An Atlas of **Tuart Woodlands**

on the Swan Coastal Plain in Western Australia

GOVERNMENT OF WESTERN AUSTRALIA

DEPARTMENT OF Conservation AND LAND MANAGEMENT
Conserving the nature of WA

Tuart Response Group

ecoscape

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1. Foreword

This *Tuart Atlas* has been developed by the Tuart Response Group with information gathered since July 2002. It represents the most accurate assessment of the extent of tuart woodlands and the condition of its associated understorey on the Swan Coastal Plain. The 'atlas' has also identified new areas not previously mapped.

The occurrence of tuart woodlands has significantly reduced since European settlement of Western Australia due to the impacts of urban development and agriculture. The status of tuart woodlands is now further threatened by a chronic decline in the health of tuart trees at Yalgorup between Mandurah and Bunbury.

In November 2001 I established the Tuart Response Group to coordinate the development of the Government's *Tuart conservation and management strategy*, to investigate the cause(s) of tuart decline, and to provide information to land owners on the protection of tuarts on private land.

This *Tuart Atlas* is a key step in the development of the 'tuart strategy'. It provides improved knowledge about the extent, density and condition of tuart woodlands, data for a review of tuart's conservation status, and a basis for developing Government and community based tuart management partnerships.

Judy Edwards

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Minister for the Environment

2. Acknowledgments

The *Tuart Atlas* is a collaborative project prepared for the Government's Tuart Response Group by Ecoscape (Australia) Pty Ltd. The following contributions are acknowledged:

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- Val English, Ecologist, Department of Conservation and Land Management;
- Greg Strelein, Senior Research Scientist, Department of Conservation and Land Management;
- Pat Collins, Senior Forester, Department of Conservation and Land Management;
- Robyn Wilson, Geographical Information System Applications Manager, Department of Conservation and Land Management;
- Holly Smith, Cartographic Officer, Department of Conservation and Land Management;
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- David Keasehagen, Director, Ecoscape (Australia) Pty Ltd;
- Louise Cullen, Environmental Scientist, Ecoscape (Australia) Pty Ltd; and
- Adrian Forest, Spatial Scientist, Ecoscape (Australia) Pty Ltd.

The Government of Western Australia acknowledges funding provided by the Department for Planning and Infrastructure, and soils and landscape data provided by the Department of Agriculture.

CALM recreation site set in tuart and peppermint woodland.
Photo – Department of Conservation and Land Management

3. Executive summary

Tuart occurs in a coastal strip from near Jurien Bay to near Busselton in Western Australia. Before European arrival there were estimated to be more than 111,600 hectares of tuart woodlands. Most have been cleared for agriculture and urban development. Since the mid-1990s there has also been a marked decline in the health and vitality of tuart trees at Yalgorup. A *Tuart conservation and management strategy* is now being developed to address tuart's remnant status, its decline in health, and to establish protection and management partnerships with community groups. The *Tuart Atlas* is an essential first stage in this 'strategy' development.

The production of the *Tuart Atlas* involved the digital capture of data on tuart occurrence, overstorey density and understorey condition, from high-resolution digital aerial colour photography. The mapping presented in the 'atlas' represents the most up-to-date and accurate assessment of tuart woodlands over its natural range. It estimates the total area of tuart woodlands remaining to be 30,311 hectares. Earlier mapping of tuart's dominant structural ecosystems estimated the current extent of tuart to be 38,829 hectares. Both estimates of tuart extent are valid. The variation occurs due to differences in mapping purpose, the level of detail of vegetation mapping, and the interpretation of remnant vegetation.

Large, majestic tuart on private land near Tuart Forest National Park.
Photo – Robert Powell

4. Introduction

Tuart is endemic to the Swan Coastal Plain, growing near the coast in a 400-kilometre band from Jurien Bay on the Plain's north to the Sabina River, east of Busselton (Keighery *et al.* 2002). Tuart is mostly confined to two coastal aeolian dune belts, the Quindalup Dunes and the Spearwood Dunes, although there is a series of outlying populations near the Murray, Serpentine, Swan and Canning Rivers (See 'Distribution of tuart woodlands' map).

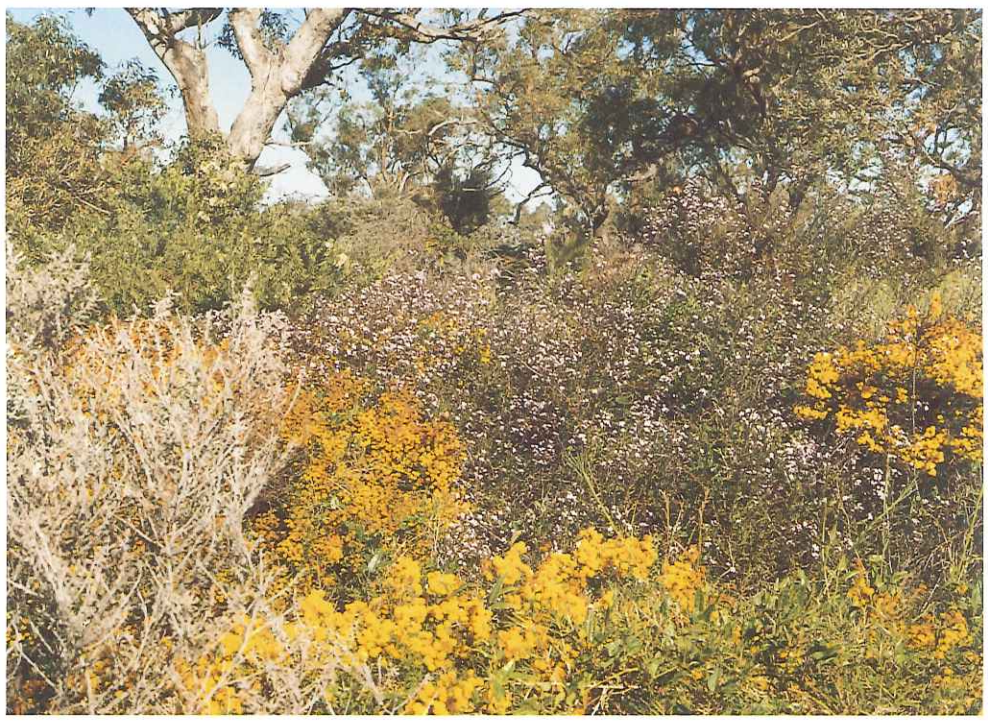
It is estimated that before Europeans arrived there were more than 111,600 hectares of tuart woodlands (Hopkins *et al.* 1996). Most have been cleared for agriculture and urban development and it is estimated that only 35 per cent remains (Hopkins *et al.* 1996). Since the mid-1990s there has also been a noticeable decline in the health and vitality of tuart trees at Yalgorup between Mandurah and Preston Beach (Government of Western Australia 2002).

Extensive tuart woodlands remain at Ludlow, Yanchep and Yalgorup National Parks (Department of Conservation and Land Management 1978, 1989, 1995). Tuart woodlands are conserved in Bold Park and Kings Park, Neerabup National Park, at the Trigg Dune bushlands, Leschenault Peninsular and the Maidens. Tuart also occurs fringing pine (*Pinus radiata*, *P. pinaster*) plantations in State forest at Myalup and McLarty, and in unallocated Crown land, regional parks and 'Bush Forever' sites at Yanchep, Woodman Point and Lakes Cooloongup and Walyungup. Smaller remnants of tuart are scattered across its natural range.

The Government of Western Australia has called for the development of a *Tuart conservation and management strategy* to address tuart's remnant status, its decline in health and to establish protection and management partnerships with community groups. The Minister for the Environment's Tuart Response Group was established in November 2001 to coordinate this work. The *Tuart Atlas* is an essential first stage in 'strategy' development. It provides a more accurate assessment of the extent of tuart woodlands and the condition of its associated understorey, and will be used to refine the present tuart reserve system and to identify conservation linkages between tuart in reserves and tuart on freehold lands.

The *Tuart Atlas* integrates and builds on four existing datasets:

- the earlier broad tuart overstorey structural units mapped by Speck (1952), that were further developed by Smith (1973, 1974) and Beard (1979a, 1979b, 1979c, 1981), and refined and consolidated by Hopkins *et al.* (1996);
- vegetation complex mapping done as part of the review of the conservation estate within the 'System 6' study area by the former Department of Conservation and Environment (Heddle *et al.*1980);
- information derived from plots on tuart's regional floristic groupings (Gibson *et al.* 1994; Department of Environmental Protection 1996); and
- mapping of tuart occurrence on lands vested in the Conservation Commission of Western Australia that was derived from the Department of Conservation and Land Management's Forest Management Information System (FMIS).



Tuarts and associated shrubby understorey at Yanchep National Park.
Photo – Department of Conservation and Land Management

5. Purpose

The purpose of the Tuart Atlas is to provide accurate and current information on (i) the extent of tuart woodlands on the Swan Coastal Plain (ii) the density of its overstorey component and (iii) the condition its associated understorey.

6. Methodology

6.1 Datasets used

Development of the *Tuart Atlas* involved the digital capture of tuart data from high-resolution digital aerial colour photography captured in January 2002. Other digital datasets used to assist in locating tuart areas included:

- broad tuart dominant structural ecosystem units after Beard (1979a, 1979b, 1979c) and Hopkins *et al.* (1996);
- soil and landscape mapping provided by the Department of Agriculture, Western Australia; and
- FMIS data provided by the Department of Conservation and Land Management.

6.2 Aerial photographic interpretation mapping

Interpretation of high-resolution digital aerial photographs formed the primary basis for identifying the current extent and condition of tuart areas on the Swan Coastal Plain. The minimum polygon size for mapping was set at one hectare and greater, with polygons created at an average on-screen scale of 1:10,000.

Identification of tuart involved interpreting canopy colour and form. Mature tuart canopies tended to have more open, grey-green (glaucous) canopy compared to jarrah (*Eucalyptus marginata*) or marri (*Corymbia calophylla*).

Tuart appearance on the aerial imagery varied according to the following factors:

- quality of the aerial mosaic that differed from tile to tile due to (i) the time of day the aerials were captured, and (ii) processing effects such as colour balancing, and conversion of aerial photographs into digital imagery mosaics; and
- variation in tuart form characterised by increasing stature and canopy density from north to south.

Digital colour photographs were not available from Lancelin north. A trial using black and white digital photographs determined that it was not possible to distinguish tuart from other canopy species. Information of tuart occurrences from Lancelin north were drawn from Keighery *et al.* (2002) and other Department of Conservation and Land Management data sources.

6.2.1 Overstorey and understorey occurrence and condition

Overstorey occurrence

The extent of tuart was mapped using Department of Conservation and Land Management Aerial Photography Mapping (API) mapping standards. Overstorey canopy was mapped in 10 per cent density classes (ie. 0–9, 10–19 ..... 90–100 per cent). Density classes included the canopies of all species and did not distinguish between tuart and other trees (usually jarrah and marri). FMIS canopy densities already classified by the Department of Conservation and Land Management during the mid-1990s on some Crown lands in tuart's southern distribution were included in the 'atlas' and were not re-mapped.

Native understorey condition

Understorey condition was mapped using three classes, namely (i) no visible disturbance, (ii) uninterpretable (ie. could only be determined by field evaluation) and (iii) high visible disturbance. Uninterpretable areas occurred where canopy cover was too dense to be able to estimate understorey condition, or where the quality of the aerial mosaic was poor.

6.2.2 Quality assurance and validation

During the initial stages of the project, a trial mapping and field validation process was used to ensure accurate identification and assessment of tuart woodlands. This process involved selecting a number of 'training sites' spread across tuart's known distribution, electronically determining canopy density and understorey condition using the aerial photographs, and then visiting the sites to validate interpretation.

Field validation of estimated tuart canopy density found that all site estimations had 30 per cent or under deviation from the verified cover, and a total of 87.5 per cent of sites were within 20 per cent of the estimated cover. This indicates a high accuracy of estimated canopy cover. Table 1 shows the percentage of sites validated at 0, 10, 20 and 30 per cent deviation from the estimated cover. Figure 1 shows the estimated percentage of tuart canopy cover and the percentage occurrence validated in the field for each training site.

Field validation of estimated understorey condition is shown in Figure 2. A total of 56.3 per cent of the training sites had the same understorey condition as estimated and a total of 75 per cent of the validated sites were within one class of the estimated condition. This indicates a generally high accuracy of estimated understorey condition class. Three of the sites (1605, 1614, 1615) were estimated as uninterpretable from the API mapping, of which two were validated as having high disturbance. Of the sites which differed between estimated and validated values (1601, 1602, 1604, 1609), all underestimated the level of disturbance thus indicating an appropriate conservative bias in the overall understorey condition assessment.

7. Discussion

7.1 Total tuart extent, canopy density and native understorey condition

The mapping of tuart woodlands presented in the *Tuart Atlas* represents the most up-to-date and accurate mapping of its extent, overstorey density and understorey condition. The 'atlas' estimates the remaining area of tuart woodlands to be 30,311 hectares (Table 2). Tuart extent is summarised by land category and is (i) ordered by local government area (Table 3), and (ii) ranked in descending total area (Table 4).

The distribution of canopy density classes as a percentage of total tuart area is shown in Figure 3. A total of 92.9 per cent of mapped areas had a canopy density of 50 per cent or less (Table 2). Understorey condition as a percentage of each canopy density class is shown in Figure 4. The level of understorey disturbance increases with decreasing canopy cover.

Table 2 shows that 10,897 hectares of remnant tuart woodlands had intact native understorey and contributed 36.0 per cent to the total area of tuart mapped. This compares with 18,207 hectares of tuart woodlands with disturbed understoreys or 60.1 per cent of the total area of tuart mapped. Within the disturbed understorey category tuarts with canopy density classes of 0–9 and 10–19 per cent were in the main paddock trees where grazing and cropping had been undertaken. These categories accounted for 7,860 hectares or 25.9 per cent of the total area of tuart mapped. Table 2 shows that only 1,207 or 3.9 per cent of tuart woodlands mapped had uninterpretable understorey condition that required further field evaluation.

7.2 Differences in tuart woodland mapping

Earlier mapping by Beard (1979a, 1979b, 1979c) and Hopkins *et al.* (1996) estimated the extent of tuart to be 38,829 hectares. The difference between this mapping and the *Tuart Atlas* is explained as follows.

