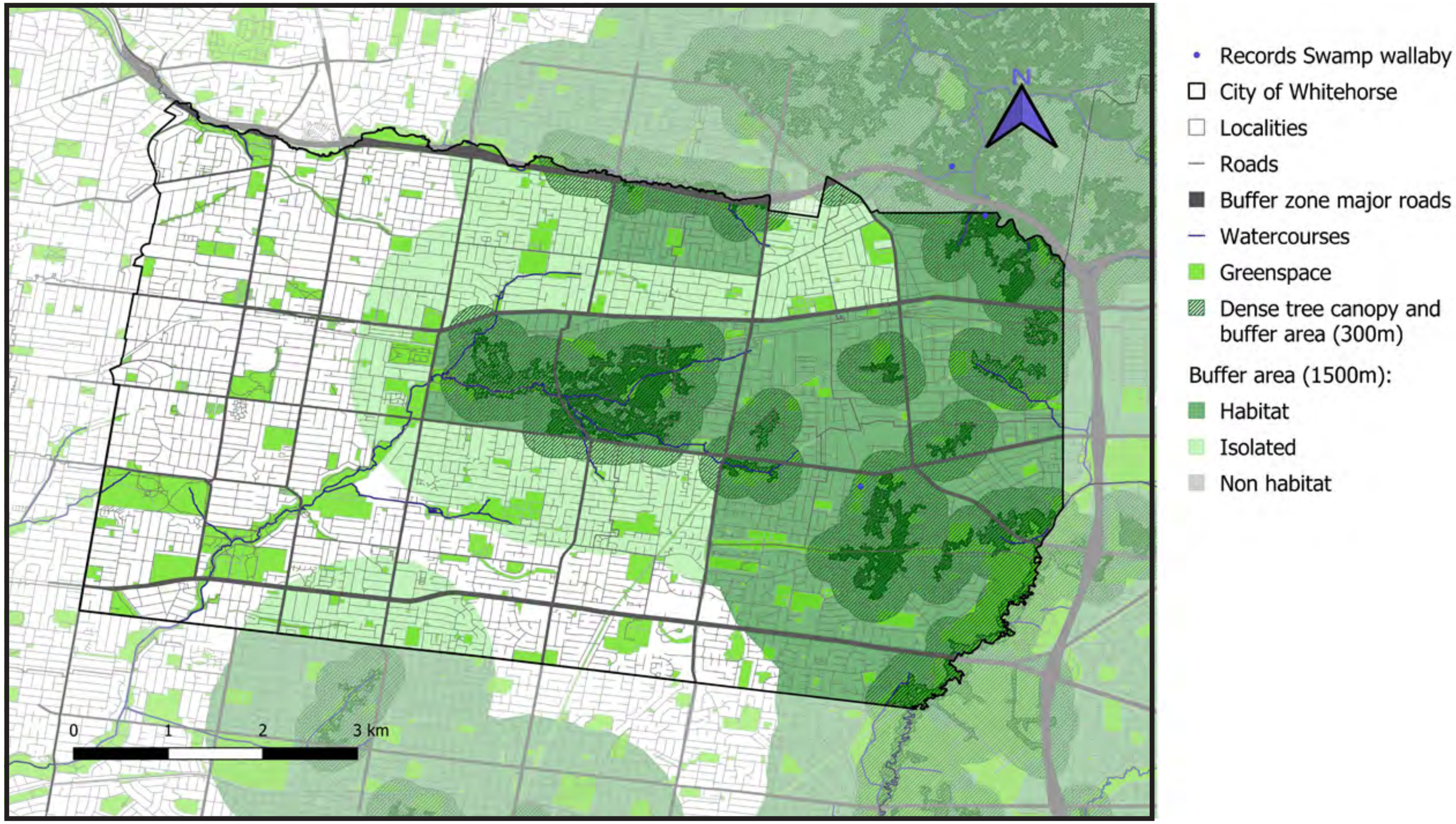


Figure 2.7a Map of habitat connectivity for the swamp wallaby *Wallabia bicolor*.

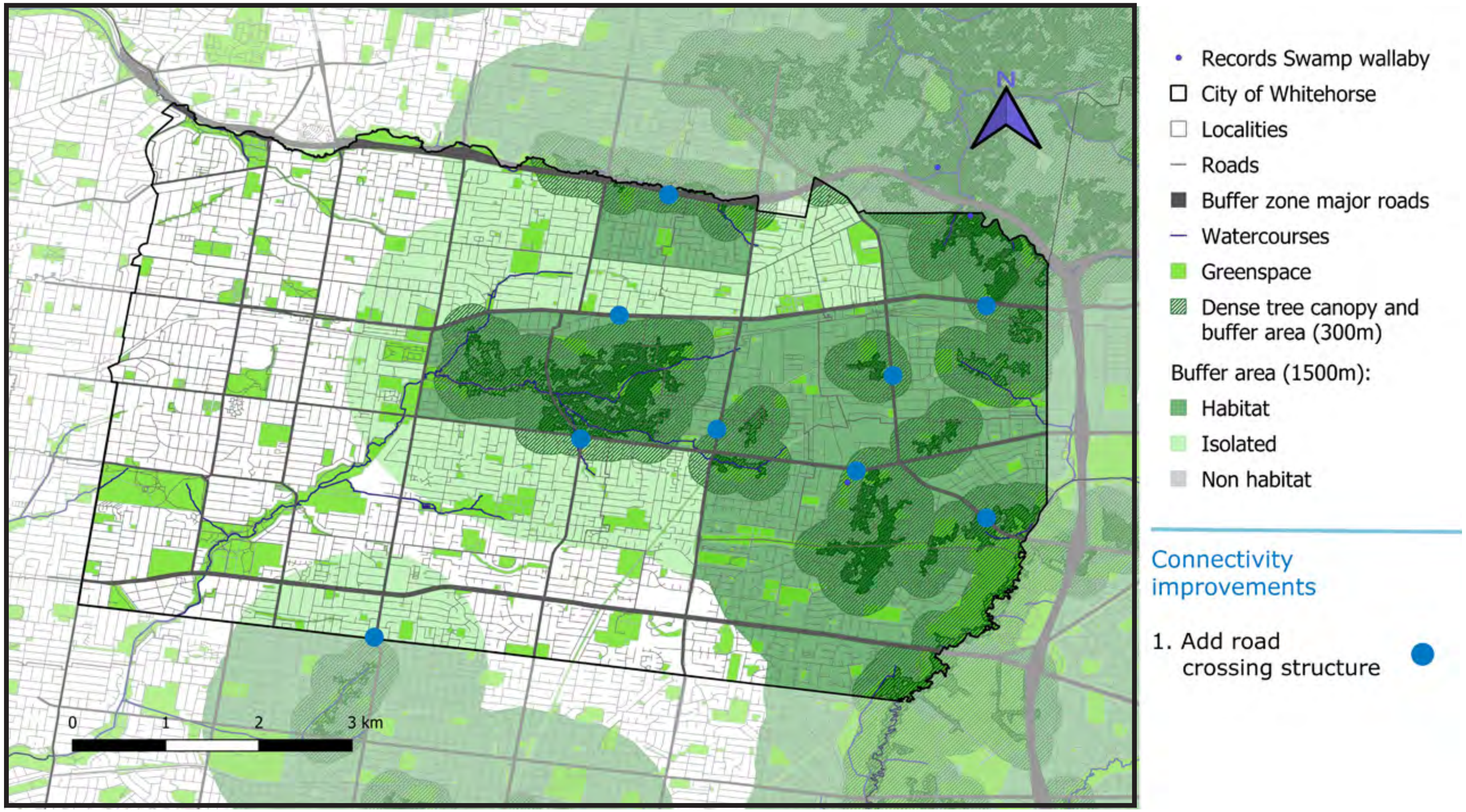


Figure 2.7b Suggested actions to improve habitat connectivity for the swamp wallaby *Wallabia bicolor*.

2.2.5. Common ringtail possum | *Pseudocheirus peregrinus*

Common ringtail possums are tree-dwelling, living in forests, woodlands, rainforests, dense scrub, and urban greenspaces. They have adapted to live in close association with humans and are often seen in residential gardens at night. Common ringtail possums are nocturnal and feed on leaves, flowers, and fruits (Australian Museum 2021).

The map of habitat connectivity for the common ringtail possum is shown in Fig. 2.6a. Areas with dense tree canopy within the City of Whitehorse are presented in dark green, surrounded by a buffer distance of 400 m in pale green. This number is based on the distance that western ringtail possums were observed from high quality vegetation on the Swan Coastal Plain of WA (Shedley and Williams 2014).

Actions to increase habitat connectivity for common ringtail possums rely largely on habitat restoration in open greenspaces, with particular emphasis on increasing tree density around areas with already dense tree canopy. Fig. 2.6b shows possible areas within Whitehorse where these actions are recommended.

Habitat and connectivity patterns highlighted in these maps also apply to other marsupials found within the Whitehorse City Council, such as the eastern ring-tailed possum *Pseudocheirus peregrinus*.

2.2.6. Swamp wallaby | *Wallabia bicolor*

Swamp wallabies live in thick forest undergrowth or sandstone heath. They feed on a variety of plants, including introduced and native shrubs, grasses, and ferns (Australian Museum 2021).

The habitat connectivity map for the swamp wallaby is shown in Fig. 2.7a. Dark green shows areas of dense vegetation surrounded by a buffer of 300 m (Downes et al. 1997), representing the core suitable habitat for swamp wallabies and their average dispersal distance. We also present a wider buffer zone, of 1500 m around dense vegetation (Downes et al. 1997), which aims to identify islands of dense vegetation (i.e. corridor) that could provide opportunities for longer dispersal for the species. The paler green tone in this second buffer represents areas within Whitehorse that remain unavailable for the wallaby due to the presence of major roads (in grey), which represent a mortality risk for the species. As such, we classified these areas, that otherwise would be part of the wider habitat for wallabies, as isolated in the map.

Increased habitat connectivity for the swamp wallaby relies on actions that reduce the risk of collision with motor vehicles. These include the addition of below or above road crossing structures for wildlife and limited traffic volume or speed around areas of dense vegetation and greenspaces. See Fig. 2.7b for suggested areas where actions could be prioritised.

Although these connectivity maps have been developed for the swamp wallaby, they are representative of the connectivity limitations and opportunities that exist for other large marsupials living in the City of Whitehorse, such as the eastern grey kangaroo *Macropus giganteus*. They may also benefit medium-bodied terrestrial marsupials such as the short-beaked echidna *Tachyglossus aculeatus*.

2.2.7. Little forest bat | *Vespadelus vulturnus*

Little forest bats roost in hollows in old trees, buildings, and timber stacks, and prey on small insects. Their colonies are comprised of up to 50 bats (Australian Museum 2021). Their habitat is considered to be areas of open space containing remnant vegetation, and they are unlikely to move across landscapes that are brightly lit. Haddock and colleagues (2019) reported they are sensitive to higher levels of artificial light at night, foraging more actively in the dark interior and edges of bushland patches, rather than the more brightly lit edges where streetlights were present.