7.2.1 Difference in purpose, scale and level of detail of vegetation mapping

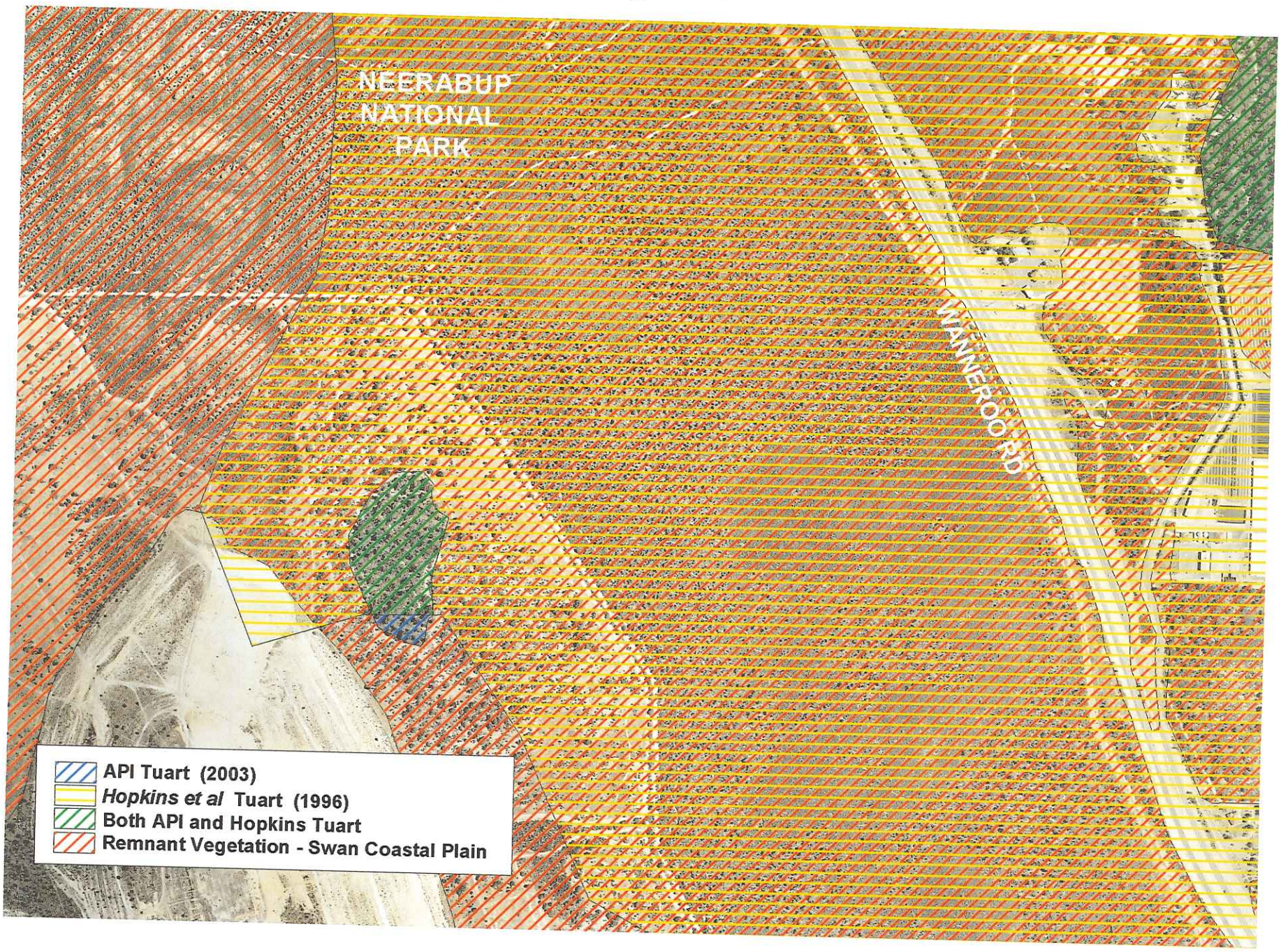
Earlier large-scale mapping has over-estimated the extent of tuart woodlands when compared to this recent fine scale mapping. The Beard (1979a, 1979b, 1979c) and Hopkins *et al.* (1996) maps were part of a project that mapped Western Australia's entire dominant structural ecosystems at a scale 1:250,000. At this scale the mapping regionalised tuart patches into larger areas that included areas not containing tuart (Plate 1 — see yellow) The *Tuart Atlas* has mapped the actual extent of tuart at a fine scale (1:10,000) thereby discriminating the isolated tuart patches (Plate 1 — see green) that were noted but aggregated by Beard in the original State mapping. These differences have been partly off-set by the capture of new tuart patches not originally mapped by 'Beard' (Plate 1 — see blue).

Plate 1: Example of difference in level of detail of vegetation mapping.

7.2.2 Differences in interpreting remnant vegetation.

During the 1990s a major mapping project was undertaken to accurately map all remnant vegetation remaining on the Swan Coastal Plain (Department of Agriculture, unpublished). When intersecting this dataset with Beard (1979a, 1979b, 1979c) and Hopkins *et al.* (1996) a remnant vegetation patch within a 'Beard' tuart ecosystem was assumed to contain tuart, regardless of the actual vegetation present. Therefore, in some areas remnant vegetation mapping has over-estimated the amount of tuart remaining. In the T*uart Atlas* only areas where tuart occurred were mapped (Plate 2).

Plate 2 : Example of difference in interpreting remnant vegetation.



8. References

Beard, J.S. (1979a). *Vegetation Survey of Western Australia* Vegmap Publications, Perth.

Beard, J.S. (1979b). *Vegetation Survey of Western Australia* 1:250,000: The Vegetation of the Pinjarra Area. Vegmap Publications, Perth.

Beard, J.S. (1979c). *Vegetation Survey of Western Australia 1:250,000: The Vegetation of the Moore and Hill River Areas.* Vegmap Publications, Perth.

Beard, J.S. (1981). *Vegetation Survey of Western Australia 1:1,000,000: Explanatory Notes to Sheet 7—The Vegetation of the Swan Area.* University of Western Australia Press, Perth.

Department of Agriculture (Unpublished). *Landuse and Vegetation, Western Australia.* Eds: G. Beeston, A. J. M. Hpkins, and D.P. Shepherd. Department of Agriculture, Western Australia and the National Land and Water Audit, Australian Capital Territory.

Department of Conservation and Land Management (1978). *Ludlow Working Plan (1978–1985).*

Department of Conservation and Land Management (1989). *Yanchep National: Park Management Plan 1989–1999*. Management Plan No. 14.

Department of Conservation and Land Management (1995). *Yalgorup National Park Management Plan 1995–2005*. Management Plan No. 29.

Department of Environmental Protection (1996). *System Six and Part System 1 Update Program: Unpublished Bushland Plot and Area Records and Analysis*.

Gibson, N., Keighery, G.J., Burbridge, A.H. and Lyons, M.N. (1994). *A Floristic Survey for the Southern Swan Coastal Plain*. Unpublished report prepared for the Department of Conservation and Land Management and the Conservation Council of Western Australia.

Government of Western Australia (2002). *Status Report: Tuart Conservation and Protection.* Prepared by the Tuart Response Group, August 2002.

Heddle, E.M., Loneragan, O.W. and Havel, J.J. (1980). *Vegetation Complexes of the Darling System Western Australia*. In: *Atlas of Natural Resources Darling System Western Australia Explanatory Text*. Department of Conservation and Environment, Western Australia, Perth.

Hopkins, A.J.M., Coker, J. Beeston, G.R., Bowan, P. and Harvey, J.M. (1996). *Conservation Status of Vegetation Types Through-out Western Australia: Final Report.* Australian Nature Conservation Agency National Reserves System Co-operative Research Program.

Keighery, B.J., Keighery, G.J. and Shepherd, D. (2002). *The Distribution and Conservation of Tuart and the Community With Which It Lives.* In: Tuart (*Eucalyptus gomphocephla*) and Tuart Communities. B.J. Keighery and V.M. Longman (eds). Perth Branch Wildflower Society of Western Australia (Inc.), Perth.

Smith, F.G. (1973). *Vegetation Map of Busselton and Augusta*. Western Australian Department of Agriculture, Perth.

Smith, F.G. (1974). *Vegetation Map of Collie*. Western Australian Department of Agriculture, Perth.

Speck, N.H. (1952). *The Ecology of the Metropolitan Sector of the Swan Coastal Plain*. Master of Science thesis, University of Western Australia.

TABLE 1

Number of validated sites for every 10% of deviation from the estimated cover

Deviation from estimated occurrence	% Sites in deviation category
0%	37.5%
0% – 10%	62.5%
0% – 20%	87.5%
0% – 30%	100%

TABLE 2

Tuart canopy density and understorey condition classes

Canopy Density Class	Understorey Condition Class						Totals	
	1		2		3			
(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
0–9	207.3	4.9	0.0	0.0	4043.6	95.1	4250.9	14.0
10–19	1307.1	25.1	93.7	1.8	3816.3	73.1	5217.1	17.2
20–29	3262.2	41.3	313.9	4.0	4318.6	54.7	7894.7	26.0
30–39	2889.5	42.7	379.2	5.6	3492.1	51.7	6760.8	22.3
40–49	2456.3	60.6	380.2	9.4	1217.6	30.0	4054.1	13.4
50–59	481.2	26.5	40.2	2.3	1291.4	71.2	1812.8	6.0
60–69	61.9	69.7	0.0	0.0	26.9	30.3	88.8	0.3
70–79	207.9	100.0	0.0	0.0	0.0	0.0	207.9	0.7
80–89	23.8	100.0	0.0	0.0	0.0	0.0	23.8	0.1
90–100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**10897.2**	**36.0**	**1207.2**	**3.9**	**18206.5**	**60.1**	**30310.9**[1]	**100.0**

[1] The difference in total tuart extent in Table 3 and Table 4 is due to "rounding-off" calculations

TABLE 3

Tuart extent summarised by land category and ordered by local government area

Local Government	Land Catagories									
	NP[2]	NR[3]	CP[4]	SF[5]	s.5(g) s.5(h)[8]	UCL[6]	UMR[7]	Other Reserves[9]	Freehold	Total
	CALM managed lands (ha)							(ha)	(ha)	(ha)
Bunbury	0.0	0.0	0.0	0.0	0.0	57.8	5.1	33.8	170.6	267.3
Busselton	594.5	2.1	0.0	213.2	0.0	2.8	5.6	0.1	118.7	937.0
Cambridge	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.6	123.5	204.1
Capel	1331.6	0.0	0.0	311.2	0.0	0.6	27.8	37.7	2165.9	3874.8
Claremont	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cockburn	0.0	63.3	0.0	0.0	0.0	54.2	0.0	55.7	198.1	371.3
Dandaragan	0.0	10.6	0.0	0.0	0.0	0.0	0.0	2.4	25.4	38.4
Dardanup	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	50.0	50.7
Fremantle	0.0	0.0	0.0	0.0	0.0	0.0	0.3	45.5	6.1	51.9
Gingin	0.0	0.0	0.0	301.9	8.6	149.7	66.7	28.9	2640.7	3196.5
Harvey	225.0	23.2	84.3	1063.5	0.0	0.1	35.1	41.1	3148.1	4620.4
Joondalup	0.0	0.1	3.4	25.1	0.0	21.9	4.2	84.8	144.1	283.6
Kwinana	0.0	250.9	0.0	0.0	0.0	94.4	26.8	54.7	454.5	881.3
Mandurah	995.1	0.0	0.0	0.0	2.0	72.9	18.7	179.6	2526.5	3794.8
Melville	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Murray	0.0	190.9	0.0	0.0	0.0	0.3	2.0	0.0	1116.6	1309.8
Nedlands	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	28.3	28.5
Perth	0.0	0.0	0.0	0.0	0.0	0.0	23.8	0.0	0.0	23.8
Rockingham	0.0	0.0	0.0	0.2	0.0	4.0	64.7	60.1	2191.3	2320.3
South Perth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
Stirling	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.1	19.4	43.5
Subiaco	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vincent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wanneroo	706.5	44.7	0.0	312.7	60.7	26.0	61.7	55.3	2091.0	3358.6
Waroona	1555.4	0.0	0.0	1094.3	7.6	74.8	1.9	66.9	1858.0	4658.9
Total	**5408.1**	**585.8**	**87.7**	**3322.1**	**78.9**	**559.7**	**344.4**	**852.0**	**19077.8**	**30316.5**

[2] NP: National park

[3] NR: Nature reserve

[4] CP: Conservation park

[5] SF: State forest, CALM Executive Director freehold lands, miscellaneous CALM managed reserves

[6] UCL: Unallocated Crown land

[7] UMR: Unmanaged reserve

[8] s.5(g);s5(h): CALM Act (1984) Sections 5(g) and Section 5(h) reserves

[9] Other reserves: Other Crown reserves not vested in the Conservation Commission, including reserves vested with local governments and other agencies such as roads and water authorities.

TABLE 4

Tuart extent summary by land category and by local government area and ranked in descending total area

Local Government	Land Catagories									
	NP	NR	CP	SF	s.5(g) s.5(h)	UCL	UMR	Other Reserves	Freehold	Total
	CALM managed lands (ha)							(ha)	(ha)	(ha)
Waroona	1555.4	0.0	0.0	1094.3	7.6	74.8	1.9	66.9	1858.0	4658.9
Harvey	225.0	23.2	84.3	1063.5	0.0	0.1	35.1	41.1	3148.1	4620.4
Capel	1331.6	0.0	0.0	311.2	0.0	0.6	27.8	37.7	2165.9	3874.8
Mandurah	995.1	0.0	0.0	0.0	2.0	72.9	18.7	179.6	2526.5	3794.8
Wanneroo	706.5	44.7	0.0	312.7	60.7	26.0	61.7	55.3	2091.0	3358.6
Gingin	0.0	0.0	0.0	301.9	8.6	149.7	66.7	28.9	2640.7	3196.5
Rockingham	0.0	0.0	0.0	0.2	0.0	4.0	64.7	60.1	2191.3	2320.3
Murray	0.0	190.9	0.0	0.0	0.0	0.3	2.0	0.0	1116.6	1309.8
Busselton	594.5	2.1	0.0	213.2	0.0	2.8	5.6	0.1	118.7	937.0
Kwinana	0.0	250.9	0.0	0.0	0.0	94.4	26.8	54.7	454.5	881.3
Cockburn	0.0	63.3	0.0	0.0	0.0	54.2	0.0	55.7	198.1	371.3
Joondalup	0.0	0.1	3.4	25.1	0.0	21.9	4.2	84.8	144.1	283.6
Bunbury	0.0	0.0	0.0	0.0	0.0	57.8	5.1	33.8	170.6	267.3
Cambridge	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.6	123.5	204.1
Fremantle	0.0	0.0	0.0	0.0	0.0	0.0	0.3	45.5	6.1	51.9
Dardanup	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	50.0	50.7
Stirling	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.1	19.4	43.5
Dandaragan	0.0	10.6	0.0	0.0	0.0	0.0	0.0	2.4	25.4	38.4
Nedlands	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	28.3	28.5
Perth	0.0	0.0	0.0	0.0	0.0	0.0	23.8	0.0	0.0	23.8
South Perth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
Claremont	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Melville	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subiaco	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vincent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**5408.1**	**585.8**	**87.7**	**3322.1**	**78.9**	**559.7**	**344.4**	**852.0**	**19077.8**	**30316.5**

FIGURE 1

Field validation of estimated tuart canopy cover

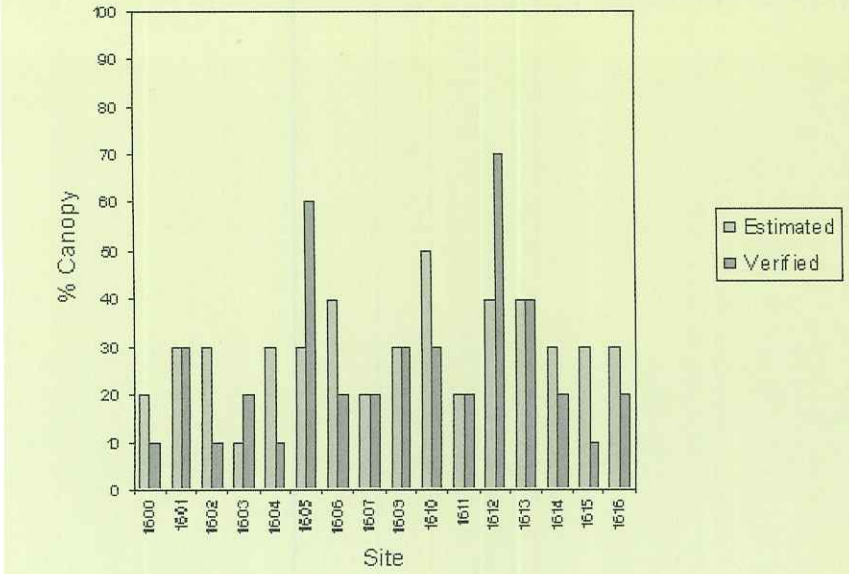


FIGURE 2

Field validation of estimated native understorey condition

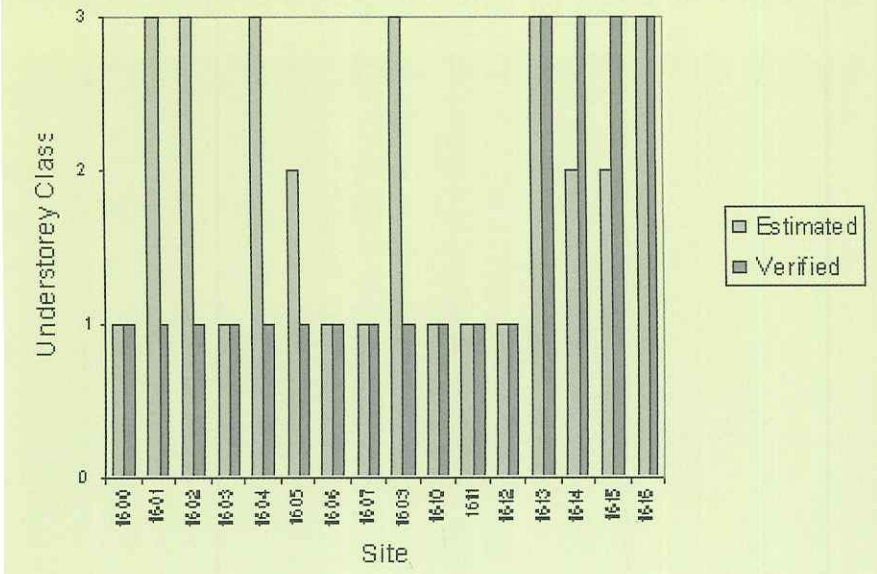


FIGURE 3

Canopy density class as a percentage of total tuart area

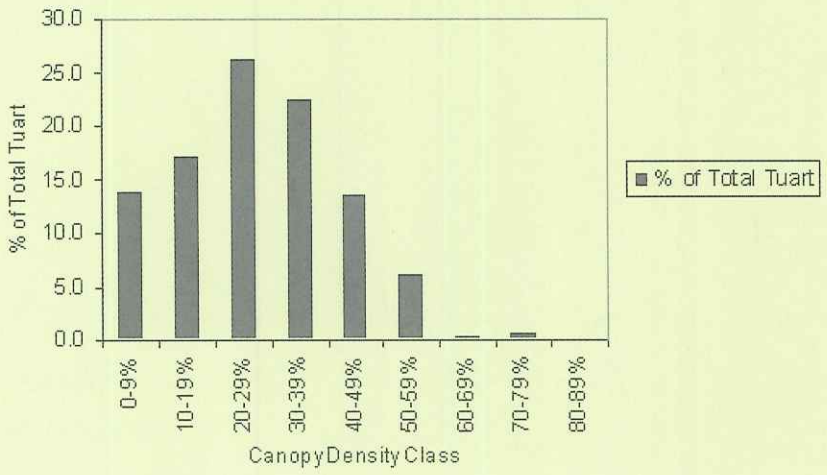
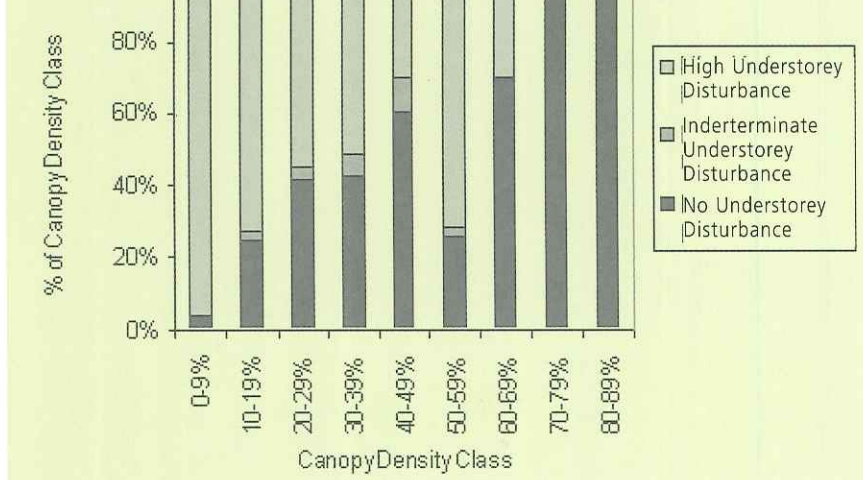


FIGURE 4

Understorey condition trend relative to canopy density class



Extent, Density and Condition of Tuart Woodlands

0 0.5 1 2 3 4 5 Kilometres

Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)

Legend

Canopy density and understorey condition of *Eucalyptus gomphocephala* Woodlands

Canopy Density Class

- 0 - 9%
- 10 - 19%
- 20 - 29%
- 30 - 39%
- 40 - 49%
- 50 - 59%
- 60 - 69%
- 70 - 79%
- 80 - 89%
- 90 - 100%

Visible native understorey condition

- No Disturbance
- Uninterpretable *
- High Disturbance

* The level of disturbance requires further ground truthing.

MAP PROJECTION
Universal Transverse Mercator adopting the Map Grid of Australia
Zone 50 CM 117° Datum: GDA 94

GDA

Lands managed by the Department of Conservation and Land Management as provided by the CALM Act (1984)

- National park
- Nature reserve
- Conservation park
- State forest, Executive Director freehold and other reserve
- Sections 5(1)(g) & 5(1)(h) reserve

Other lands managed by CALM

- Unallocated Crown land
- Unmanaged reserve

Other tenure

- Other Crown reserve
- Private property

Management boundaries and access

- Local government boundary
- Regional park boundary
- Sealed road, two or more lanes
- Sealed road, one lane
- Unsealed road

DATA DIRECTORY

THEME	SOURCE	DATE	CUSTODIAN
LGAs	DOLA	July 2000	DOLA
Regional Parks	Regional Parks Unit	Dec. 2001	Regional Parks Unit
Topography	Dept of Cons & Land Mgt / DOLA	Sept. 2002	Dept of Cons & Land Mgt / DOLA
Tenure	Dept of Cons & Land Mgt	July 2002	Dept of Cons & Land Mgt

Produced by Information Management Branch
under the direction of Keiran McNamara, Executive Director,
Department of Conservation and Land Management
for the Tuart Response Group

For further information contact Drew Haswell, Project Manager,
Department of Conservation and Land Management;
Executive Officer, Tuart Response Group
ph: (08) 9334 0337 email: drewh@calm.wa.gov.au

October 2003
IMB : 04011501

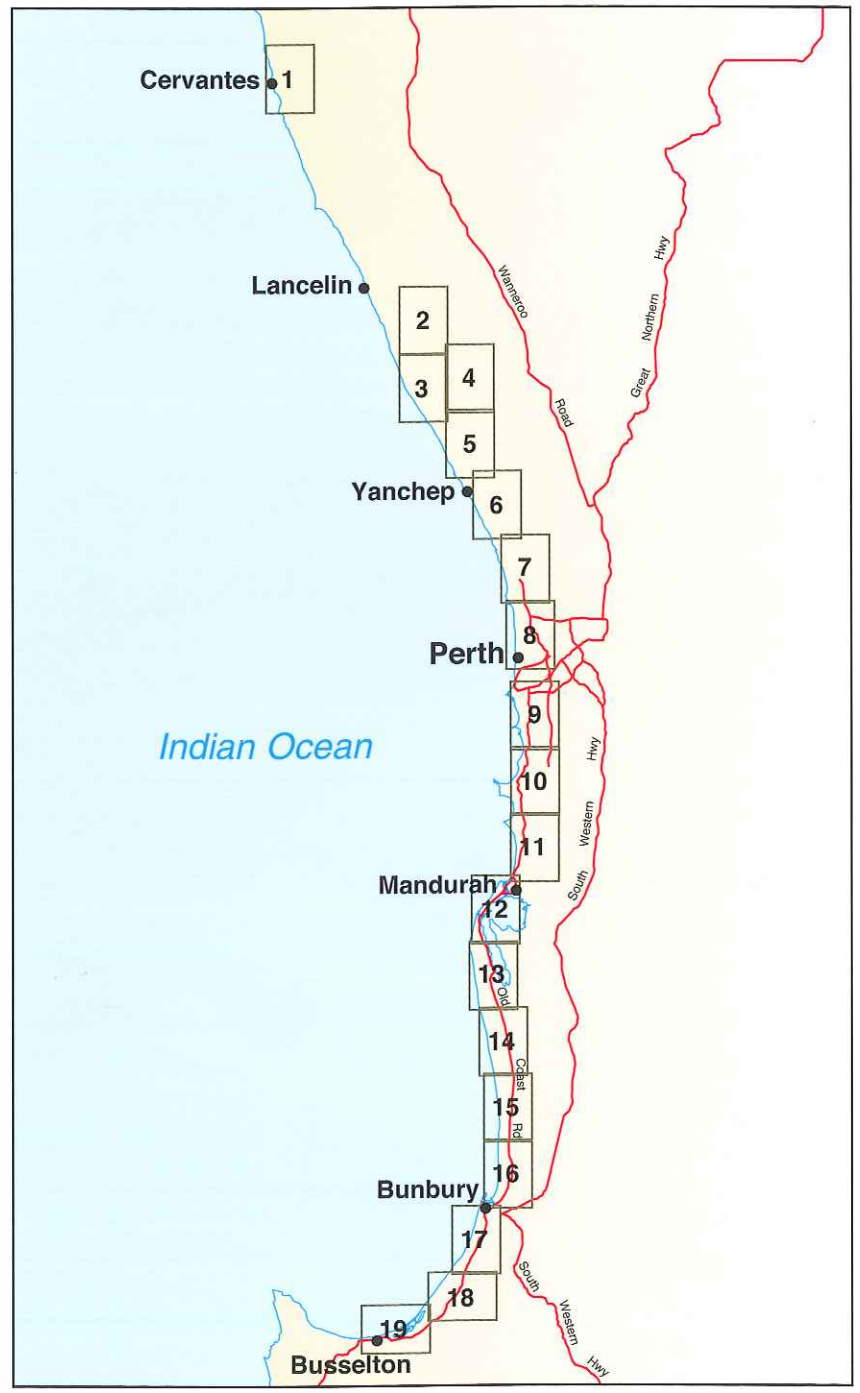
GOVERNMENT OF WESTERN AUSTRALIA

DEPARTMENT OF Conservation AND LAND MANAGEMENT
Conserving the nature of WA

ecoscape

Tuart Response Group

Map Index of Tuart Extent



Index map

Distribution map

Existing Distribution of Tuart Woodlands on the Swan Coastal Plain

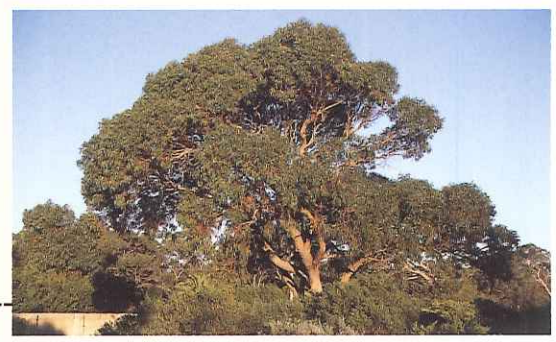
300000mE 350000mE 400000mE 450000mE 500000mE 550000mE

6650000mN 6600000mN 6550000mN 6500000mN 6450000mN 6400000mN 6350000mN 6300000mN 6250000mN

Cervantes
Lancelin
Yanchep
Perth
Mandurah
Bunbury
Busselton
Indian Ocean
Wanneroo Road
Great Northern Hwy
Swan River
South Western Hwy
Peel Inlet
Serpentine River
Lake Clifton
Harvey Estuary
Murray River
Lake Preston
Old Coast Rd
Leschenault Estuary
Collie River
Vasse Estuary

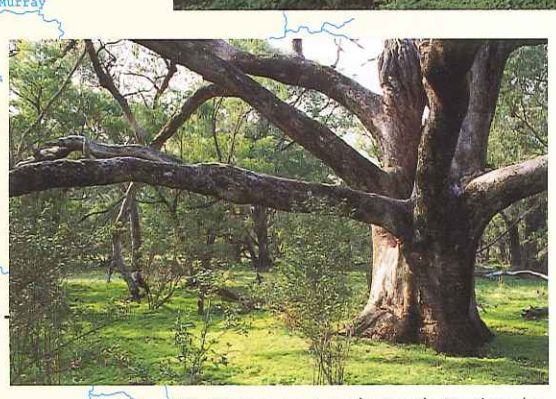
Open tuart woodland north of Cervantes, near northern limit of range.
Photo – Robert Powell

Tuart woodland, Yanchep National Park.
Photo – Robert Powell



Tuarts at City Beach with low, broad, dense canopies, in response to very salty sea winds.
Photo – Robert Powell

Tuart woodland from White Hill in Yalgorup National Park. The trees are kept low by sea winds.
Photo – Robert Powell