The map of habitat connectivity for the little forest bat is shown in Figure 2.8a. Open space areas with remnant vegetation, suitable for nesting, are shown in dark green. They are surrounded by a pale green buffer of 600 m, which represents the average distance this species has been captured away from the nest (i.e. average flight distance; Gonsalves et al. 2013). Within these buffers, grey areas represent locations with dark night light (i.e. average nighttime radiance below 9 nW/cm2/sr). These areas can be considered for habitat restoration actions such as planting additional tree and shrub species the little forest bats are known to feed near. The areas in pale yellow are locations with more bright night light (i.e. average nighttime radiance above 9 nW/cm2/sr). In these areas, habitat connectivity could be improved by reducing light levels down as far as possible through the use of wildlife friendly lighting initiatives. Examples of these initiatives include

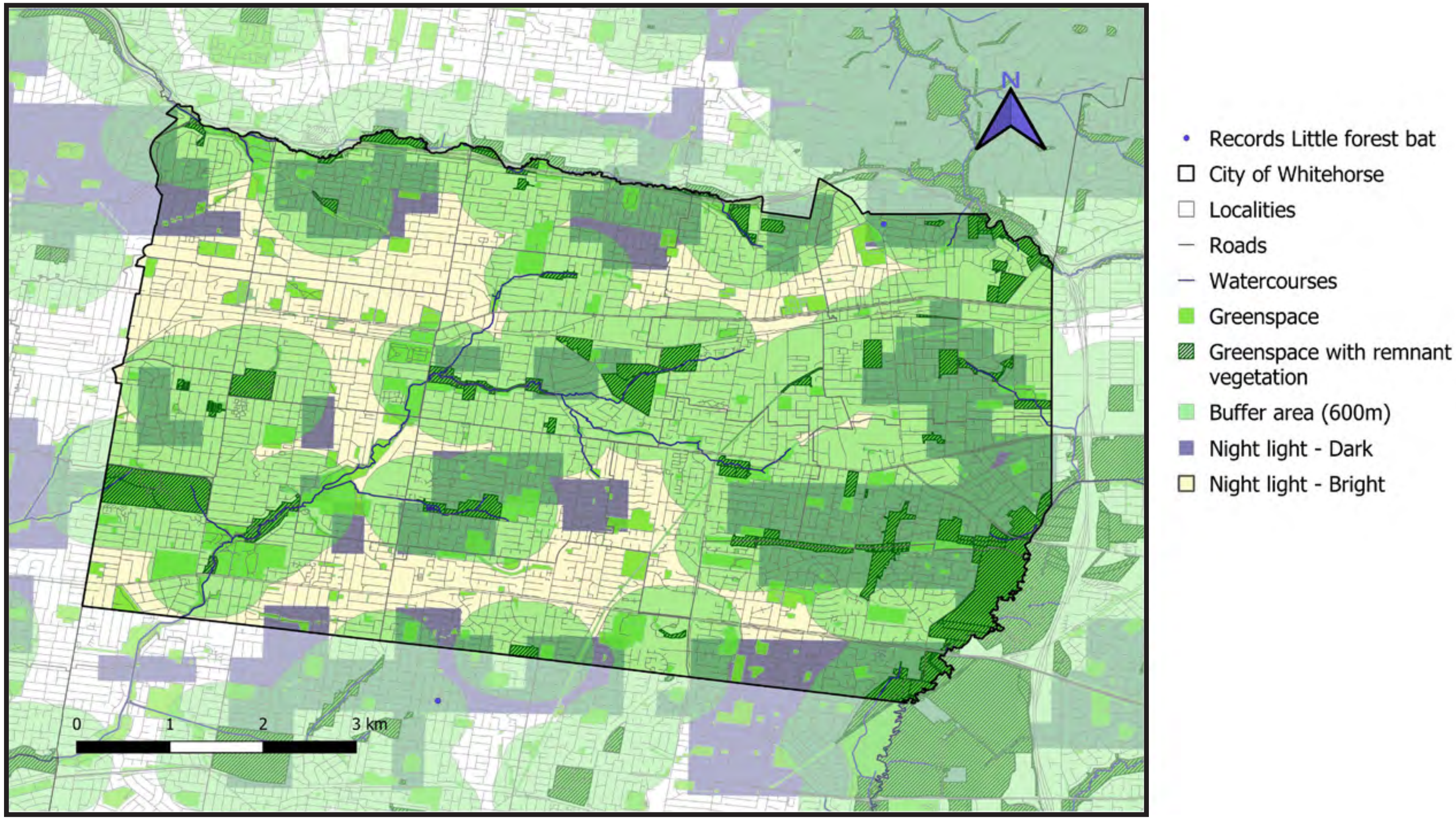


Figure 2.8a Map of habitat connectivity for the little forest bat *Vespadelus vulturnus*.

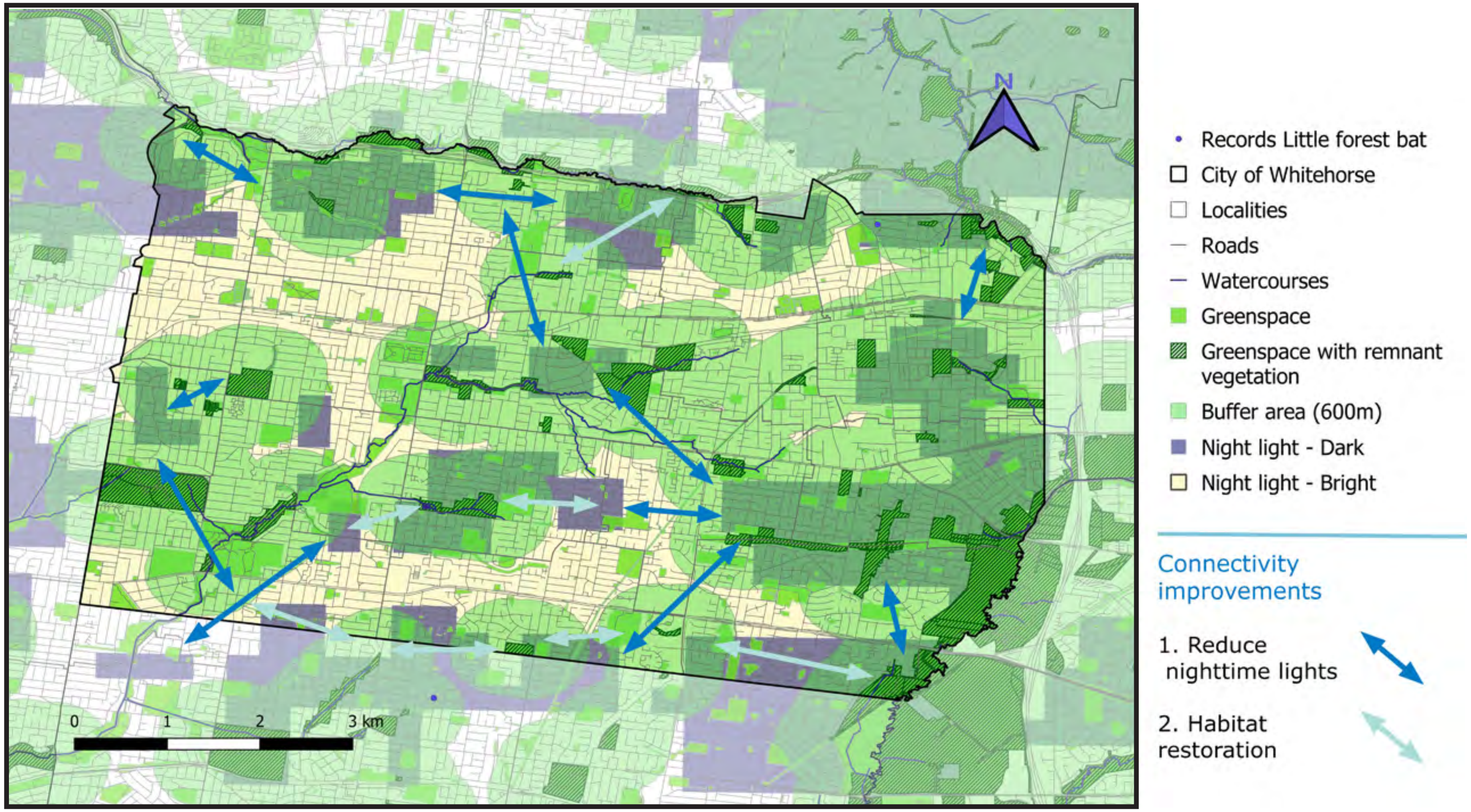


Figure 2.8b Suggested actions to improve habitat connectivity for the Little forest bat *Vespadelus vulturnus*.

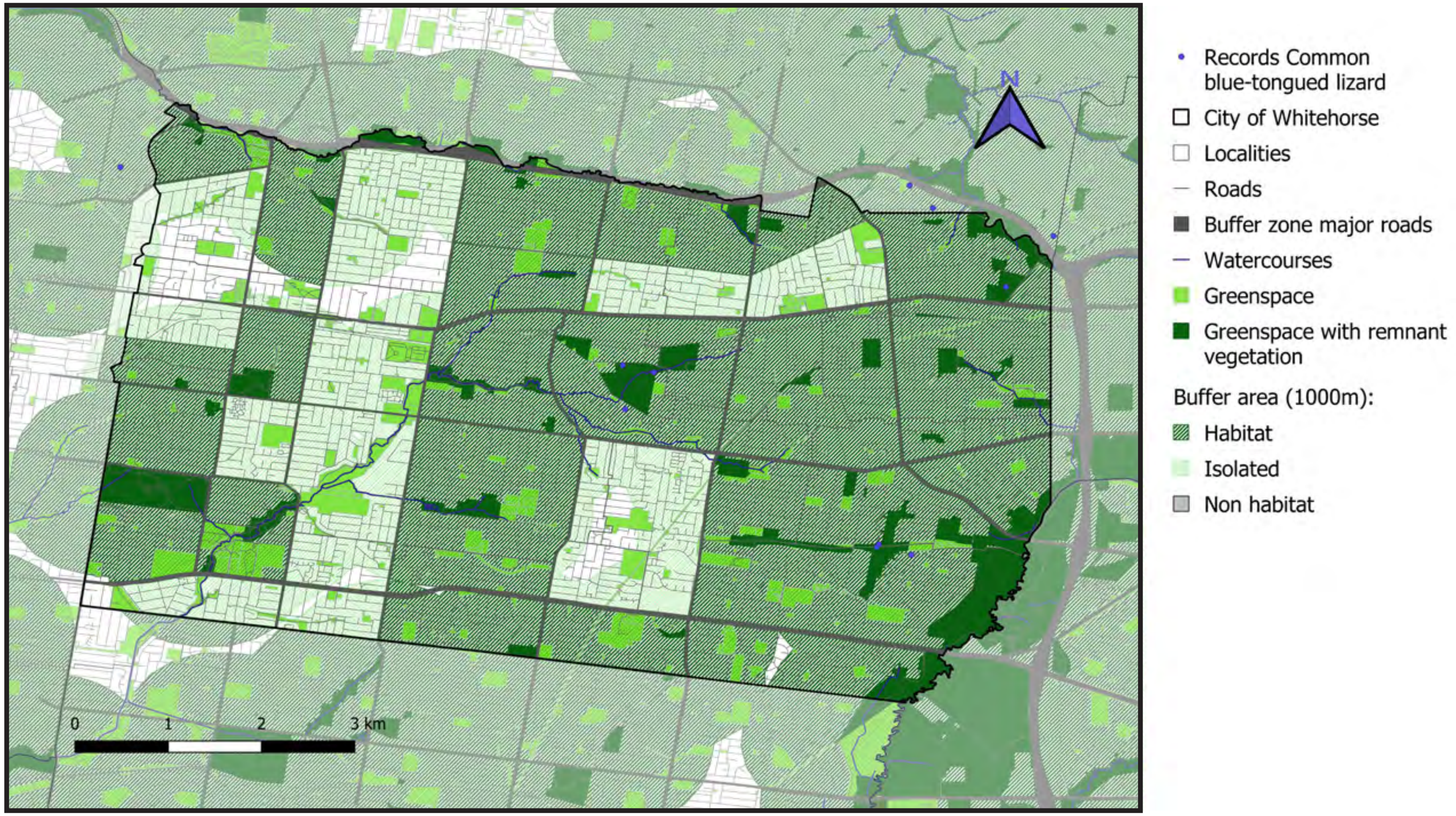


Figure 2.9a Map of habitat connectivity for the common blue-tongued lizard *Tiliqua scincoides*.