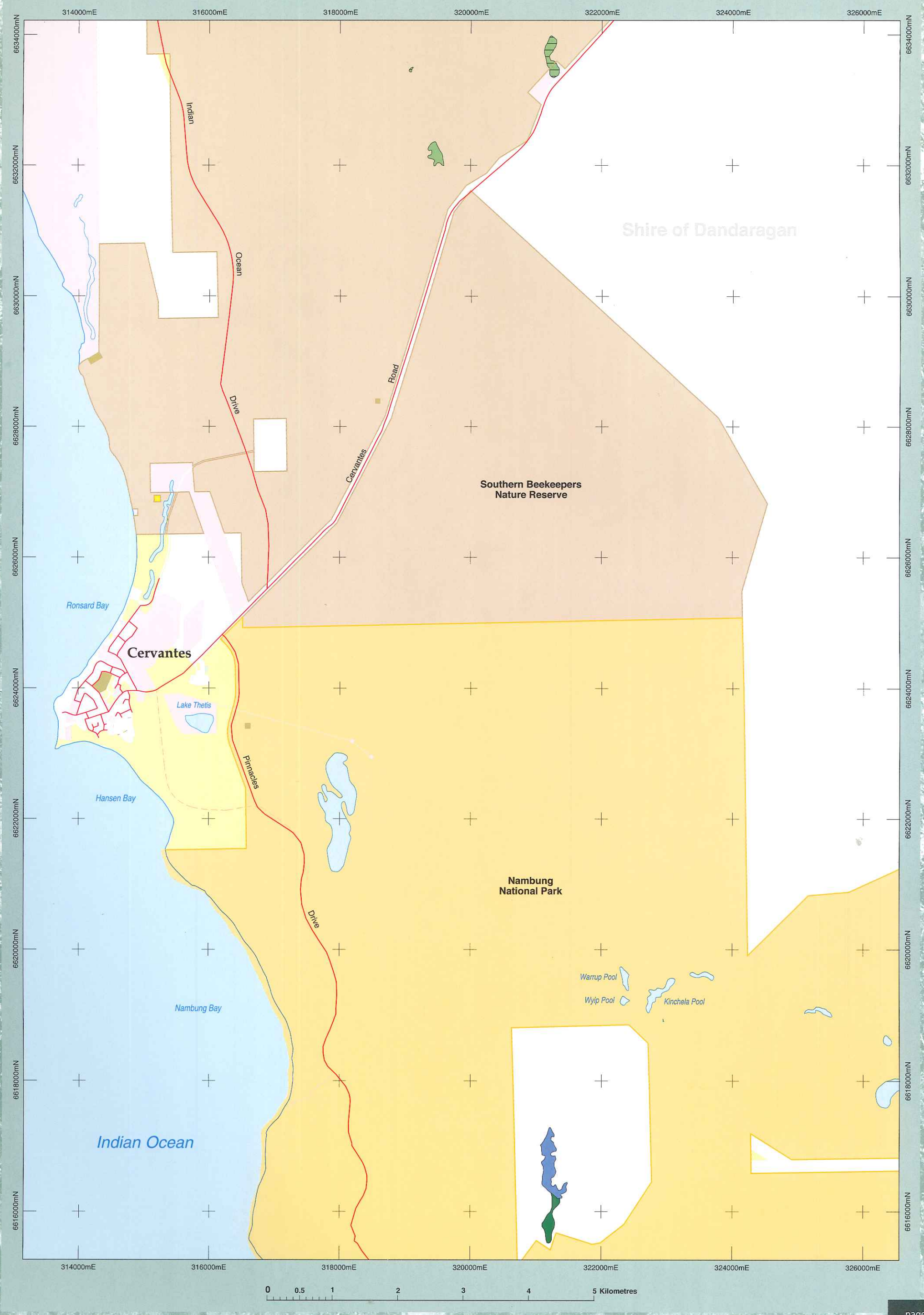
Tuart tree on Leschenault Peninsula.
Photo – Rob Olver

Tuart woodland, Minninup Block, Tuart Forest National Park
Photo – Robert Powell

N

0 10 20 40 60 80 100 Kilometres

Map 1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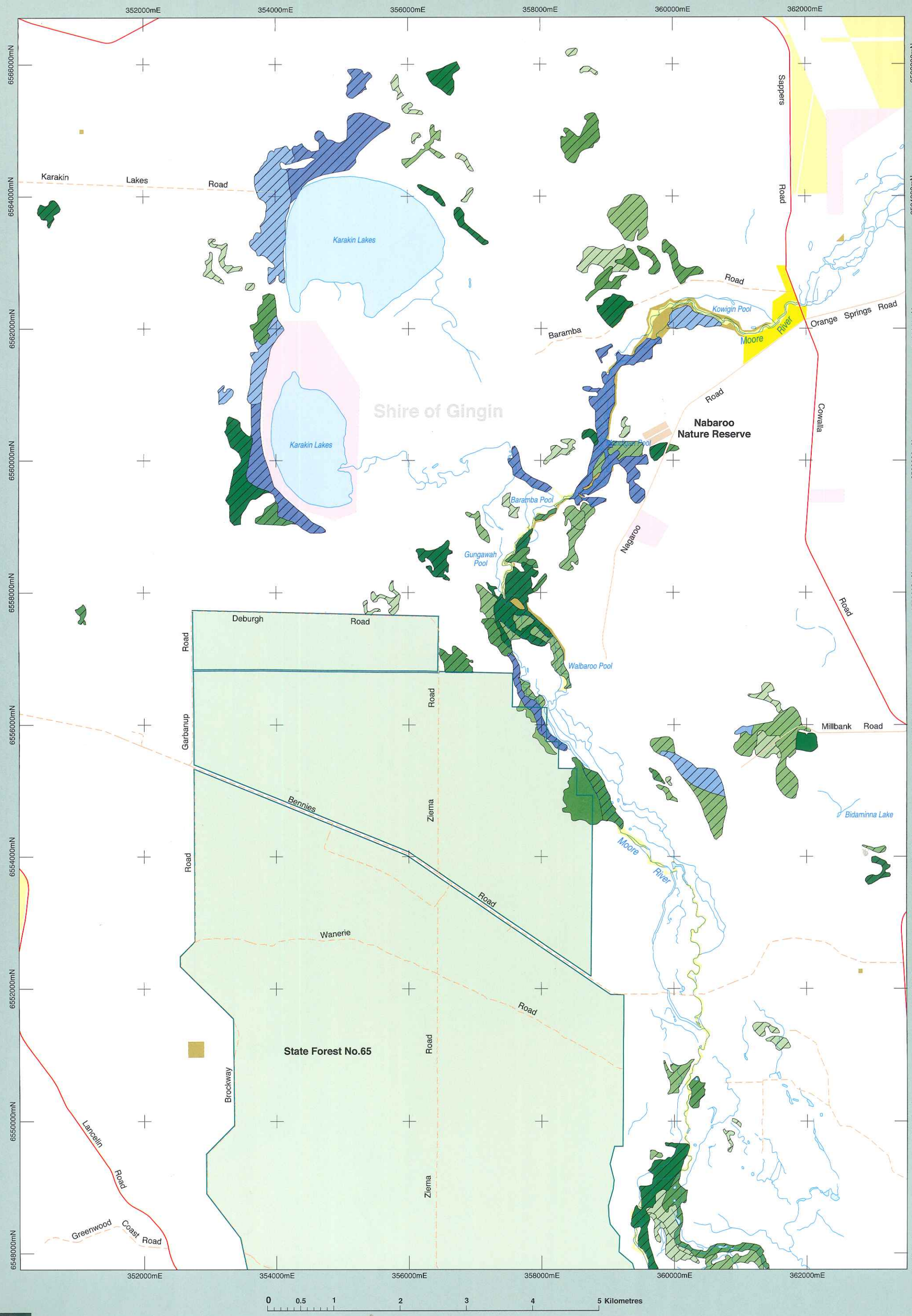
6616000mN
Indian Ocean Drive
Cervantes Road
Shire of Dandaragan
Southern Beekeepers Nature Reserve
Ronsard Bay
Cervantes
Lake Thetis
Pinnacles Drive
Hansen Bay
Nambung National Park
Warrup Pool
Wyip Pool
Kinchela Pool
Nambung Bay
Indian Ocean
0 0.5 1 2 3 4 5 Kilometres

Map 2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Karakin Lakes Road
Karakin Lakes
Shire of Gingin
Karakin Lakes
Sappers Road
Road
Baramba Road
Kowigin Pool
Moore River
Orange Springs Road
Road
Nabaroo Nature Reserve
Karakin Pool
Baramba Pool
Cowalla Road
Nagaroo Road
Gungawah Pool
Deburgh Road
Road
Walbaroo Pool
Garbanup Road
Road
Millbank Road
Bennies Road
Ziema Road
Bidaminna Lake
Moore River
Wanerie Road
State Forest No.65
Brockway Road
Ziema Road
Lancelin Road
Greenwood Coast Road
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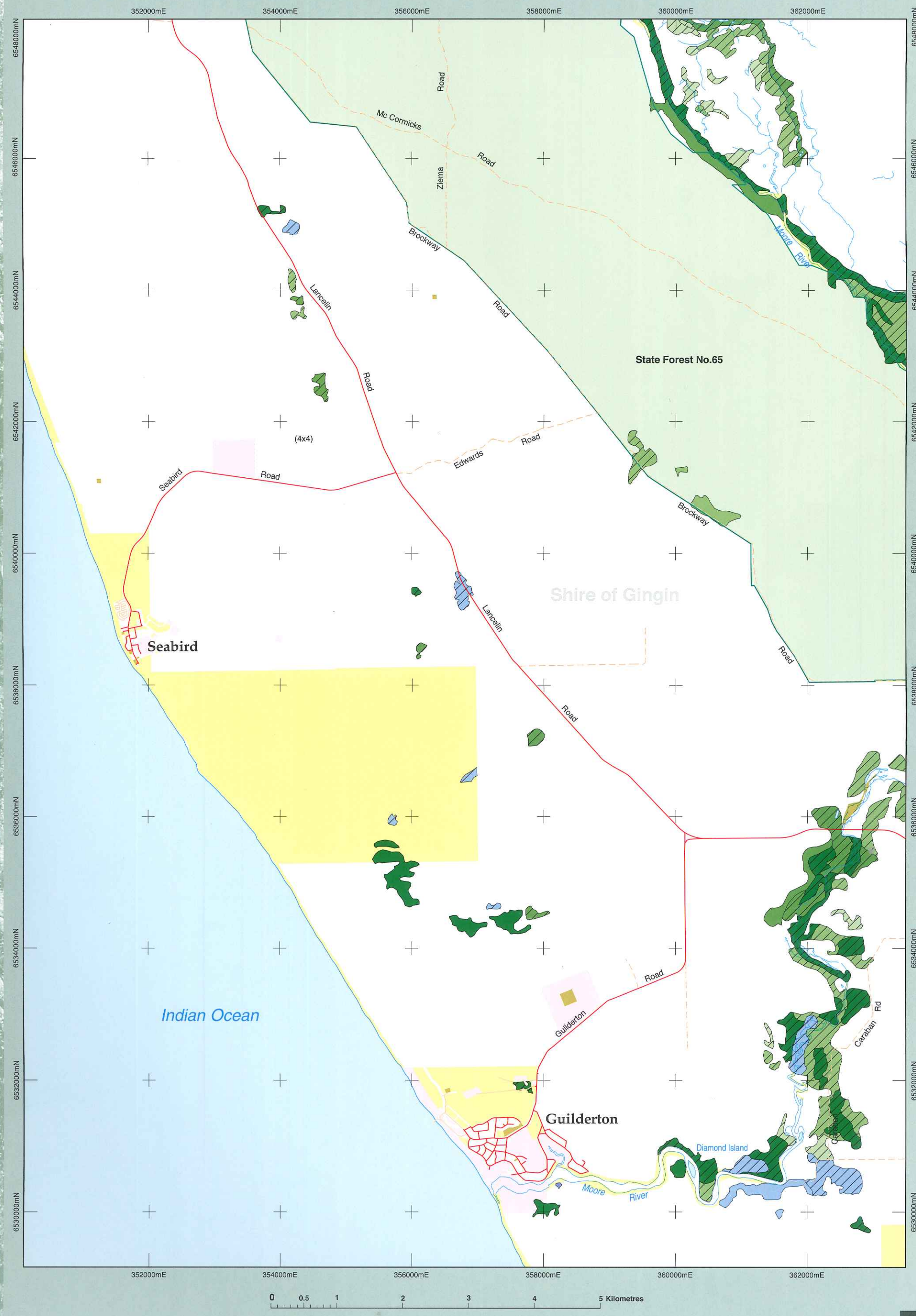
Map 3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6532000mN
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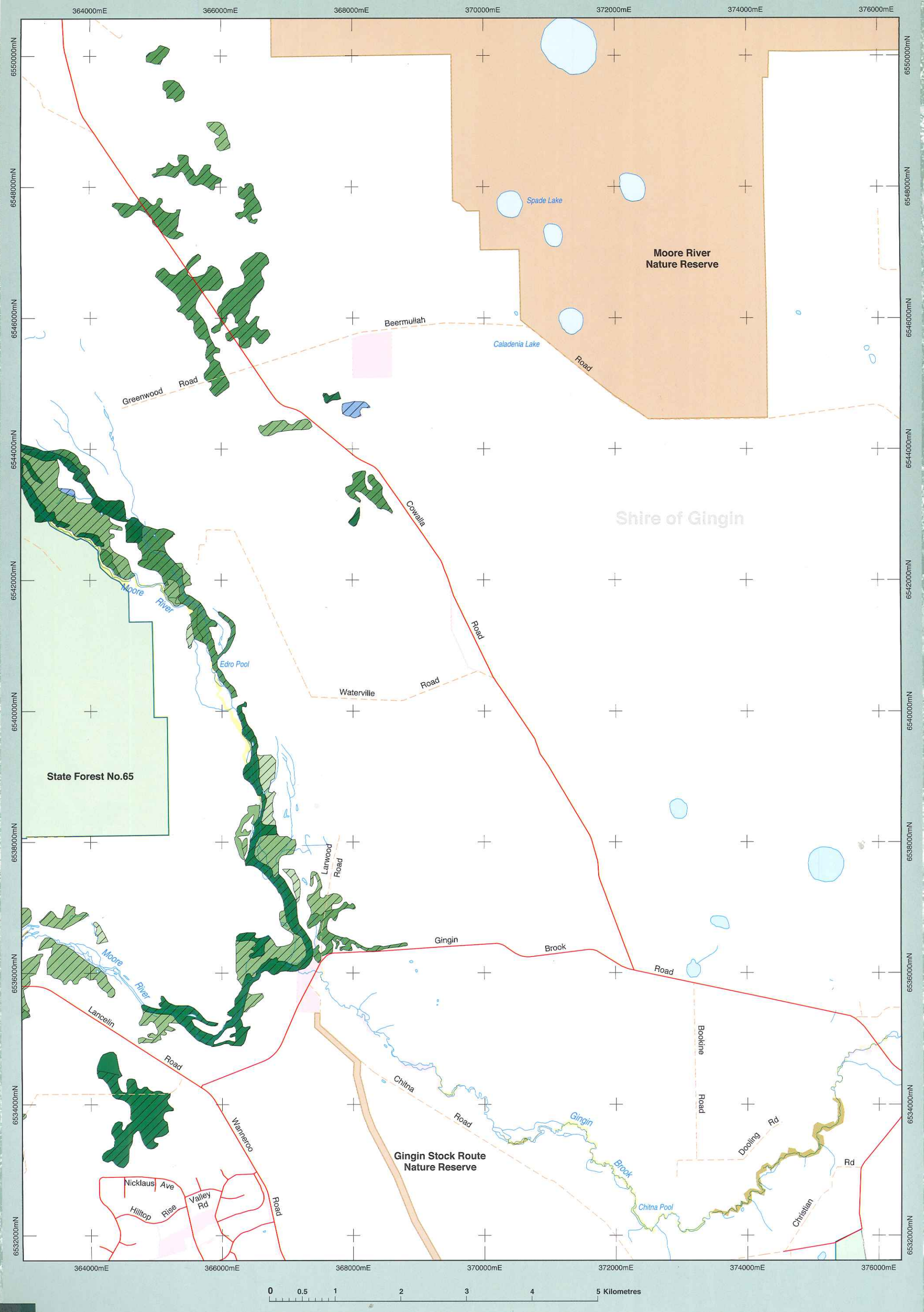
Mc Cormicks Road
Ziema Road
Brockway Road
Lancelin Road
Seabird Road
(4x4)
Edwards Road
Moore River
State Forest No.65
Shire of Gingin
Seabird
Guilderton
Diamond Island
Caraban Rd
Indian Ocean
0 0.5 1 2 3 4 5 Kilometres