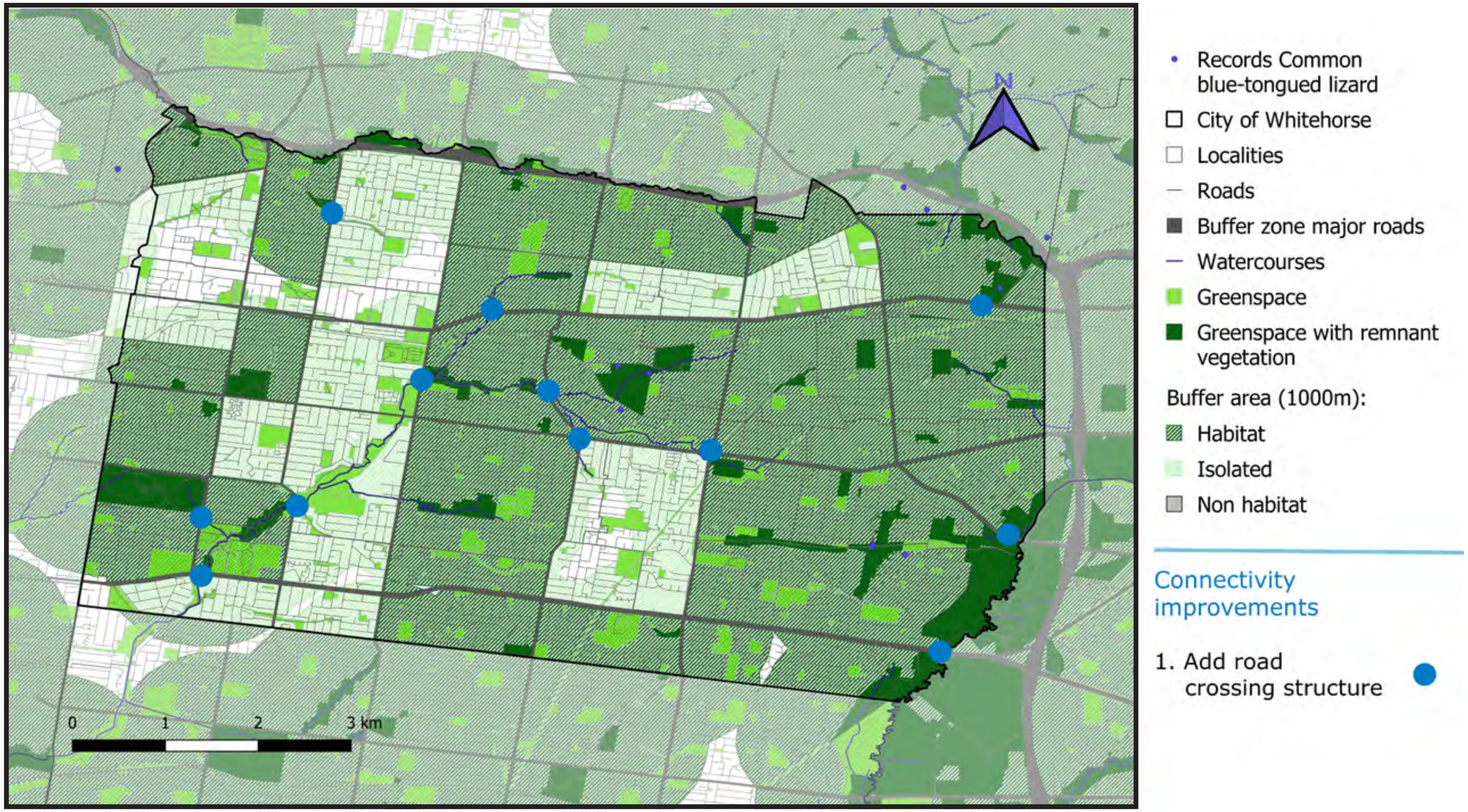


Figure 2.9b Suggested actions to improve habitat connectivity for the common blue-tongued lizard *Tiliqua scincoides*.

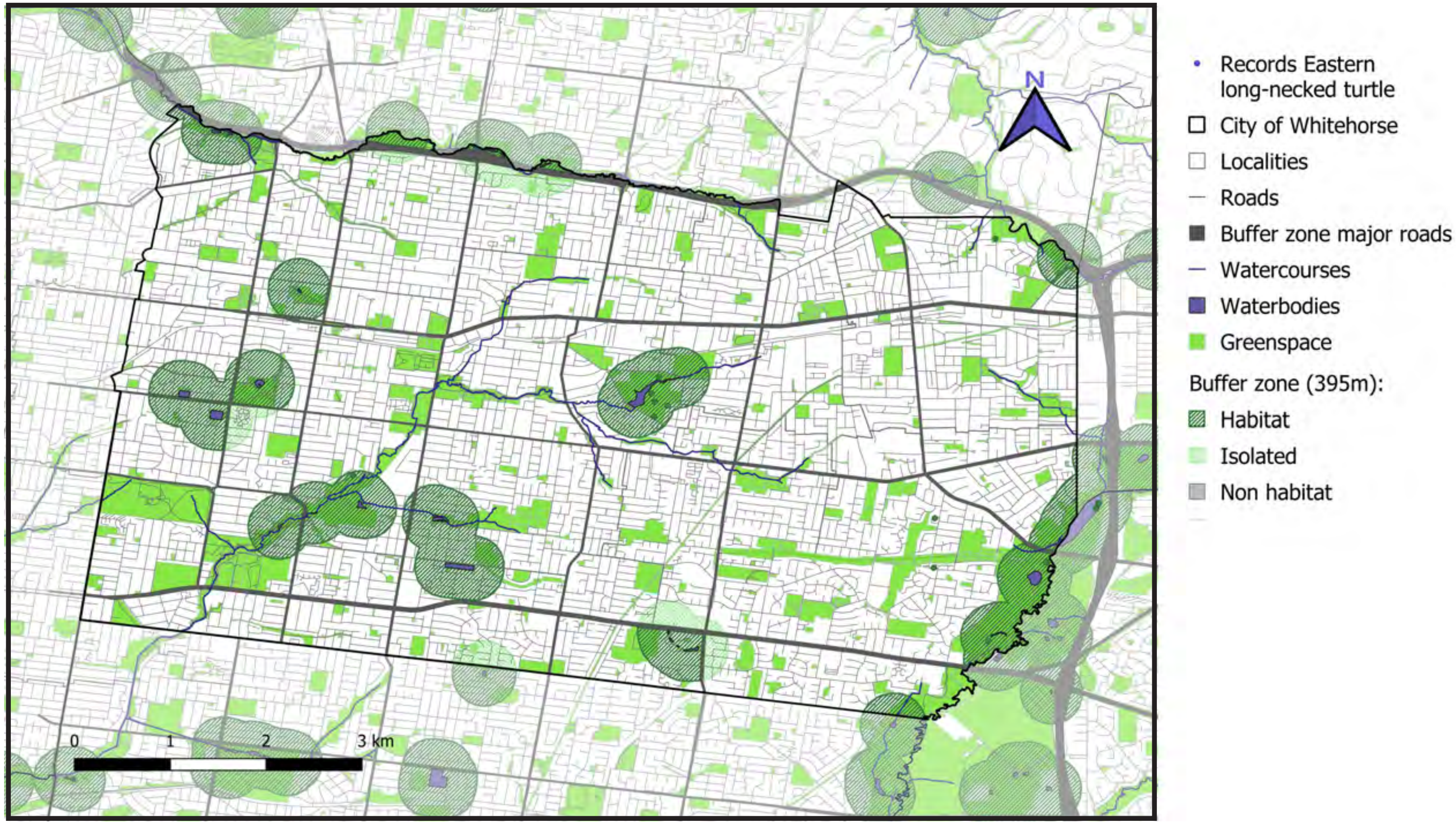


Figure 2.10a Map of habitat connectivity for the eastern long-necked turtle *Chelodina longicollis*.

Figure 2.10b Suggested actions to improve habitat connectivity for the eastern long-necked turtle *Chelodina longicollis*.

physical shielding of the streetlights to prevent upward spill, reduction of the light intensity (lux), or installation of timers that allow some lights to be dimmed or turned off during periods of little human activity (e.g., 1am – 4 am).

The other areas in the municipality with darker night time lights (grey areas) that occur outside of the 600 m buffer also have potential for habitat restoration, through actions such as increasing greenspace area or providing additional habitat, particularly when close to areas of open space with remnant vegetation.

Suggested locations for different habitat connectivity actions for little forest bat are shown in Figure 2.8b.

These maps of habitat connectivity are representative of the issues faced by other microbats in the City of Whitehorse, including, for example the lesser long-eared bat *Nyctophilus geoffroyi*, the chocolate wattled bat *Chalinolobus morio* and the Gould's long-eared bat *Nyctophilus gouldi*.

2.2.8. Common blue-tongued lizard | *Tiliqua scincoides*

Common blue-tongued lizards are amongst the largest members of the skink family, growing to almost 60 cm in length. They live in open country with lots of ground cover such as tussocky grasses or leaf litter, and shelter at night in amongst the leaf litter or under rocks and logs. Common blue-tongued lizards feed on a wide variety of plants and animals (Australian Museum 2021). Major roads represent a barrier for the dispersal of this species (Koenig et al 2002).

The map of habitat connectivity for the common blue-tongued lizard is shown in Fig. 2.9a. In dark green are greenspace areas with remnant vegetation, surrounded by a buffer zone of 1 km that represents the species' average dispersal distance (Kirk et al. 2018). Within this buffer zone, areas that can be accessed from patches of remnant vegetation are shown in dark green, while areas that are unavailable due to the presence of major roads (in grey) are shown in pale green. We classified these areas as isolated for the blue-tongued lizard, given that they would need to cross a major road in order to get access to them. Greenspaces without remnant vegetation are presented in bright green and watercourses in dark blue.

Connectivity for this species in the City of Whitehorse relies mostly on actions that reduce the risk of collision with motor vehicles when moving among different patches of suitable habitat. This can be achieved by building crossing structures that wildlife can use above or below the roads. Habitat restoration in greenspaces with no remnant vegetation, especially the increase of ground cover, for example with indigenous grasses, would be beneficial to facilitate the species movement across the City of Whitehorse. We suggest locations where these actions would improve habitat connectivity in Fig. 2.9b.

The maps of habitat connectivity developed for the common blue-tongued lizard can be used to understand issues faced by other lizards, skinks and snakes found in the City of Whitehorse.

2.2.9. Eastern long-necked turtle | *Chelodina longicollis*

Eastern long-necked turtles live in freshwater habitats. They feed on aquatic invertebrates, tadpoles, and small fishes. Hatchlings are eaten by fish and birds, and adults may be killed by cars while moving overland (Australian Museum 2021). Their habitat is considered to be waterbodies, particularly those which are located close to drainage ditches. Rees and colleagues (2009) noted that eastern long-necked turtles in urban areas around Canberra did not use terrestrial sites, and all of their movement was located along drainage ditches. They are able to use road underpasses when available, which can reduce the number of individuals killed by cars (Rees et al. 2009).

The map of habitat connectivity for the eastern long-necked turtle is shown in Figure 2.10a. Waterbodies in the City of Whitehorse are represented by dark blue. Waterbodies are surrounded by a buffer of 395 m, which represents the turtle's dispersal ability based on a radio-tracking study by Roe and Georges (2007). These authors recorded 95% of turtle locations within 395 m of the nearest wetland. Areas within this buffer are considered unavailable to turtles, if they need to cross a major road to access them. We have classified these areas within the buffer as isolated habitat for the species and represented them in pale green in the map. Major roads were defined as anything that is Class Code 3 or lower in the VicMap Transport Roads dataset, as these are usually multi-laned and support traffic speeds above 60 km/h. We also show watercourses in the City of Whitehorse in dark blue.