Map 4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Spade Lake
Moore River Nature Reserve
Beermullah
Road
Caladenia Lake
Greenwood
Road
Cowalla
Road
Shire of Gingin
Moore
River
Edro Pool
Waterville
Road
State Forest No.65
Larwood
Road
Gingin
Brook
Road
Moore
River
Lancelin
Road
Wanneroo
Road
Nicklaus
Ave
Hilltop
Rise
Valley
Rd
Chitna
Road
Gingin Stock Route Nature Reserve
Gingin
Brook
Chitna Pool
Bookine
Road
Dooling
Rd
Rd
Christian
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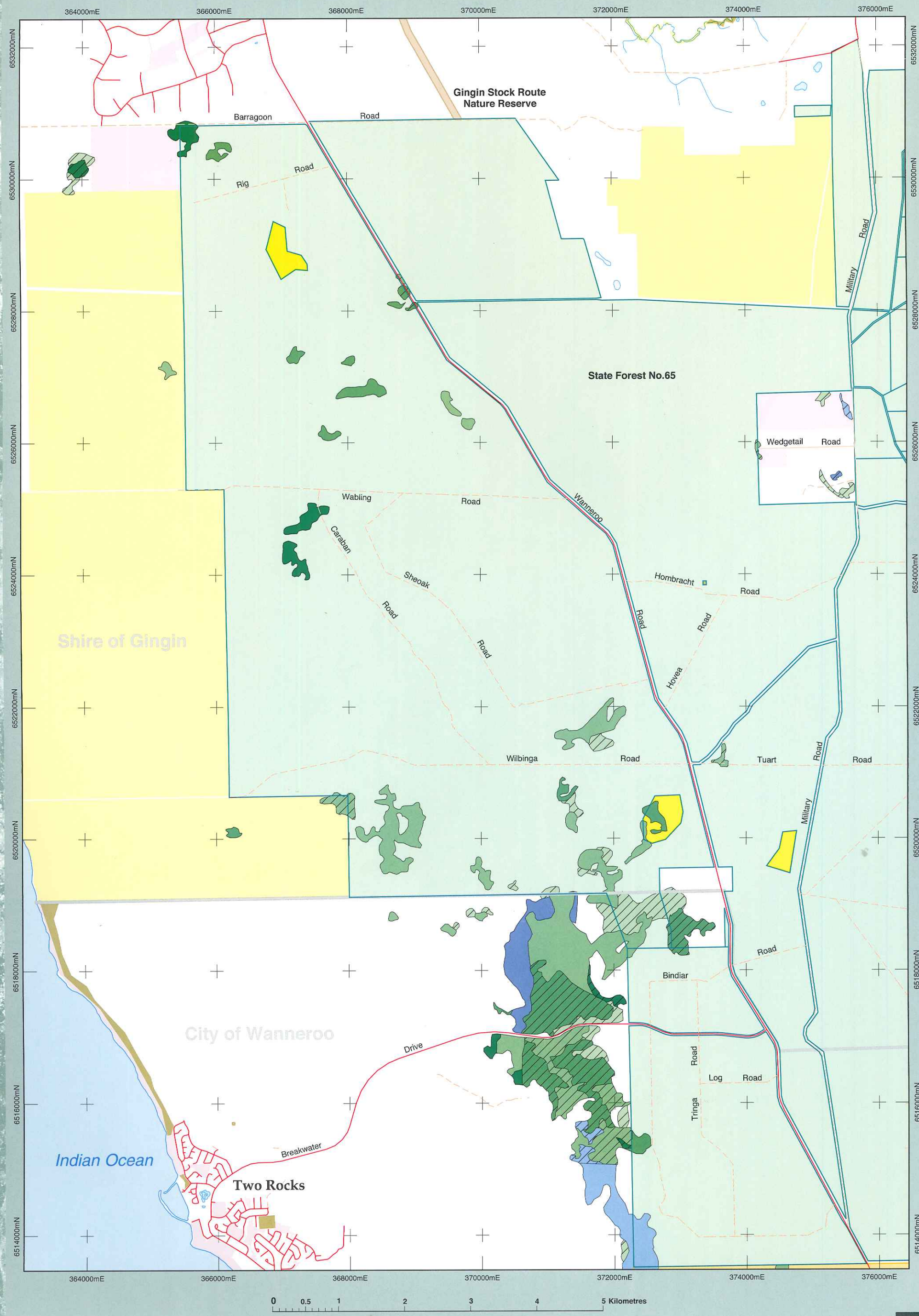
0.5
1
2
3
4
5 Kilometres

Map 5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Gingin Stock Route
Nature Reserve
Barragoon Road
Rig Road
State Forest No.65
Military Road
Wedgetail Road
Wabling Road
Caraban
Sheoak Road
Wanneroo Road
Hombracht Road
Hovea Road
Shire of Gingin
Wilbinga Road
Tuart Road
Military Road
Bindiar Road
Tringa Road
Log Road
City of Wanneroo
Drive
Breakwater
Indian Ocean
Two Rocks
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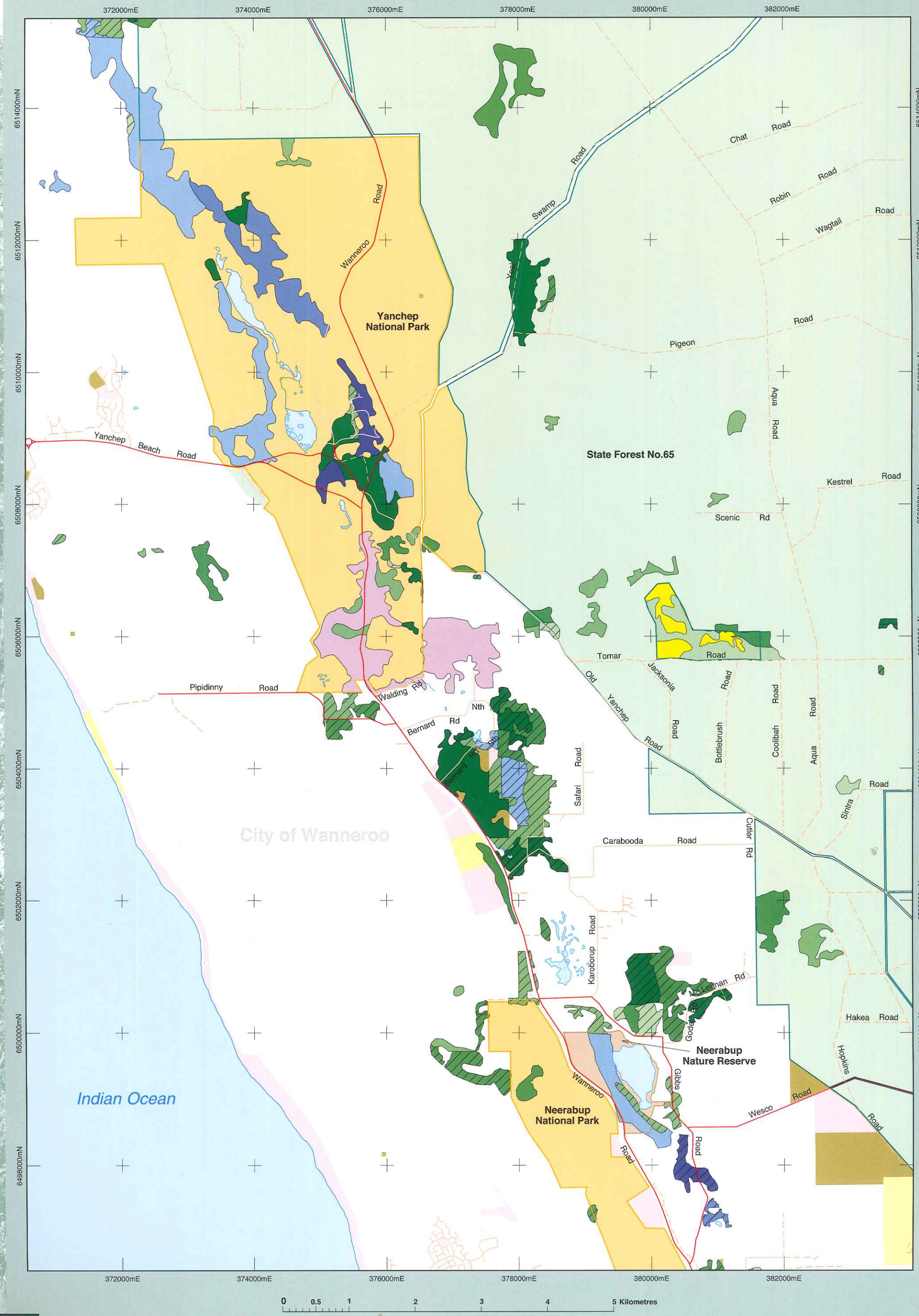
Map 6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Wanneroo Road
Yanchep National Park
Swamp Road
Chat Road
Robin Road
Wagtail Road
Pigeon Road
Aqua Road
State Forest No.65
Kestrel Road
Scenic Rd
Tomar Road
Old Yanchep Road
Jacksonia Road
Bottlebrush Road
Coolibah Road
Aqua Road
Sintra Road
Pipidinny Road
Walding Rd
Bernard Rd Nth
Bernard Rd Sth
Safari Road
Carabooda Road
Cutler Rd
Karoborup Road
McLennan Rd
Godden Rd
Hakea Road
Hopkins Road
Gibbs Road
Wesco Road
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Neerabup National Park
City of Wanneroo
Indian Ocean
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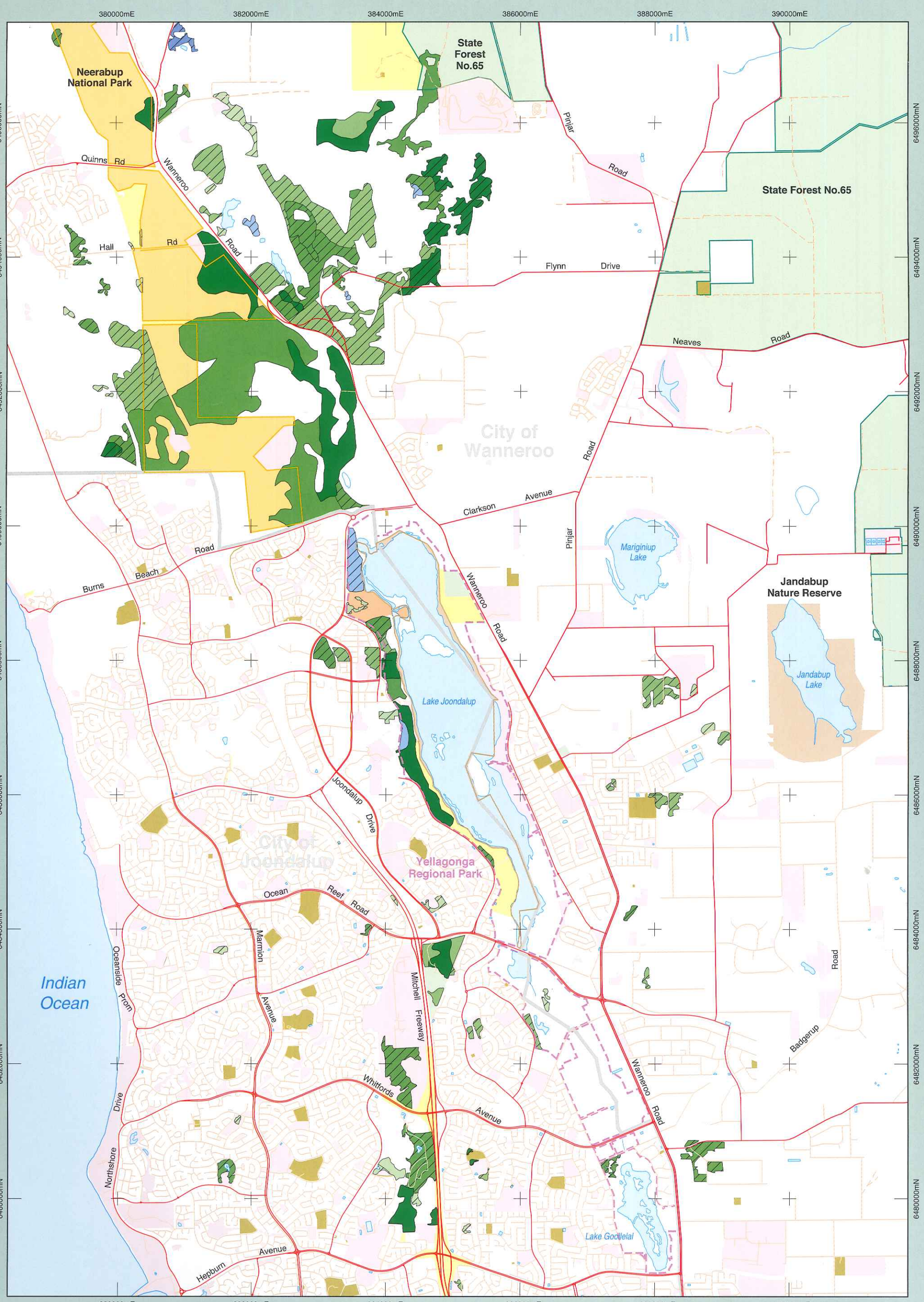
Map 7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State Forest No.65
State Forest No.65
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Wanneroo Road
Hall Rd
Pinjar Road
Flynn Drive
Neaves Road
City of Wanneroo
Clarkson Avenue
Burns Beach Road
Lake Joondalup
Wanneroo Road
Pinjar Road
Mariginiup Lake
Jandabup Nature Reserve
Jandabup Lake
Joondalup Drive
City of Joondalup
Yellagonga Regional Park
Ocean Reef Road
Indian Ocean
Oceanside Prom
Marmion Avenue
Mitchell Freeway
Whitfords Avenue
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Hepburn Avenue
Wanneroo Road
Badgerup Road
Lake Goollelal
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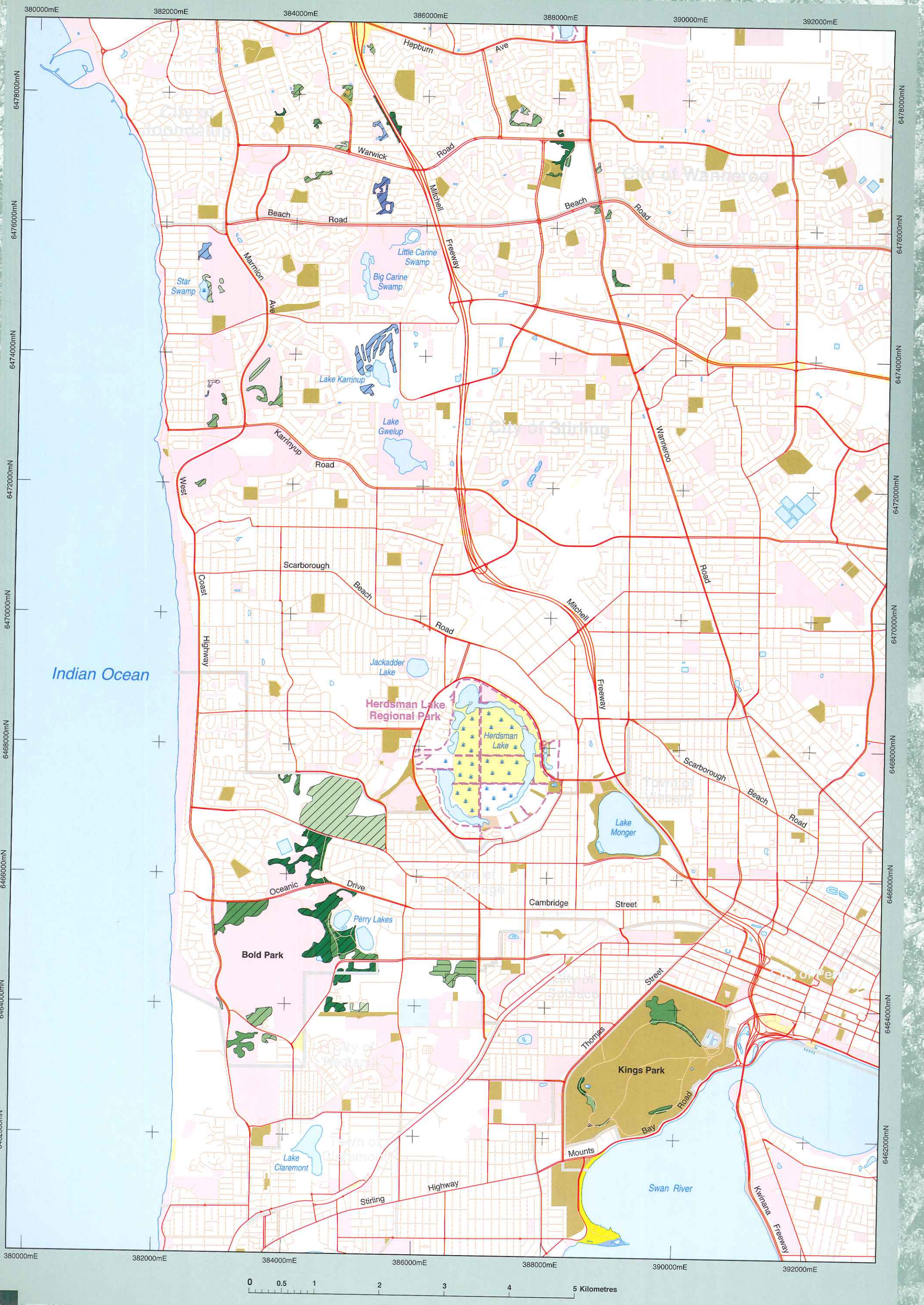
Map 8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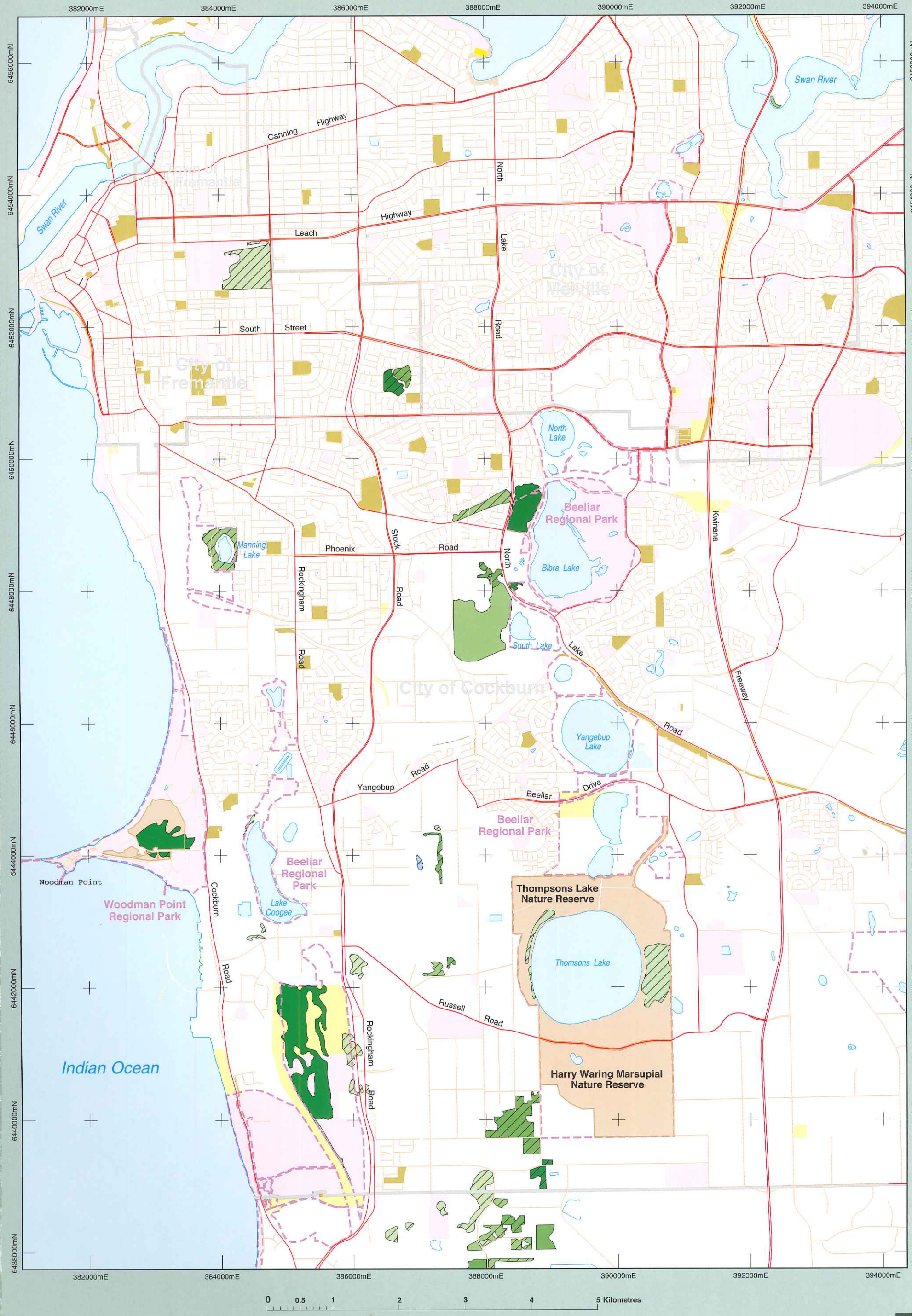
Hepburn Ave
Warwick Road
Beach Road
Mitchell Freeway
Marmion Ave
Little Carine Swamp
Big Carine Swamp
Star Swamp
Lake Karrinup
Lake Gwelup
Karrinyup Road
West Coast Highway
Scarborough Beach Road
Jackadder Lake
Herdsman Lake Regional Park
Herdsman Lake
Wanneroo Road
Lake Monger
Scarborough Beach Road
Oceanic Drive
Perry Lakes
Bold Park
Cambridge Street
Thomas Street
Kings Park
Mounts Bay Road
Lake Claremont
Stirling Highway
Swan River
Kwinana Freeway
Indian Ocean
City of Wanneroo
City of Stirling
0 0.5 1 2 3 4 5 Kilometres

Map 9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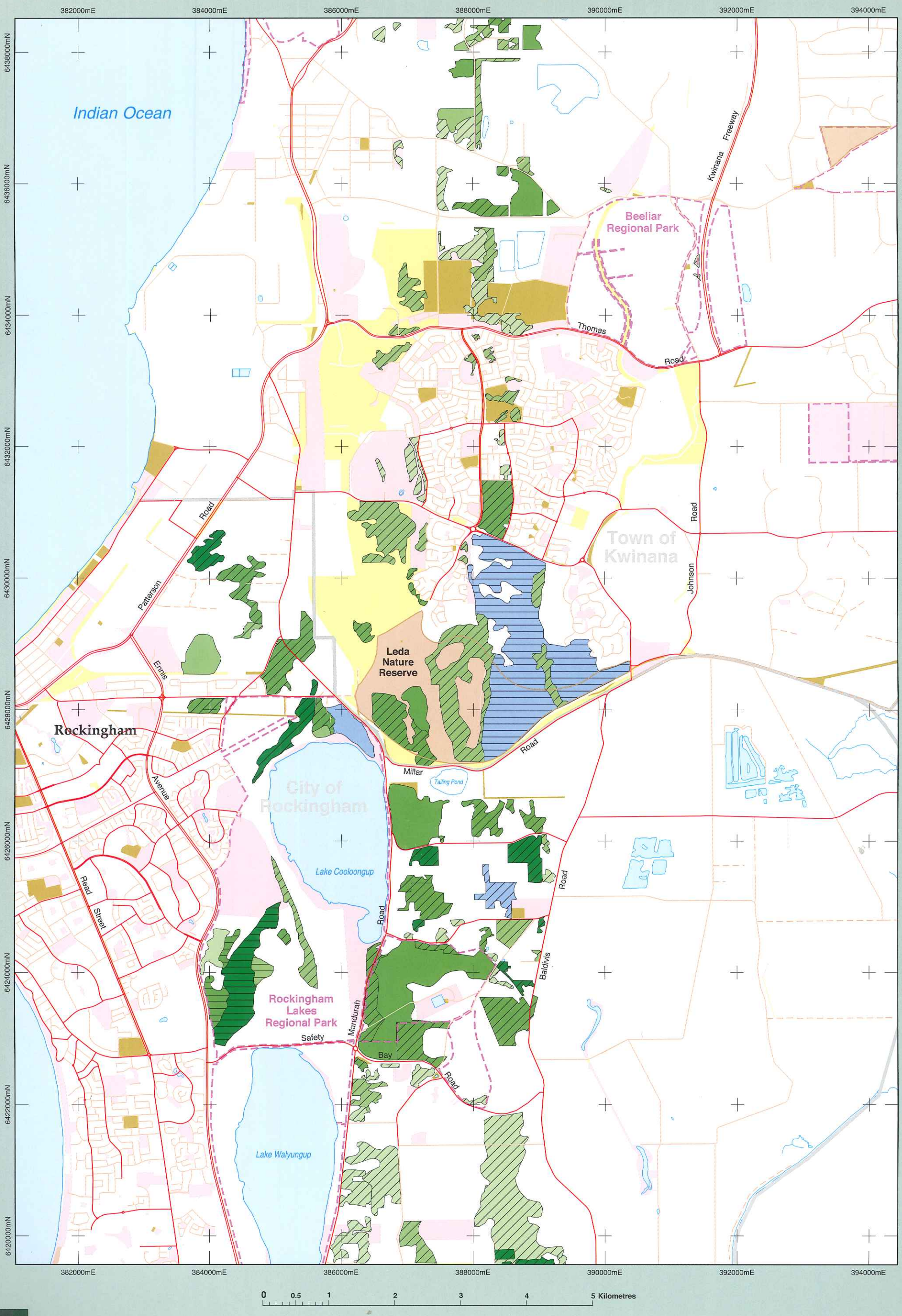
Canning Highway
North Lake Road
Leach Highway
South Street
Lake Road
North Lake
Beeliar Regional Park
Bibra Lake
Kwinana Freeway
Manning Lake
Phoenix Road
Stock Road
Rockingham Road
South Lake
Yangebup Lake
Yangebup Road
Beeliar Drive
Woodman Point
Woodman Point Regional Park
Cockburn Road
Lake Coogee
Thompsons Lake Nature Reserve
Thomsons Lake
Russell Road
Harry Waring Marsupial Nature Reserve
Indian Ocean
City of Fremantle
City of Melville
City of Cockburn
0 0.5 1 2 3 4 5 Kilometres

Map 10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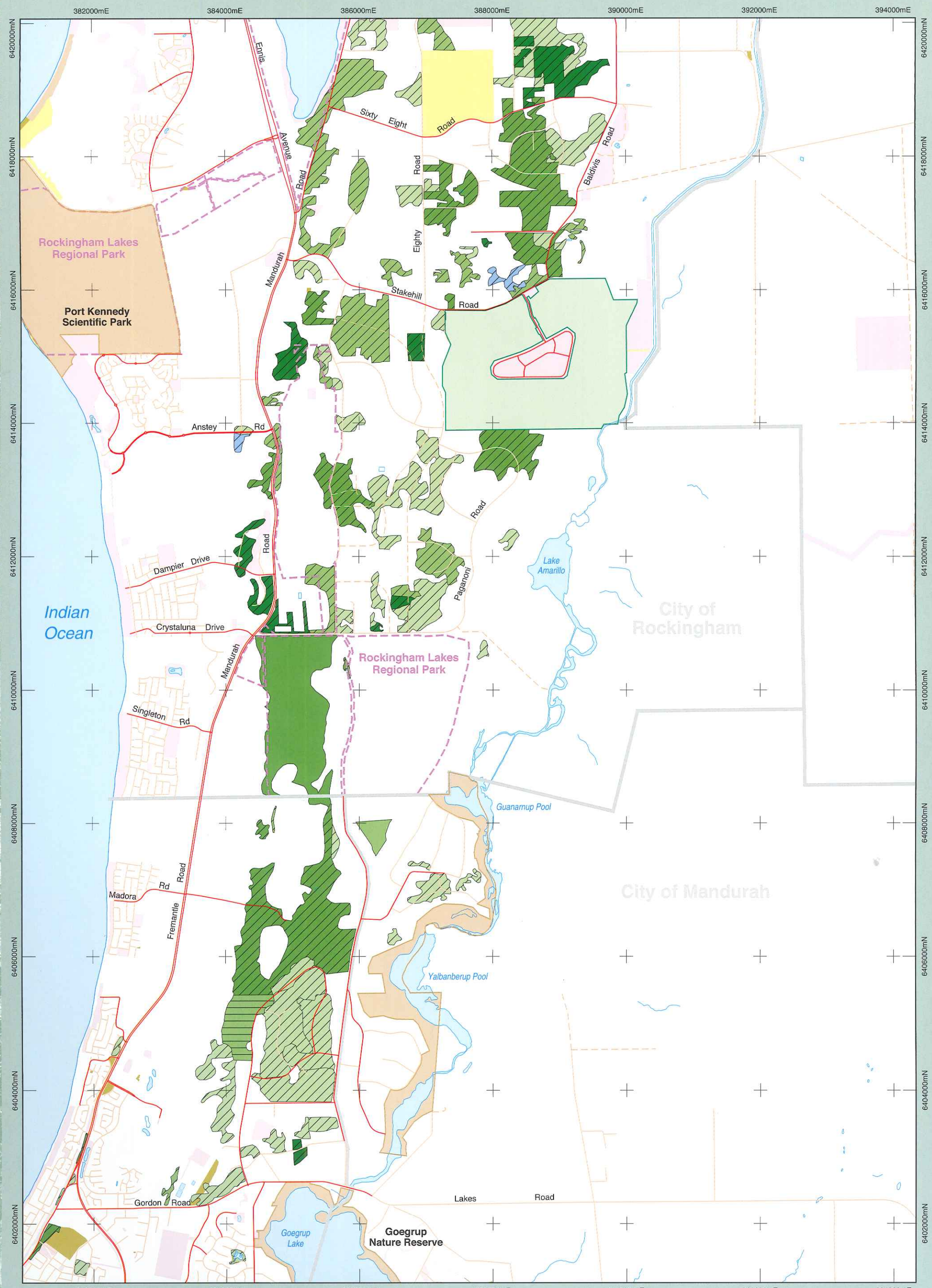
Indian Ocean
Beeliar Regional Park
Kwinana Freeway
Thomas Road
Town of Kwinana
Johnson Road
Patterson Road
Ennis Avenue
Rockingham
Leda Nature Reserve
Millar Road
Tailing Pond
City of Rockingham
Lake Cooloongup
Read Street
Mandurah Road
Baldivis Road
Rockingham Lakes Regional Park
Safety Bay Road
Lake Walyungup
0 0.5 1 2 3 4 5 Kilometres