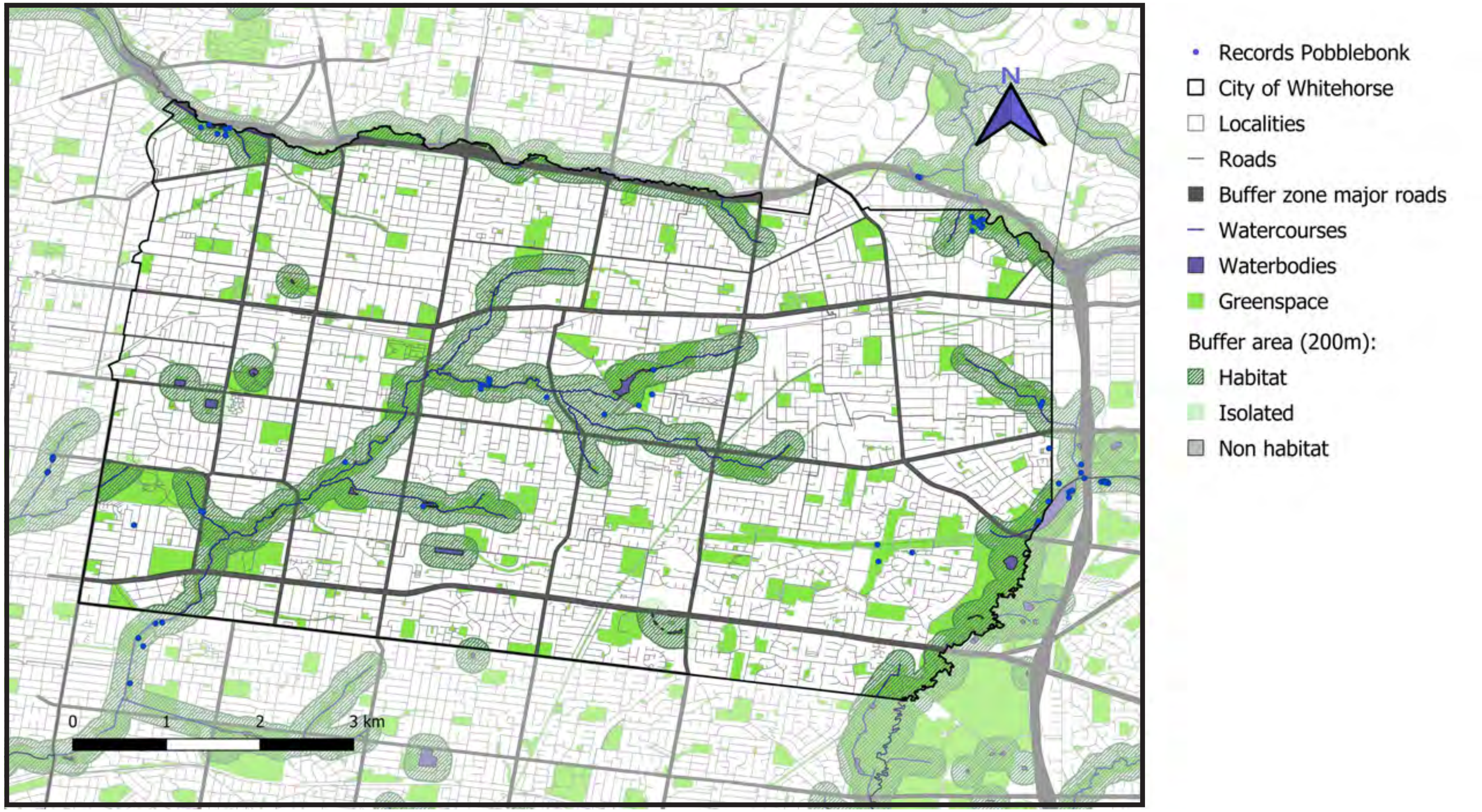


Figure 2.11a Map of habitat connectivity for the pobblebonk *Limnodynastes dumerilii*.

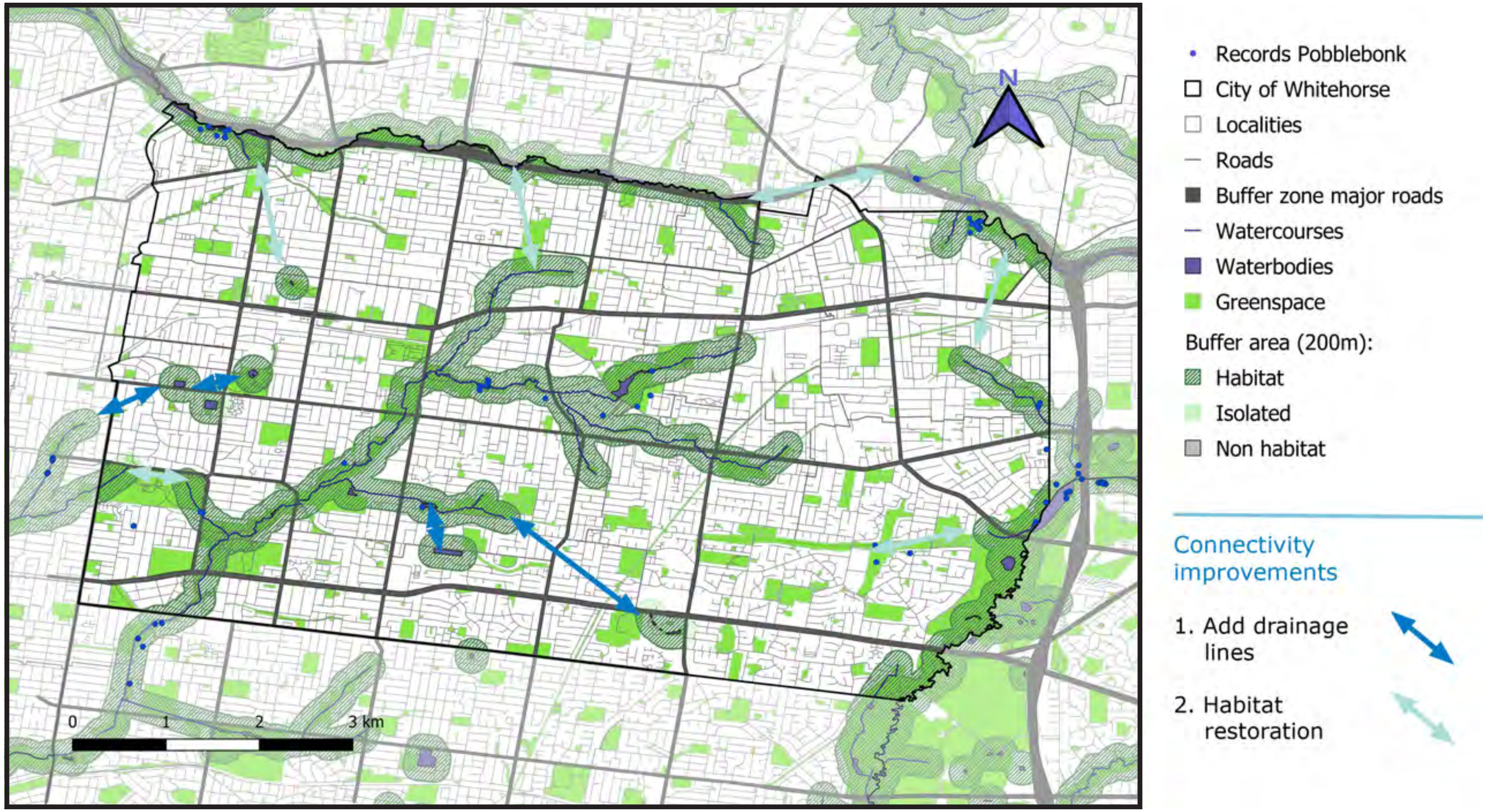


Figure 2.11b Suggested actions to improve habitat connectivity for the pobblebonk *Limnodynastes dumerilii*.

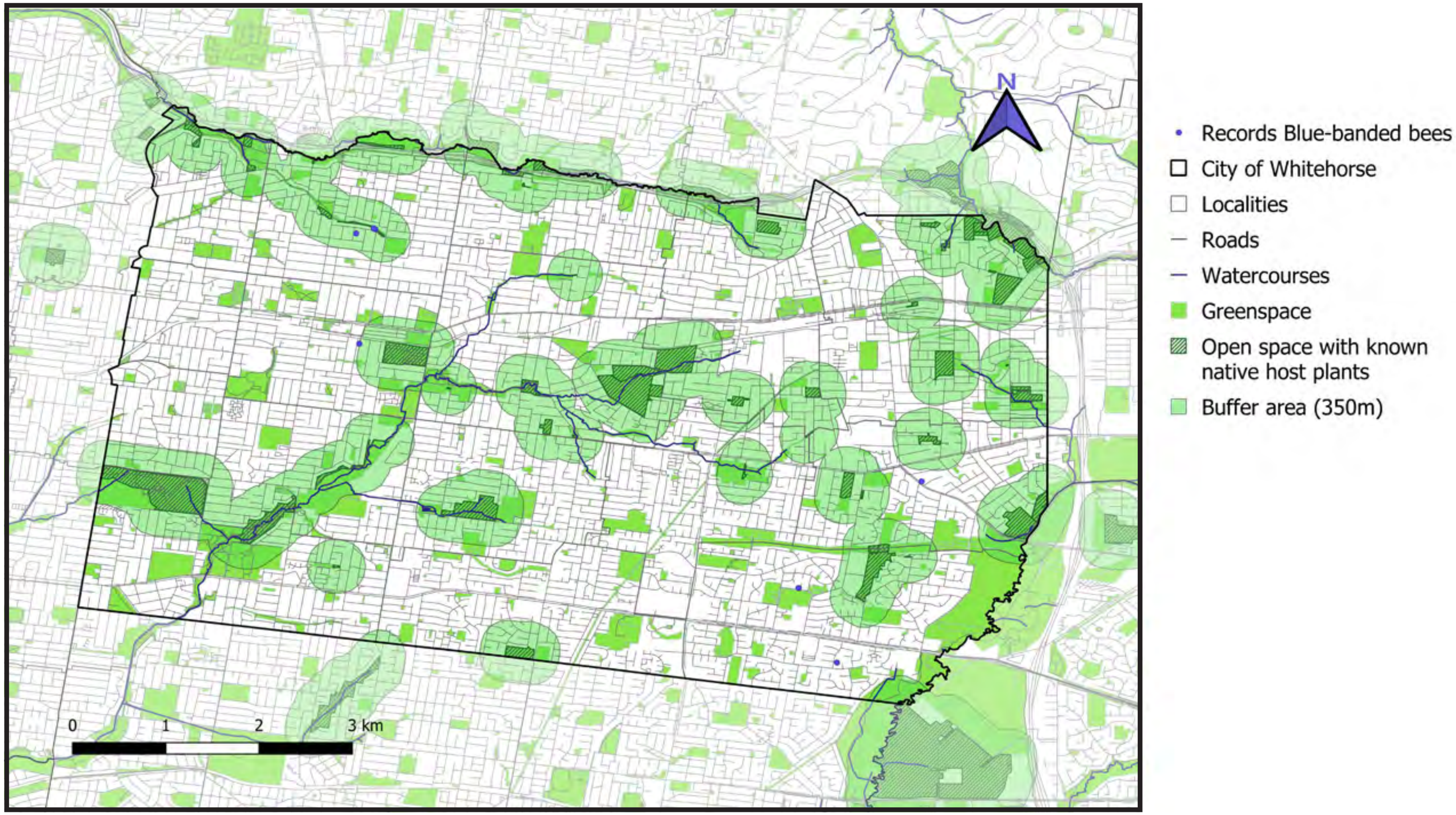


Figure 2.12a Map of habitat connectivity for the blue-banded bees *Amegilla asserta* and *Amegilla chlorocyanea*.

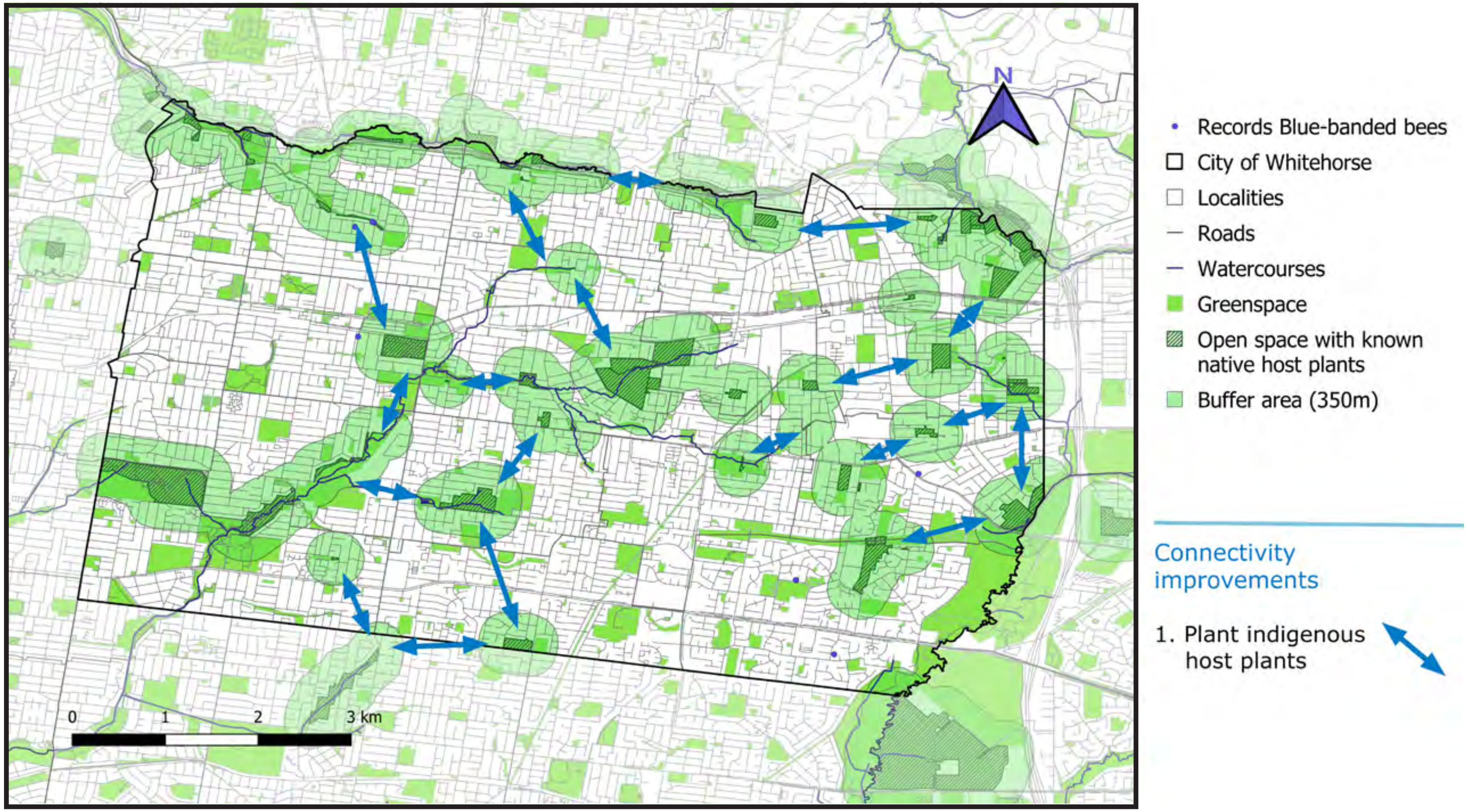


Figure 2.12b Suggested actions to improve habitat connectivity for the blue-banded bees *Amegilla asserta* and *Amegilla chlorocyanea*.

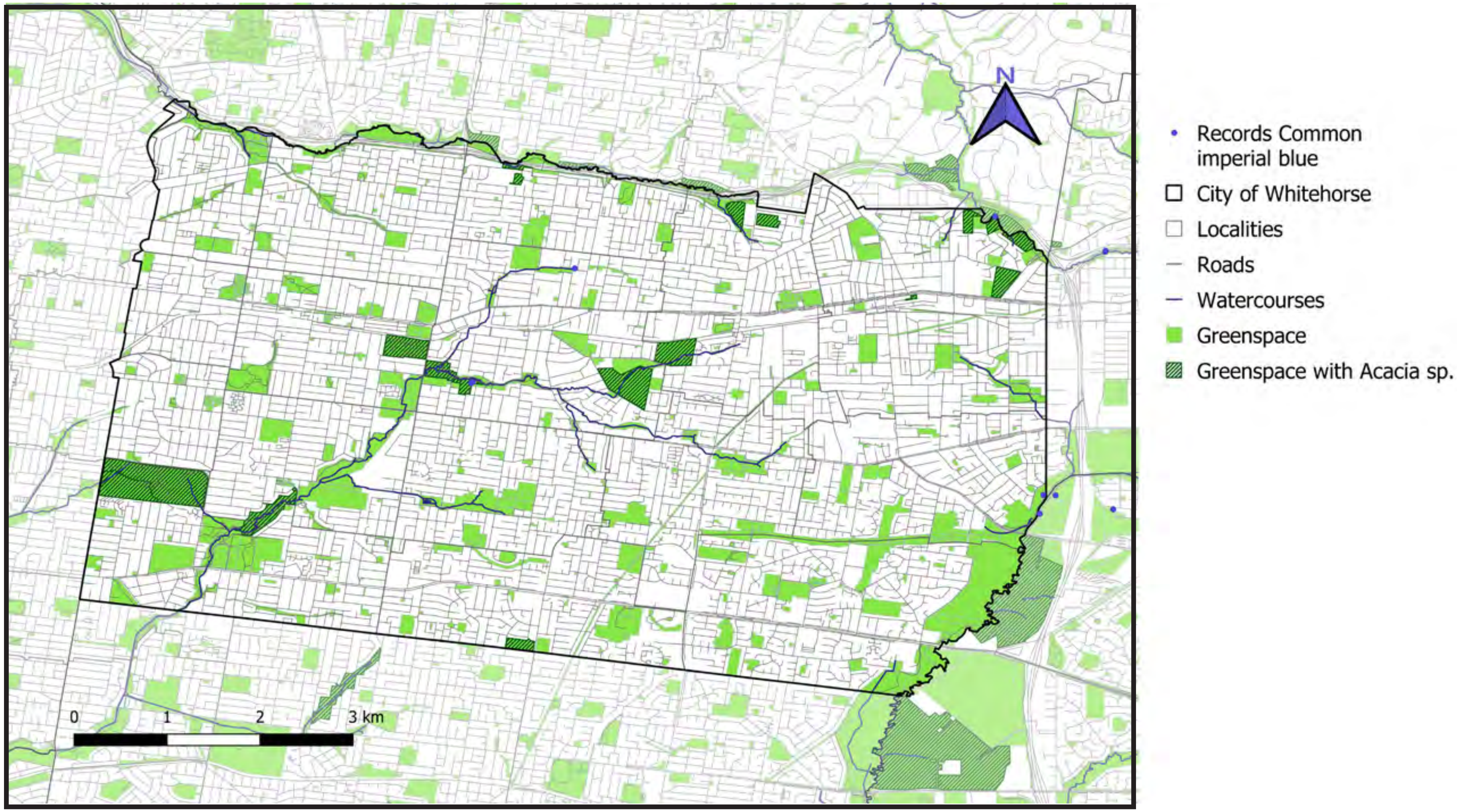


Figure 2.13a Map of habitat connectivity for the common imperial blue *Jalmenus evagoras*.

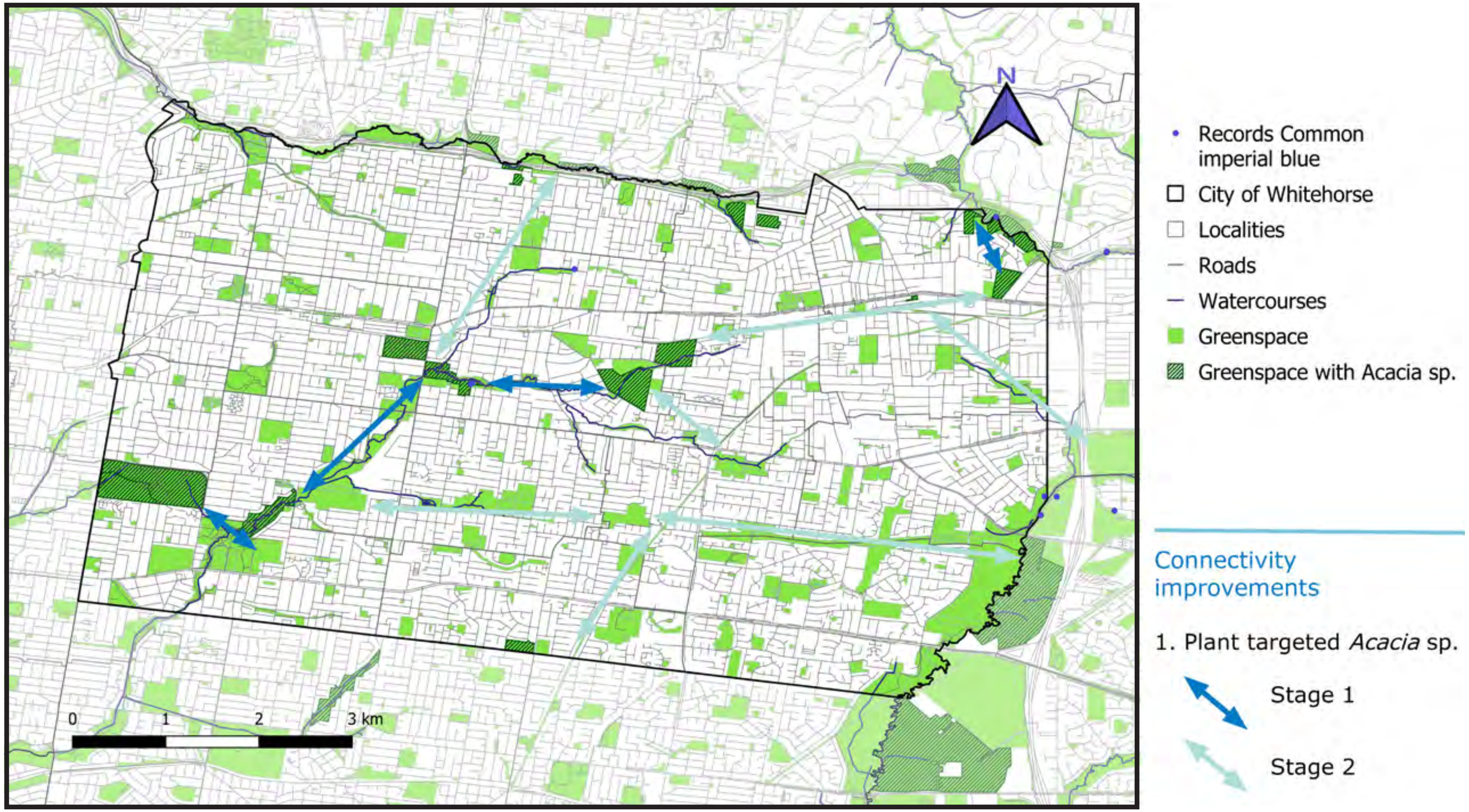


Figure 2.13b Suggested actions to improve habitat connectivity for the common imperial blue *Jalmenus evagoras*.

Additional drainage lines that connect waterbodies to the larger stream network could significantly increase connectivity for this species by supporting the movement of the individuals. The construction of additional ponds along an existing riparian area could also promote the dispersal of the species by decreasing the travel distance between suitable aquatic habitats. Suggested locations for different habitat connectivity actions for eastern long-necked turtles are shown in Figure 2.10b.

The connectivity maps developed for the eastern long-necked turtle can be extrapolated to other riparian and wetland dependent species such as the Rakali *Hydromys chrysogaster* or other turtle species living in the City of Whitehorse, such as the Murray river turtle *Emydura macquarii* and the broad-shelled turtle *Chelodina expansa*.

2.2.10. Pobblebonk | *Limnodynastes dumerilii*

Pobblebonks, also known as the southern bullfrog or the eastern banjo frog, live in a wide range of habitats, including urban, heath, and sclerophyll forest areas close or around wetlands and waterbodies. They burrow in loamy soils and emerge to feed and breed after rains (Frogwatch SA 2021). They place their eggs in points of still water, where they hatch and their tadpoles grow (State of Victoria 2017). Pobblebonks are sensitive to roads, and are less likely to occur at ponds with higher density of roads in the surrounding 500 m (Parris 2006).

The map of habitat connectivity for the pobblebonk is shown in Fig. 2.11a. Waterbodies and watercourses are shown in dark blue, surrounded by a dark green buffer zone of 200 m that represents the average distance around aquatic habitats that are used by a similar sized frog (growling grass frog *Litoria raniformis*) (State of Victoria 2013). Major roads are considered a disruptor for this species and therefore sections of the buffer that can only be accessed by crossing a major road (in grey) are considered unavailable and classified as isolated in the map. These isolated parts of otherwise suitable habitat are presented in pale green.

Additional drainage lines that connect isolated waterbodies to the larger stream network could significantly increase connectivity for this species. The improvement of riparian vegetation as well as vegetation in close-by greenspaces could also promote the dispersal of the species by providing suitable nesting habitat in areas along the creek that may be suboptimal at the moment. Suggested locations for different habitat connectivity actions for pobblebonks are shown in Figure 2.11b.

The connectivity maps developed for the pobblebonk highlight connectivity opportunities and limitations for other native ground frogs living in the City of Whitehorse, such as the striped marsh frog *Limnodynastes peronii* and the spotted marsh frog *Limnodynastes tasmaniensis*.

2.2.11. Blue-banded bees | *Amegilla asserta* and *Amegilla chlorocyanea*

Blue-banded bees are solitary bee, building their nest in shallow burrows in clay soil or mudbricks (Aussie Bees 2021). Adult blue-banded bees in Greater Melbourne feed on a small range of indigenous plant species, including flax-lilies (genus *Dianella*), austral stork's-bill (*Pelargonium australe*), hop goodenia (*Goodenia ovata*), showy isotome (*Isotoma axillaris*), small crowea (*Crowea exalata*), bulbine lily (*Bulbine bulbosa*), and bluebells (genus *Wahlenbergia*). They have also been recorded on a few plant species that are not indigenous to Victoria (e.g. species of *Eremophila*, *Westringia*, and *Pimelea*), as well as some plant species that have been introduced into Australia by the ornamental gardening industry (e.g. species of *Salvia*).