Map 11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6402000mN
Ennis Avenue Road
Sixty Eight Road
Road
Baldivis Road
Eighty Road
Mandurah Road
Stakehill Road
Rockingham Lakes Regional Park
Port Kennedy Scientific Park
Anstey Rd
Road
Dampier Drive
Crystaluna Drive
Singleton Rd
Madora Rd
Fremantle Road
Gordon Road
Lakes Road
Indian Ocean
Lake Amarillo
Guanarnup Pool
Yalbanberup Pool
Goegrup Lake
Goegrup Nature Reserve
City of Rockingham
City of Mandurah
0 0.5 1 2 3 4 5 Kilometres

Map 12


372000mE
374000mE
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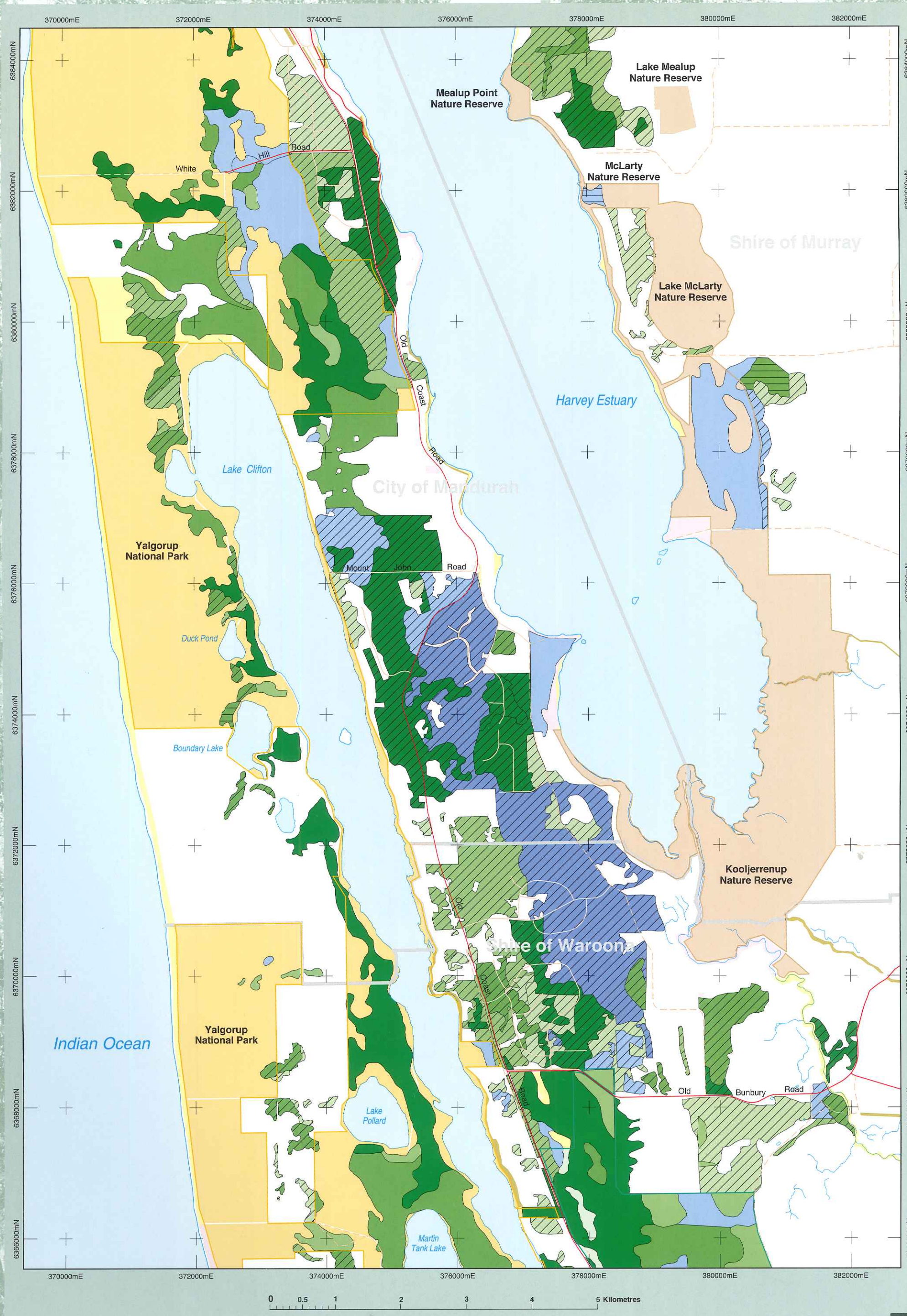
Indian Ocean
Halls Head
Mandurah
Terrace
Fremantle Road
Mandurah Estuary
Old Coast Road
Mandurah Bypass
Len Howard Conservation Park
Creery Island
Boundary Island
City of Mandurah
Peel Inlet
Shire of Murray
Dawesville Channel
Ocean Rd
Dawesville Road
Harvey Estuary
Austin Bay Nature Reserve
Robert Bay
Austin Bay
Yalgorup National Park
0 0.5 1 2 3 4 5 Kilometres

Map 13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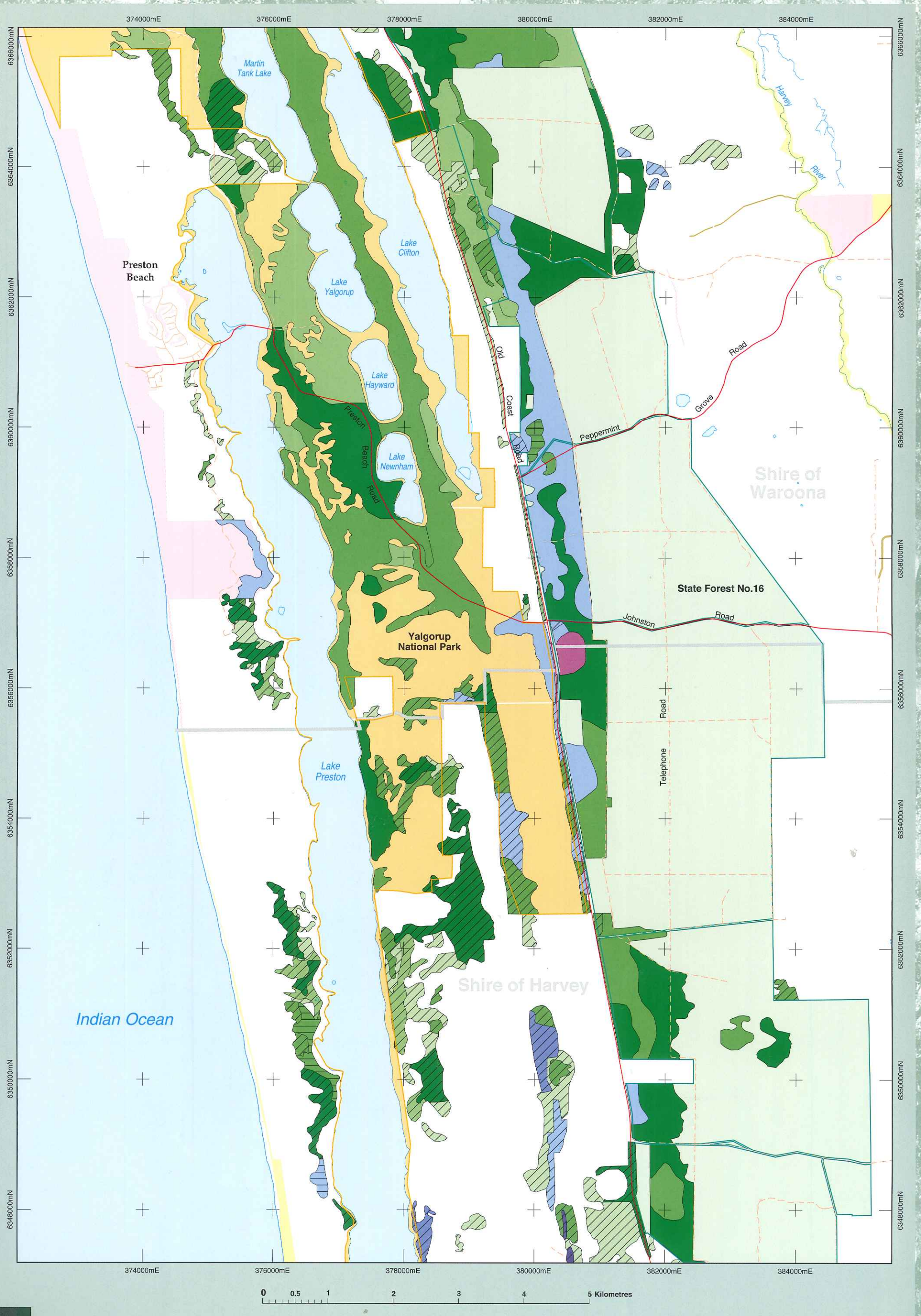
Mealup Point Nature Reserve
Lake Mealup Nature Reserve
McLarty Nature Reserve
Lake McLarty Nature Reserve
Shire of Murray
White Hill Road
Old Coast Road
Harvey Estuary
Lake Clifton
City of Mandurah
Yalgorup National Park
Mount John Road
Duck Pond
Boundary Lake
Kooljerrenup Nature Reserve
Shire of Waroona
Indian Ocean
Old Coast Road
Old Bunbury Road
Lake Pollard
Martin Tank Lake
0 0.5 1 2 3 4 5 Kilometres

Map 14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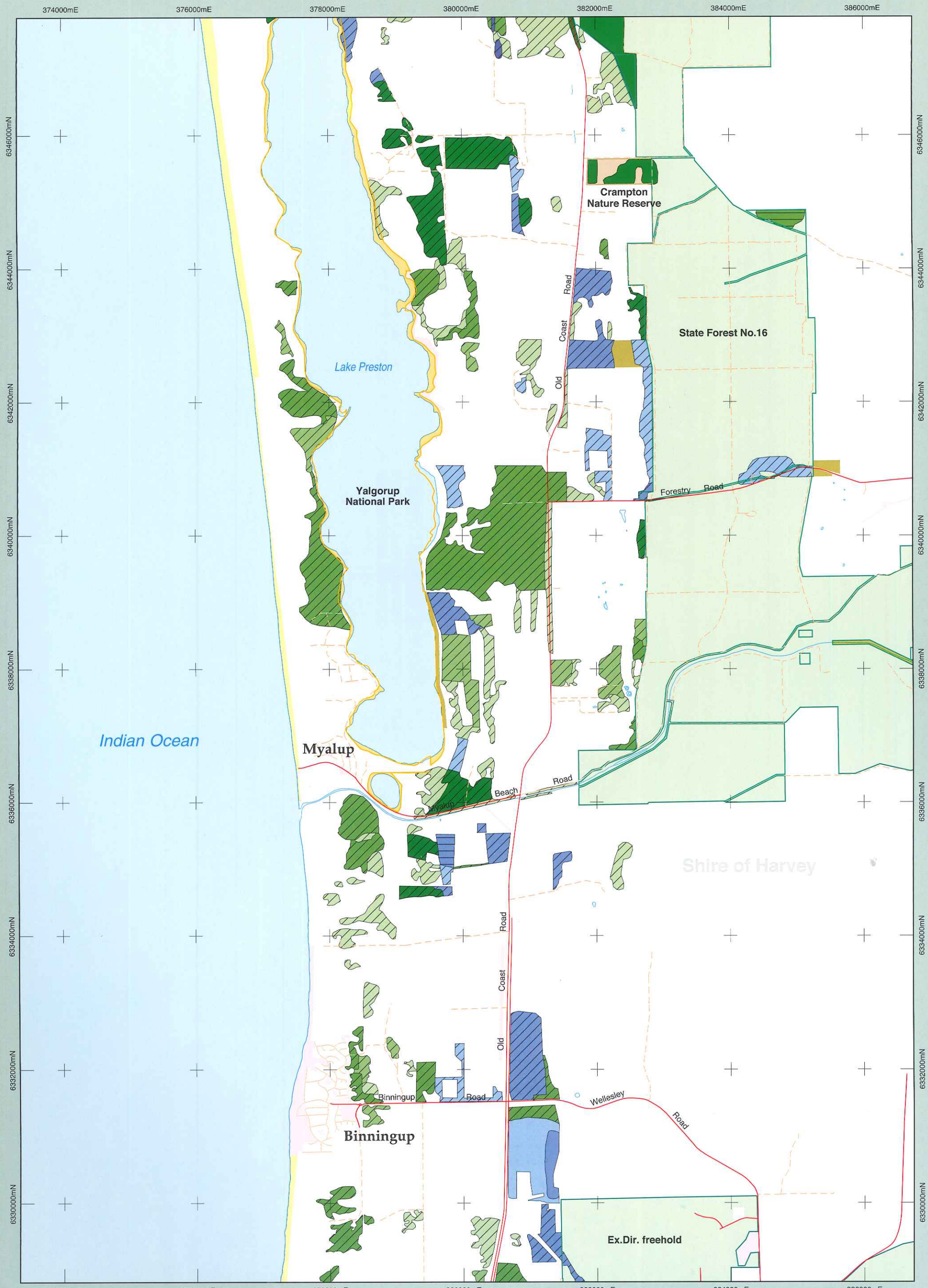
Martin Tank Lake
Lake Clifton
Lake Yalgorup
Lake Hayward
Lake Newnham
Lake Preston
Preston Beach
Preston Beach Road
Old Coast Road
Harvey River
Road
Peppermint Grove
Shire of Waroona
State Forest No.16
Johnston Road
Yalgorup National Park
Telephone Road
Shire of Harvey
Indian Ocean
0 0.5 1 2 3 4 5 Kilometres