The map of habitat connectivity for blue-banded bees is shown in Fig. 2.12a. Dark green areas represent open space that coincides with records of the indigenous plant species listed above. The pale green buffers represent the mean dispersal distance of these bees (350 m; Kirk et al. 2018).

Habitat connectivity for blue-banded bees could be improve by increasing the amount and coverage of the indigenous species that the bees are known to forage on in public greenspaces across Whitehorse, as well as promoting the use of these plant species in private gardens by Whitehorse residents. In both cases, these actions would be concomitantly implemented with improvements of the bees nesting requirements. Suggested locations within the City of Whitehorse public greenspaces to implement these actions are shown in Fig. 2.12b.

The connectivity maps developed for the blue-banded bees heavily rely on the specificity between these insect species and the indigenous species they are attracted to. Despite not directly applicable to show habitat connectivity patterns for other pollinators, the same approach could be used to develop specific habitat connectivity maps for other insects with well-known host specificity.

2.2.12. Common imperial blue | *Jalmenus evagoras*

Adult common imperial blues fly close to the ground around their food plant or close to their breeding habitat (Bradby 2016). They live in woodland, open-forests, foothills, and montane areas. Common imperial blues caterpillars are attended by meat ants (genus *Iridomyrmex*) and feed on a range of wattles, including the black wattle *Acacia mearnsii*. Their habitat within the City of Whitehorse is considered to be areas of open space that contain trees of *Acacia mearnsii*, *Acacia melanoxylon*, or *Acacia implexa*.

The map of habitat connectivity for the common imperial blue is shown in Figure 2.13a. The dark green areas represent open space that coincide with Atlas of Living Australia records of the three wattle species that are local hosts for this butterfly. As this species displays high fidelity to a site, it is unlikely to move far from an individual wattle tree, and therefore, we did not add a buffer area for dispersal around these greenspaces.

Actions to increase connectivity for this species largely involve extending the planting of the host wattle species in areas adjacent to populations of common imperial blues, potentially in a staged approach where the first stage focuses on shorter connections, and the second stage takes a longer-term approach. Suggested locations for these actions are shown in Figure 2.13b.

As for the connectivity maps developed for the blue-banded bees, the maps developed for the Common imperial blue butterfly heavily rely on the specificity between the butterfly and the indigenous species they are attracted to. Again, a same methodological approach could be used to develop specific habitat connectivity maps for other butterflies with well-known host preferences.

3 Synthesised wildlife habitat connectivity maps for the City of Whitehorse

While understanding the individual habitat connectivity requirements of different focal species can be important, it makes sense to look more closely for synergies amongst species as this will help to identify synergies where a small number of actions can deliver multiple benefits.

We identified 28 locations within the City of Whitehorse that are key areas of connectivity (Figures 3.1 and 3.2). These corridors are either associated with known areas of connected greenspaces (such as Corridors 2, 4, 8, 10, 18, 20 and 24), or represent key opportunities to develop actions to help connect existing corridors - for example, Corridor 9 would help connect Corridors 8 (Fulton Rd) and 18 (Jolimont Rd). A synthesised picture of habitat connectivity across the municipality for multiple terrestrial functional groups (represented by the focal taxa) is presented in Figures 3.1. Figure 3.2 presents a synthesised picture of habitat connectivity for aquatic functional groups.

Management actions that can improve the benefits of each corridor are presented in Table 3.1, along with the functional groups (represented by the focal species) that can benefit from such actions. Three corridor locations have been identified that are important for 7-10 different functional groups. These are the Corridors 1 (Gardiners Creek North), 2 (Gardiners Creek), and 3 (Forest Hill – Heatherdale). Five additional corridors have been identified as being important habitat connectors for 6 of the different functional groups. These are Corridors 4 (Koonung Creek), 5 (Wattle Park – Gardiners Creek), 6 (Blackburn Lake – Antonio Park), 7 (Antonio Park – Heatherdale) and 8 (Fulton Rd).

Increasing connectivity in these corridors largely involves undertaking work to increase the complexity and connectivity of vegetation and provide drainage lines and additional wetlands for aquatic species. For several of these corridors, these actions can be undertaken on public lands.

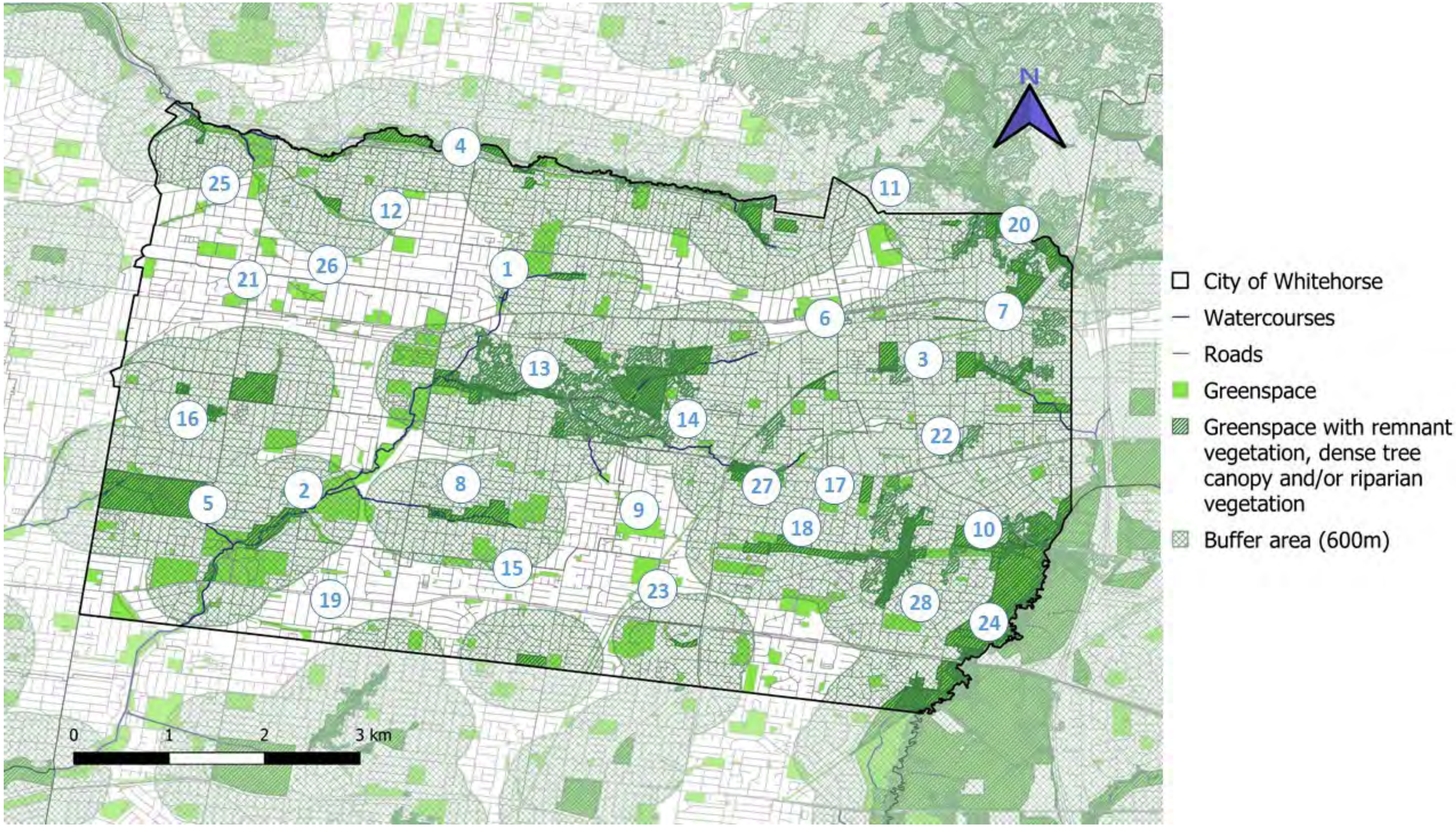


Figure 3.1 Map of the main corridors for habitat connectivity in the City of Whitehorse for terrestrial species. See Table 3.1 for more information on each corridor.

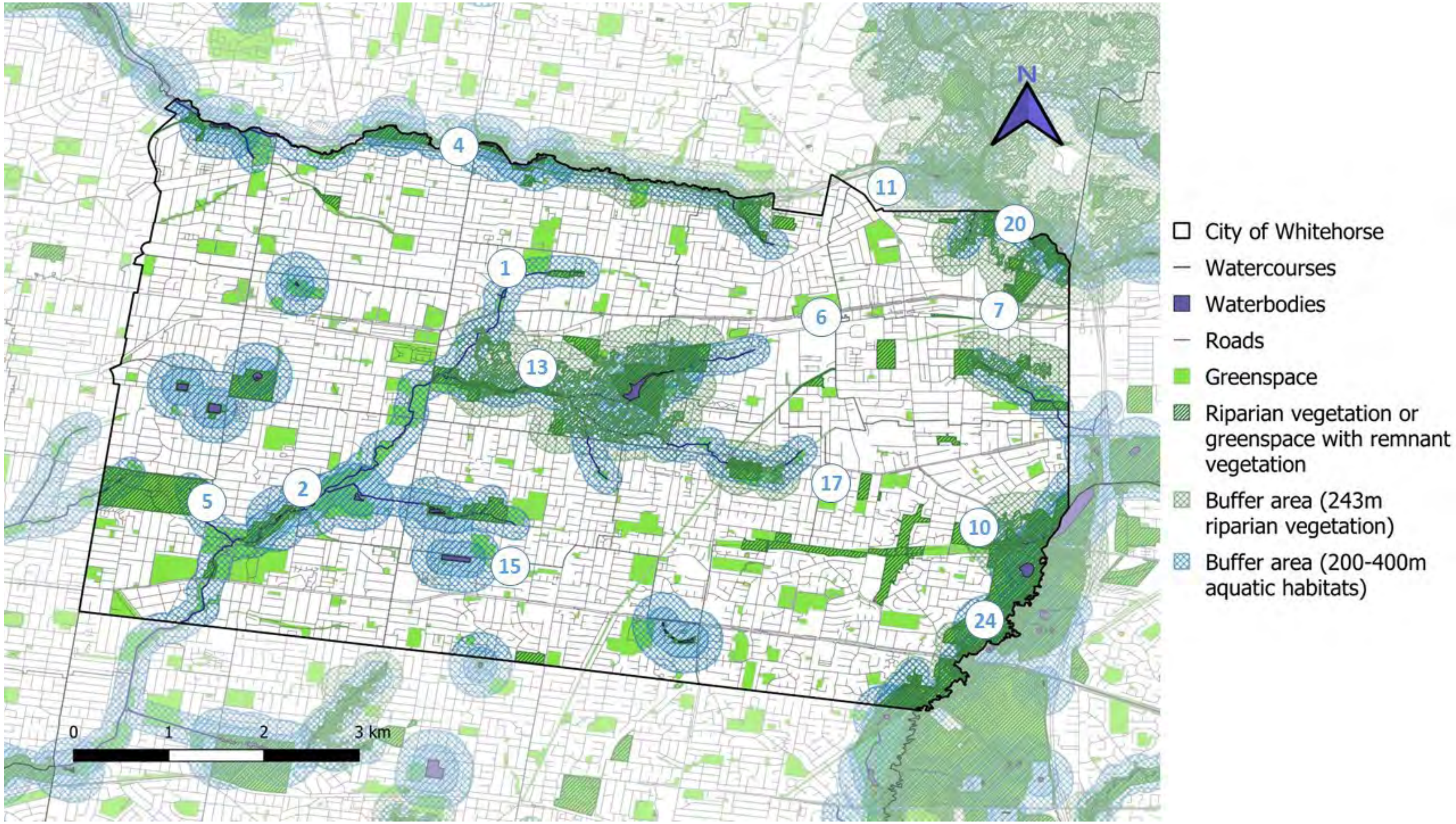


Figure 3.2 Map of the main corridors for habitat connectivity in the City of Whitehorse for aquatic species. See Table 3.1 for more information on each corridor.

Table 3.1 Main habitat connectivity corridors in the City of Whitehorse.

Corridor	Functional group (focal taxa)	Actions
1. Gardiners Creek North	Spotted pardalote	Restore riparian habitats
	Eastern yellow robin	Habitat restoration (Shrub layer)
	Brown goshawk	Increase tree density
	Sugar glider	Habitat restoration (Large trees within 30 m)
	Common ringtail possum	Plant trees
	Little forest bat	Reduce nighttime lights
	Common blue-tongued lizard	Add road crossing structure
	Pobblebonk	Habitat restoration (riparian vegetation, pond creation, drainage lines between ponds)
	Blue-banded bees	Plant indigenous host plants
	Common imperial blue	Plant *Acacia* spp. (stage 2)
2. Gardiner's Creek	Spotted pardalote	Restore riparian habitats
	Brown goshawk	Restore riparian vegetation
	Sugar glider	Habitat restoration (Large trees within 30 m)
	Common ringtail possum	Plant trees
	Common blue-tongued lizard	Add road crossing structure
	Eastern long-necked turtle	Add ponds
	Blue-banded bees	Plant indigenous host plants
	Common imperial blue	Plant *Acacia* spp. (stage 1)
3. Forest Hill - Heatherdale	Eastern yellow robin	Habitat restoration (Shrub layer)
	Brown goshawk	Restore riparian vegetation
	Sugar glider	Habitat restoration (Large trees within 30 m)
	Common ringtail possum	Plant trees
	Swamp wallaby	Add road crossing structure
	Blue-banded bees	Plant indigenous host plants
	Common imperial blue	Plant *Acacia* spp. (stage 2)

Table 3.1 ***Cont.*** Main habitat connectivity corridors in the City of Whitehorse.

Corridor	Functional group (focal taxa)	Actions
4. Koonung Creek	Eastern yellow robin	Habitat restoration (Shrub layer)
	Brown goshawk	Increase tree density and restore riparian vegetation
	Sugar glider	Habitat restoration (Large trees within 30 m)
	Swamp wallaby	Add road crossing structure
	Little forest bat	Reduce nighttime lights
	Eastern long-necked turtle	Add ponds
5. Wattle Park – Gardiner's Creek	Brown goshawk	Increase tree density
	Sugar glider	Habitat restoration (Large trees within 30 m)
	Little forest bat	Reduce nighttime lights
	Eastern long-necked turtle	Add ponds
	Pobblebonk	Habitat restoration (riparian vegetation, pond creation, drainage lines between ponds)
	Common imperial blue	Plant *Acacia* spp. (stage 1)
6. Blackburn Lake – Antonio Park	Spotted pardalote	Plant *Eucalyptus* spp.
	Eastern yellow robin	Habitat restoration (Shrub layer)
	Brown goshawk	Increase tree density
	Eastern long-necked turtle	Add drainage lines
	Pobblebonk	Add drainage lines
	Common imperial blue	Plant *Acacia* spp. (stage 2)
7. Antonio Park - Heatherdale	Sugar glider	Habitat restoration (Large trees within 30 m)
	Swamp wallaby	Add road crossing structure
	Little forest bat	Reduce nighttime lights
	Common blue-tongued lizard	Add road crossing structure
	Pobblebonk	Habitat restoration (riparian vegetation, pond creation, drainage lines between ponds)
	Blue-banded bees	Plant indigenous host plants

Table 3.1 ***Cont.*** Main habitat connectivity corridors in the City of Whitehorse.

Corridor	Functional group (focal taxa)	Actions
8. Fulton Rd	Eastern yellow robin	Habitat restoration (Shrub layer)
	Brown goshawk	Restore riparian vegetation
	Sugar glider	Habitat restoration (Large trees within 30 m)
	Little forest bat	Habitat restoration (more complex vegetation structure)
	Blue-banded bees	Plant indigenous host plants
	Common imperial blue	Plant *Acacia* spp. (stage 2)
9. Fulton Rd – Jolimont Rd	Spotted pardalote	Plant *Eucalyptus* spp.
	Eastern yellow robin	Habitat restoration (Shrub layer)
	Brown goshawk	Increase tree density
	Little forest bat	Reduce nighttime lights
	Common imperial blue	Plant *Acacia* spp. (stage 2)
10. Bellbird Dell – Dandenong Creek A	Brown goshawk	Increase tree density
	Swamp wallaby	Add road crossing structure
	Pobblebonk	Habitat restoration (riparian vegetation, pond creation, drainage lines between ponds)
	Blue-banded bees	Plant indigenous host plants
	Common imperial blue	Plant *Acacia* spp. (stage 2)
11. Eastern Freeway	Spotted pardalote	Plant *Eucalyptus* spp.
	Eastern long-necked turtle	Add ponds
	Pobblebonk	Habitat restoration (riparian vegetation, pond creation, drainage lines between ponds)
	Blue-banded bees	Plant indigenous host plants
12. Ruffey Creek	Spotted pardalote	Plant *Eucalyptus* sp.
	Brown goshawk	Increase tree density
	Sugar glider	Habitat restoration (Large trees within 30 m)
	Blue-banded bees	Plant indigenous host plants

Table 3.1 ***Cont.*** Main habitat connectivity corridors in the City of Whitehorse.

Corridor	Functional group (focal taxa)	Actions
13. Gardiners Creek – Blackburn Lake	Spotted pardalote Eastern long-necked turtle Blue-banded bees Common imperial blue	Restore riparian habitats Add ponds Plant indigenous host plants Plant *Acacia* spp. (stage 1)
14. Blackburn Lake – Forest Hill	Spotted pardalote Common ringtail possum Common blue-tongued lizard Common imperial blue	Plant *Eucalyptus* spp. and restore riparian habitats Plant trees Add road crossing structure Plant *Acacia* spp. (stage 2)
15. Fulton Rd – Highbury Park	Spotted pardalote Eastern long-necked turtle Pobblebonk Blue-banded bees	Plant *Eucalyptus* spp. Add drainage lines Add drainage lines Plant indigenous host plants
16. Wattle Park – Box Hill	Eastern yellow robin Sugar glider Little forest bat	Habitat restoration (Shrub layer) Habitat restoration (Large trees within 30 m) Reduce nighttime lights
17. Forest Hill – Bellbird Dell	Spotted pardalote Sugar glider Common ringtail possum	Plant *Eucalyptus* spp. Habitat restoration (Large trees within 30 m) Plant trees
18. Jolimont Rd	Spotted pardalote Brown goshawk Common imperial blue	Plant *Eucalyptus* spp. Increase tree density Plant *Acacia* spp. (stage 2)
19. Eley Rd	Swamp wallaby Little forest bat Blue-banded bees	Add road crossing structure Habitat restoration (more complex vegetation structure) Plant indigenous host plants

Table 3.1 ***Cont.*** Main habitat connectivity corridors in the City of Whitehorse.

Corridor	Functional group (focal taxa)	Actions
20. Mullum Mullum Creek	Eastern long-necked turtle Common imperial blue	Add ponds Plant *Acacia* spp. (stage 1)
21. Gawler Chain – Box Hill	Spotted pardalote Eastern yellow robin	Plant *Eucalyptus* spp. Habitat restoration (Shrub layer)
22. Bellbird Dell	Eastern yellow robin Sugar glider	Habitat restoration (Shrub layer) Habitat restoration (Large trees within 30 m)
23. Highbury Park – Forest Hill	Little forest bat Common imperial blue	Reduce nighttime lights Plant *Acacia* spp. (stage 2)
24. Dandenong Creek	Common blue-tongued lizard Eastern long-necked turtle	Add road crossing structure Add ponds
25. Gawler Chain	Little forest bat	Reduce nighttime lights and habitat restoration (more complex vegetation structure)
26. Gawler Chain – Gardiner's Creek	Brown goshawk	Increase tree density
27. Forest Hill – Jolimont Rd	Sugar glider	Habitat restoration (Large trees within 30 m)
28. Bellbird Dell – Dandenong Creek B	Little Forest Bat	Reduce nighttime lights

Table 3.2 Relevant habitat connectivity corridors for each functional group (focal taxa). See Figures 3.1 and 3.2 for corridor location in the City of Whitehorse.

Functional group (focal taxa)	Corridors
Spotted pardalote	1, 2, 6, 9, 11, 12, 13, 14, 15, 17, 18, 21
Eastern yellow robin	1, 3, 4, 6, 8, 9, 16, 21, 22
Brown goshawk	1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 18, 26
Sugar glider	1, 2, 3, 4, 5, 7, 8, 12, 16, 17, 22, 27
Common ringtail possum	1, 2, 3, 14, 17
Swamp wallaby	3, 4, 7, 10, 19
Little forest bat	1, 4, 5, 7, 8, 9, 16, 19, 23, 25, 28
Common blue-tongued lizard	1, 2, 7, 14, 24
Eastern long-necked turtle	2, 4, 5, 6, 11, 13, 15, 20, 24
Pobblebonk	1, 2, 5, 6, 7, 10, 11, 15
Blue-banded bee	1, 2, 3, 7, 8, 10, 11, 12, 13, 15, 19
Common imperial blue	1, 2, 3, 5, 6, 8, 9, 10, 13, 14, 18, 20, 23

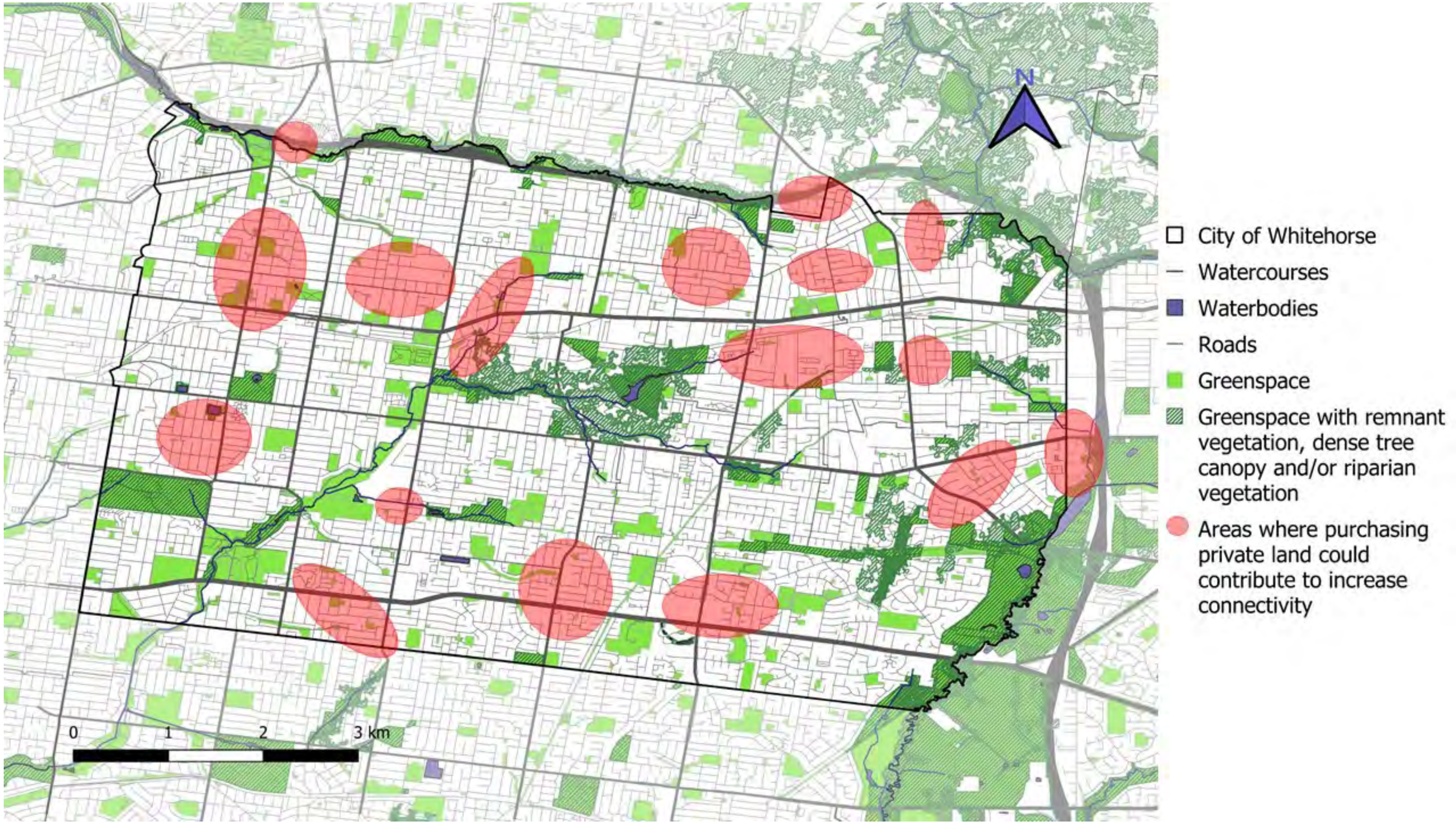


Figure 3.3 Areas within the City of Whitehorse where private property could be purchased and transformed to increase wildlife connectivity through the corridors presented in Table 3.1 and shown in Figures 3.1 and 3.2.