Map 15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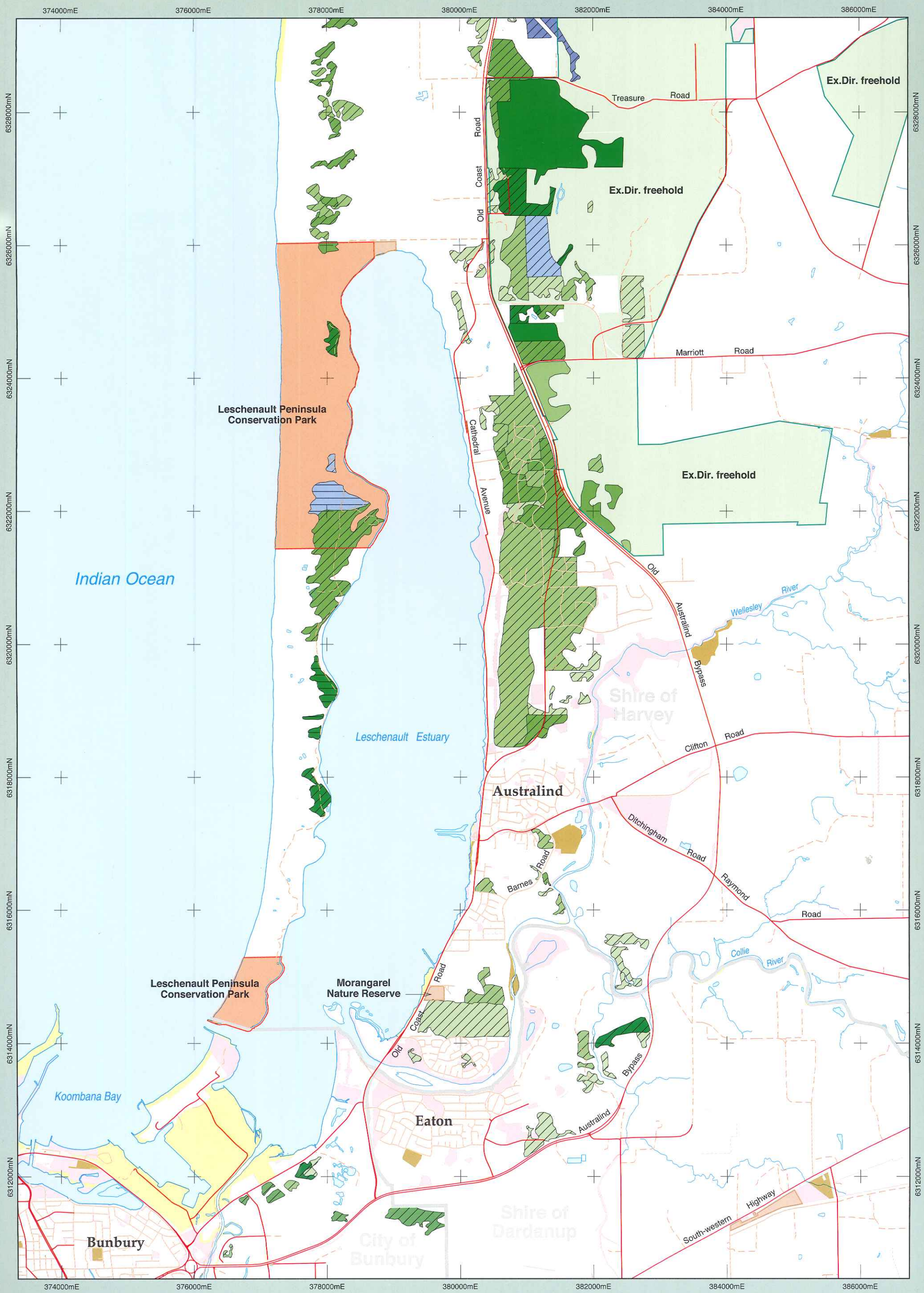
6338000mN
6336000mN
6334000mN
6332000mN
6330000mN
Lake Preston
Crampton
Nature Reserve
State Forest No.16
Old Coast Road
Yalgorup
National Park
Forestry Road
Indian Ocean
Myalup
Myalup Beach Road
Road
Shire of Harvey
Old Coast Road
Binningup Road
Wellesley Road
Binningup
Ex.Dir. freehold
0 0.5 1 2 3 4 5 Kilometres

Map 16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6320000mN
6318000mN
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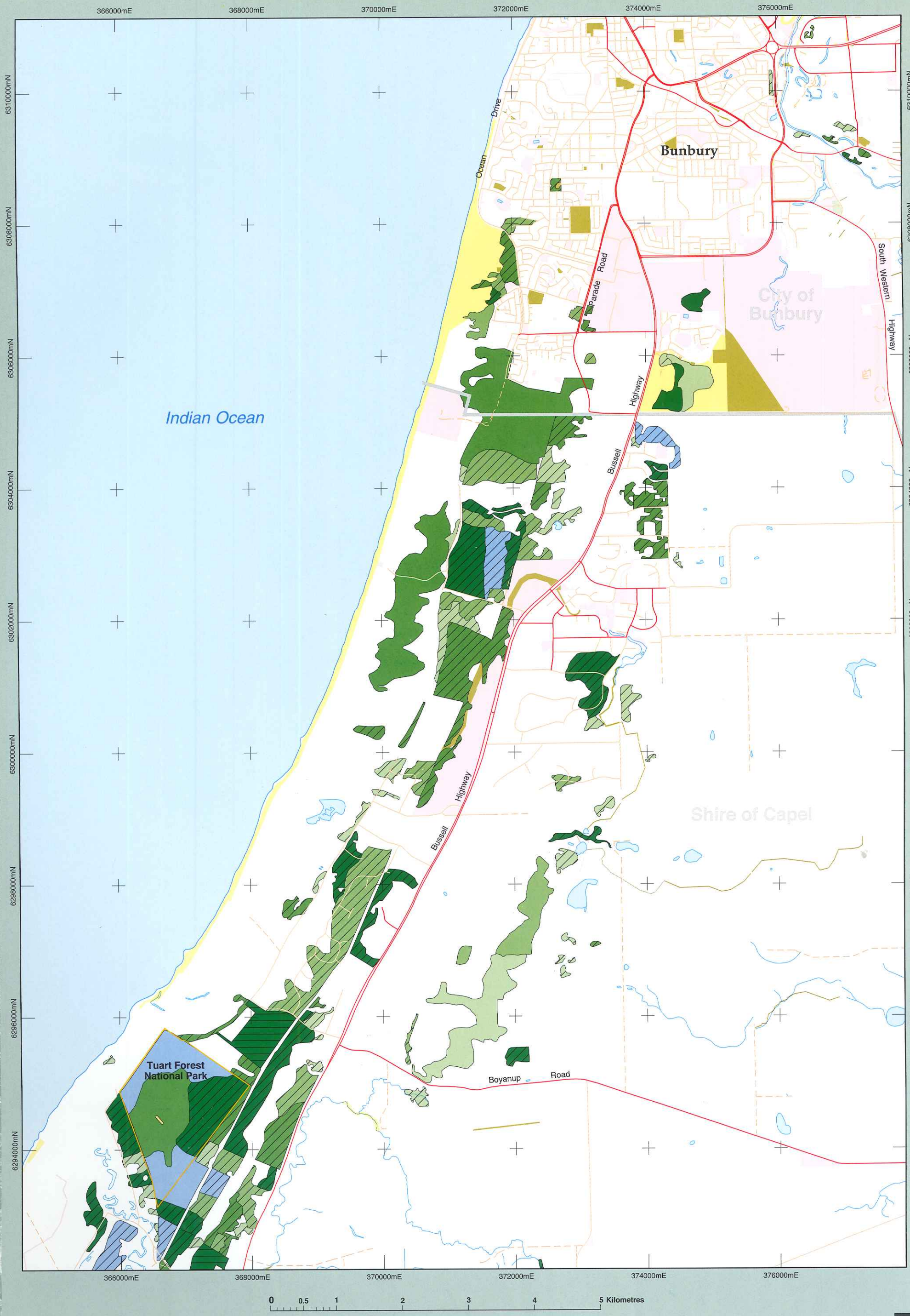
6314000mN
6312000mN
Treasure Road
Ex.Dir. freehold
Old Coast Road
Ex.Dir. freehold
Marriott Road
Leschenault Peninsula Conservation Park
Cathedral Avenue
Ex.Dir. freehold
Indian Ocean
Old Australind Bypass
Wellesley River
Shire of Harvey
Leschenault Estuary
Clifton Road
Australind
Ditchingham Road
Barnes Road
Raymond Road
Collie River
Leschenault Peninsula Conservation Park
Morangarel Nature Reserve
Old Coast Road
Bypass
Koombana Bay
Eaton
Australind
Shire of Dardanup
City of Bunbury
South-western Highway
Bunbury
0 0.5 1 2 3 4 5 Kilometres

Map 17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6302000mN
6300000mN
6298000mN
6296000mN
6294000mN
Indian Ocean
Ocean Drive
Bunbury
Parade Road
South Western Highway
City of Bunbury
Bussell Highway
Shire of Capel
Tuart Forest National Park
Boyanup Road
0 0.5 1 2 3 4 5 Kilometres

358000mE 360000mE 362000mE 364000mE 366000mE 368000mE 370000mE 372000mE 374000mE 376000mE

6292000mN 6290000mN 6288000mN 6286000mN 6284000mN 6282000mN 6280000mN

Indian Ocean

Capel River

Tuart Forest National Park

North Road

Stirling Road

Ludlow

Gully

Layman

Bussell Highway

Capel

Railway Road

Gavins Road

Tuart Forest National Park

Tuart Drive

Capel Nature Reserve

Tuturup Road

Goodwood Road

North Goodwood Road

Capel River

Shire of Capel

Highway

Bussell

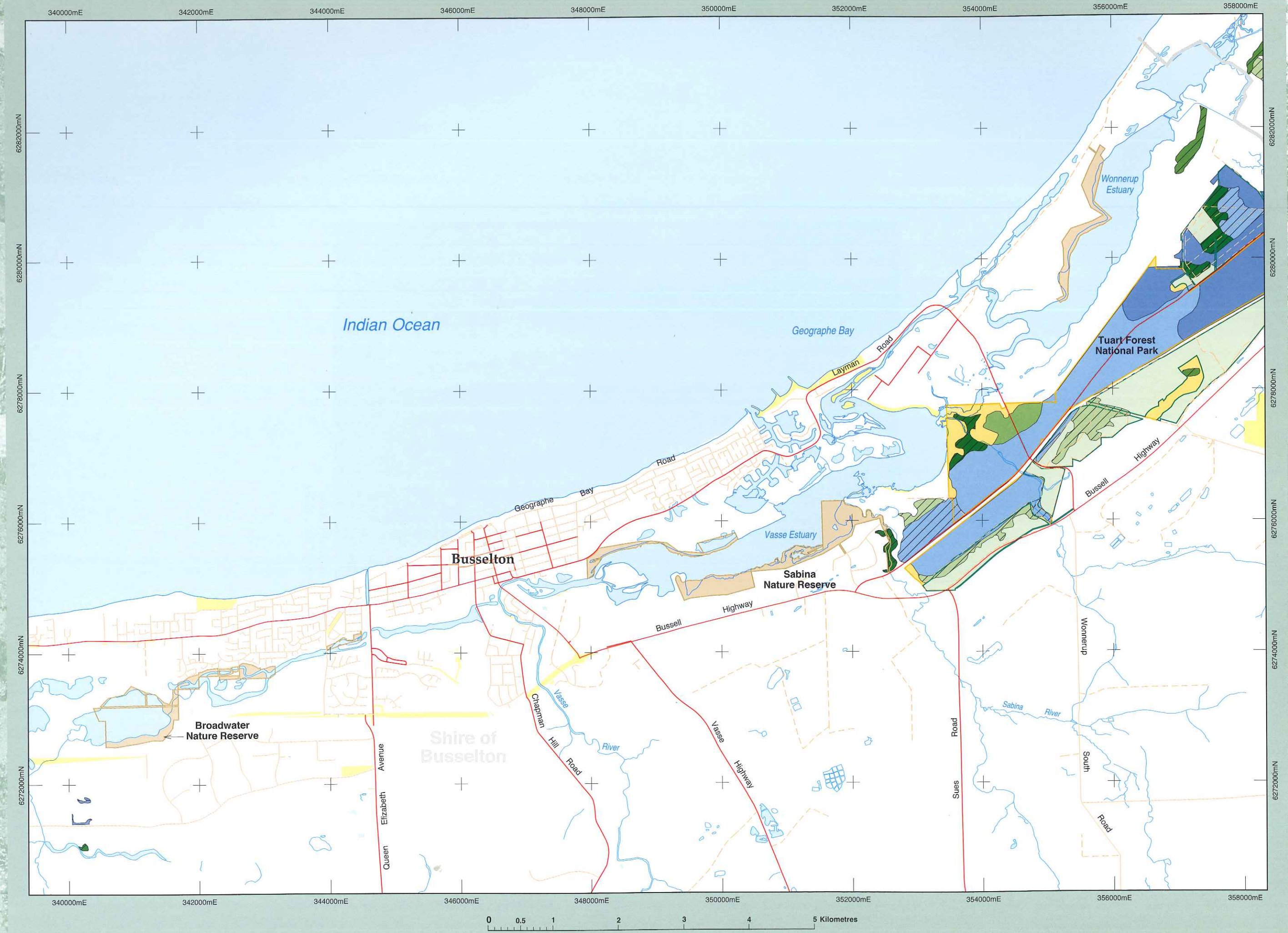
State Forest No.2

State Forest No.12

Tuart Forest National Park

Shire of Busselton

0 0.5 1 2 3 4 5 Kilometres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6280000mN
6278000mN
6276000mN
6274000mN
6272000mN
Indian Ocean
Geographe Bay
Layman Road
Wonnerup Estuary
Tuart Forest National Park
Bussell Highway
Geographe Bay Road
Busselton
Vasse Estuary
Sabina Nature Reserve
Bussell Highway
Broadwater Nature Reserve
Shire of Busselton
Elizabeth Avenue
Queen
Chapman Hill Road
Vasse River
Vasse Highway
Sues Road
Sabina River
Wonnerup South Road
0 0.5 1 2 3 4 5 Kilometres