Other corridors (e.g. Corridor 6) may require alternative arrangements, such as targeting Gardens For Wildlife activities or collaborating with other custodians (e.g. VicTrack). In Figure 3.3, we highlight several areas where agreements with private land owners or purchase of private lands by the local government can greatly increase the support these corridors can offer for the movement of both terrestrial and aquatic wildlife across the City of Whitehorse.

There are multiple locations with opportunities to increase connectivity for all 12 of the functional groups examined here (Table 3.2). This is a positive position, since it reflects a well distributed arrangement of the existing habitat for these groups. Providing additional habitat, reducing urban impacts, and creating stepping stones to help these taxa move through the landscape, will support populations of these functional groups into the future. Focusing on the targeted locations identified in Figure 3.1 will allow a finer scale investigation and prioritization of actions that are likely to be of great benefit to the functional groups investigated in this study.

4 Technical Considerations

This report maps habitat connectivity across a landscape, rather than modelling the likely movement of a target species. Habitat connectivity mapping uses the spatial arrangement of features known to be similar to habitats where the focal species occur. It is not a guarantee that the focal taxa are already present at the site. It is simply a tool for mapping where suitable habitat for that species is already present in the landscape.

Any mapping exercise is only as detailed as the spatial data available to use as input. For this report, we were relying on data from the State of Victoria, which is largely produced at the scale of the entire state. For examining general connectivity patterns across the entire municipality, this resolution of data is acceptable. However, it is important to note that a finer scale investigation may reveal additional patches of potential habitat (e.g. waterbodies, small areas of remnant vegetation) or instances where the data do not reflect the current circumstances for other reasons (e.g. an area of vegetation has now been cleared). Therefore, it is worth interpreting these outcomes as a reliable first step to identify areas suitable for a more detailed investigation.

5 Summary

Whitehorse City Council is home to a wide diversity of plant and animal species, and supports a number of locations with key habitats for the 12 functional groups investigated in this report. The existing corridors are largely located along riparian areas, such as the Koonung Creek, the Dandenong Creek, the Gardiner's Creek and the Mullum Mullum Creek. Protecting these existing corridors, managing potential urban impacts, such as artificial light at night, and adding additional habitat within the corridors to help increase connectivity will help to enhance the habitat value of these existing assets.

This study has also identified additional locations for actions to help increase connectivity, often through residential landscapes and terrestrial areas between different riparian corridors. These locations may provide additional challenges for delivering increased connectivity, but the restoration actions and the actions required to reduce urban impacts are similar. Focusing on the functional groups that have been linked to these corridors will help to narrow the number of activities to target in those locations. Actions to support additional taxa can potentially be considered at a later stage.

This report was a desktop study that relied on existing spatial data. Collecting additional data at a finer scale within specific corridor locations will help provide a clearer picture of how to supplement existing habitats with additional areas. Capturing this information will also assist future studies by providing more detailed information that can allow for a more in depth mapping and investigation in the future.

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Appendix 1

Details of methodological approach

1. Summarising biodiversity records – overview of methods

Summarise biodiversity records for the municipality and a 1 km buffer of the surrounding landscape

Produce maps illustrating the distribution of species richness in 500 m2 grid cells across the municipality for major taxonomic groups

Use the information from the biodiversity records and mapping exercise to identify important taxonomical and functional groups within the municipality and to help inform the selection of 12 focal taxa to act as representatives for each group.

2. Connectivity mapping – overview of methods

Investigate available literature to identify information related to habitat requirements, dispersal distances, and minimum patch sizes relevant to each focal taxon, and the aspects of the urban landscape known to influence the likelihood of observing that species.

Use the information from the literature to create spatial themes that represent potential connectivity of habitat for each focal taxon based on those conditions.

Use the information from the literature to create spatial themes that represent potential barriers or less suitable habitat for each focal taxon.

Intersect the potential habitat connectivity theme with the potential barriers/urban threats theme to create a map of the current connectivity conditions across the municipality.

Use the map of current connectivity conditions to identify opportunities for actions that will increase connectivity across the municipality.

Document these opportunities in both map form and with an accompanying table of recommended actions.

3. Connectivity mapping – specific methods related to habitat elements

Remnant vegetation - Native Vegetation - Modelled 2005 Ecological Vegetation Classes (with Bioregional Conservation Status) (NV2005_EVCBCS/EVCBCS). State of Victoria | Creative Commons Attribution 4.0 International licence.

Dense tree canopy - Tree Density 1:25,000 - Vicmap Vegetation (tree_density_dense). State of Victoria | Creative Commons Attribution 4.0 International licence.

Waterbodies - HY_WATER_AREA_POLYGON Water Area (polygon) 1:25,000 - Vicmap Hydro. State of Victoria | Creative Commons Attribution 4.0 International licence. Mitcham reservoir was removed from this layer.

Watercourses – Hy_watercourse Network 1:25,000 - Vicmap Hydro. State of Victoria | Creative Commons Attribution 4.0 International licence.

Open space – Melbourne metropolitan open space network (VPA_Draft_Open_Space_Data). Planning Victoria |Creative Commons Attribution 4.0 International licence.

Open space with remnant vegetation – Select by location all 'open space' features that intersect NV2005_EVCBCS. Saved as VPA_OS_EVCs.

Open space with *Eucalyptus* species present – Select by location all 'open space' features that intersect records where [Genus] = 'Eucalyptus'. Saved as VPA_OS_Eucalyptus.

Open space with *Acacia* species present – Select by location all 'open space' features that intersect records where [Species] = 'Acacia melanoxylon' OR [Species] = 'Acacia mearnsii' or [Species] = 'Acacia implexa'. Saves as VPA_OS_Acacias.

Open space with indigenous plant species in which adult blue-banded bees are known to forage – Select by location all 'open space' features that intersect records where [Species] = 'Pelargonium australe' OR [Species] = 'Goodenia ovata' OR [Species] = 'Isotoma axillaris' OR [Species] = 'Crowea exalata' OR [Species] = 'Bulbine bulbosa' OR [Genus] = 'Dianella' OR [Genus] = 'Wahlenbergia'. Saves as VPA_OS_Pollination.

Dense riparian vegetation – Select by location patches of 'dense tree' canopy that intersect the watercourses + 200 m buffer. Saves as Dense_Riparian_Veg.

Nighttime light levels – Version 1 Nighttime VIIRS Day/Night Band Composites with VIIRS Cloud Mask - Outlier Removed - Nighttime Lights layer (SVDNB_npp_20160101-20161231_00N060E_vcm-orm-ntl_v10_c201807311200.avg_rade9). Earth Observation Group, NOAA/NCEI.

4. Connectivity mapping – specific methods related to each focal taxon

Spotted pardalote | *Pardalotus punctatus*

Habitat connectivity: Open space patches with Eucalypts (VPA_OS_Eucalyptus). 150 m around patches smaller than 1 ha, 1.3 km buffer around patches larger than 6 ha, 500 m buffer around patches 1-6 ha in size. Saved as VPA_OS_Eucalyptus_buffered_by_size.

Habitat disruptor: Unable to be represented by available spatial data.

Eastern yellow robin | *Eopsaltria australis*

Habitat connectivity: 75 m buffer around greenspaces (VPA_Draft_Open_Space_Data) and 189 m buffer around greenspaces with remnant vegetation (VPA_OS_EVCs). Minimum patch size 5 ha. Saved as VPA_OS_75m_VPA_OS_EVCs_189m_5ha.

Habitat disruptor: Unable to be represented by available spatial data.

Brown goshawk | *Accipiter fasciatus*

Habitat connectivity: 243 m buffer around dense riparian vegetation (Dense_Riparian_Veg). Saved as Dense_Riparian_Veg_243m.

Habitat disruptor: Unable to be represented by available spatial data.

Sugar glider | *Petaurus breviceps*

Habitat connectivity: 30 m buffer around open space patches with remnant vegetation (VPA_OS_EVCs). Saved as VPA_OS_EVCs_30m.

Habitat disruptor: Medium to high density residential housing, and isolated patches.

Common ringtail possum | *Pseudocheirus peregrinus*

Habitat connectivity: 400 m buffer around areas of dense vegetation (tree_density_dense). Saved as tree_density_dense_400m.

Habitat disruptor: Lack of tree cover to facilitate dispersal.

Swamp wallaby | *Wallabia bicolor*

Habitat connectivity: 300 m and 1500 m buffer around dense vegetation (tree_density_dense). Saved as tree_density_dense_300m and tree_density_dense_1500m.

Habitat disruptor: Major roads. Variable buffer for roads with Class Code > 4 based on information from the VicRoads Supplement to AGRD Part 3 - Geometric design (2016) and visual assessment of number of lanes for key roads within the municipality. Saved as roads_CClt4_Buffered.

Little forest bat | *Vespadelus vulturnus*

Habitat connectivity: 600 m buffer around VPA_OS_EVCs. Saves as VPA_OS_EVCs_600m.

Habitat disruptors: Brightly lit areas – Band calculator to select all raster cells with radiance value > 9 in Version 1 Nighttime VIIRS Day/Night Band Composites with VIIRS Cloud Mask - Outlier Removed - Nighttime Lights layer (SVDNB_npp_20160101-20161231_00N060E_vcm-orm-ntl_v10_c201807311200.avg_rade9). Earth Observation Group, NOAA/NCEI. Saved as 16VCmOrmNtl_gt9_polygons.

Common blue-tongued lizard | *Tiliqua scincoides*

Habitat connectivity: 1000 m buffer around greenspaces with remnant vegetation (VPA_OS_EVCs). Saved as VPA_OS_EVCs_1000m.

Habitat disruptor: Major roads. Variable buffer for roads with Class Code > 4 based on information from the VicRoads Supplement to AGRD Part 3 - Geometric design (2016) and visual assessment of number of lanes for key roads within the municipality. Saved as roads_CClt4_Buffered.

Eastern long-necked turtle | *Chelodina longicollis*

Habitat connectivity: 395 m buffer around waterbodies (HY_Waterbodies). Saved as Hy_waterbodies_Whitehorse_395.

Table A1 Buffer distance applied to different classes of roads

	Class Code 0	Class Code 1	Class Code 2	Class Code 3
Total number of lanes frequently observed	9	8	6	3
Buffer distance (m)	30	20	15	5

Habitat disruptor: Major roads with a width of more than 3 lanes. Variable buffer applied to features of Vicmap TR_ROADS that had a Class_Code of 0 – 3. See Table A1 for details. Saved as roads_CClt4_Buffered.

Pobblebonk | *Limnodynastes dumerilii*

Habitat connectivity: 200 m buffer around watercourses and waterbodies. Saved as Hy_waterbodies_watercourse_200.

Habitat disruptor: Major roads. Buffered roads with Class Code > 4 based on information from the VicRoads Supplement to AGRD Part 3 - Geometric design (2016) and visual assessment of number of lanes for key roads within the municipality. Variable buffer using the information provided in Table A1. Saved as roads_CClt4_Buffered.

Blue-banded bees | *Amegilla asserta* and *Amegilla chlorocyanea*

Habitat connectivity: 350 m buffer around areas of open space that contain the indigenous plant species on which the bees are known to forage (VPA_OS_Pollination). Saved as VPA_OS_Pollination_350m.

Habitat disruptor: Unable to be represented by available spatial data.

Common imperial blue | *Jalmenus evagoras*

Habitat connectivity: VPA_OS_Acacias with 0 m buffer. Individuals rarely travel far from the host plants of *Acacia implexa*, *A. mearnsii*, and *A. melanoxylon*.

Habitat disruptors: Unable to be represented using available spatial data due to highly localised distributions.

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